automotive council UK

ADVANCED PROPULSION CENTRE UK

Lightweight Vehicle and Powertrain Structures Roadmap

Updated by the Advanced Propulsion Centre in collaboration with and on behalf of the Automotive Council

Executive summary: *Lightweight Vehicle and Powertrain Structures*

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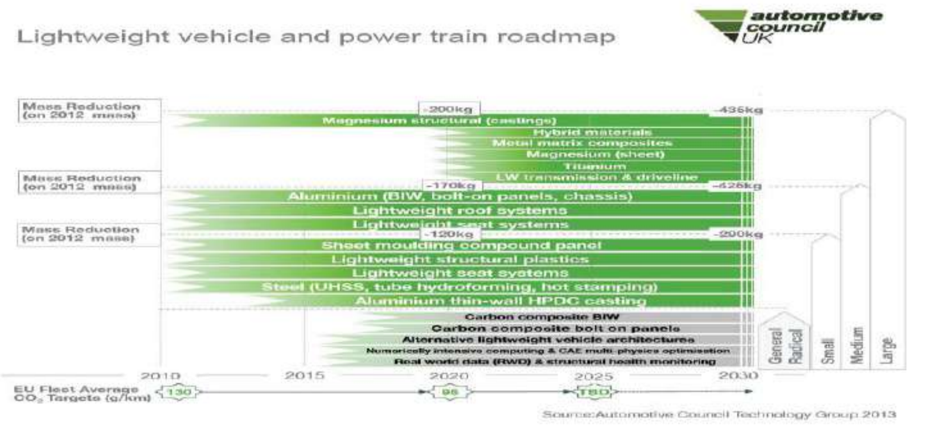

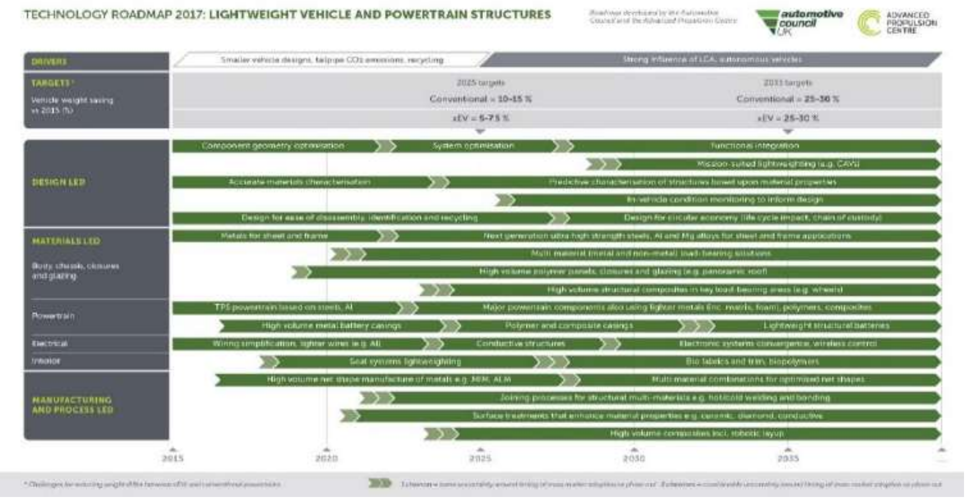

- **The 2013 roadmap focussed on materials,** with the natural progression of more advanced materials trickling down from larger and premium vehicles into medium and small car segments

- **2017 roadmap has built upon the targets created in 2013 and has been reinforced by a wide range of industry and academic experts**. The targets reflect the different challenges in conventional and xEV (short term) and how the greater levels of autonomy impact design over the longer term

- **The 2017 roadmap reflects an acceleration to lower emissions and zero emission solutions**, requiring lighter weight to offset additionality in conventional powertrain systems and to increase the range or reduce mass of battery required in xEVs

- **The 2017 roadmap focusses on design, materials and manufacturing weight saving themes**, acknowledging all three have an equally important role to play in supporting weight optimised vehicle systems

- **The roadmap and research challenges acknowledge sustainability** and the life cycle impact of different materials and manufacturing processes

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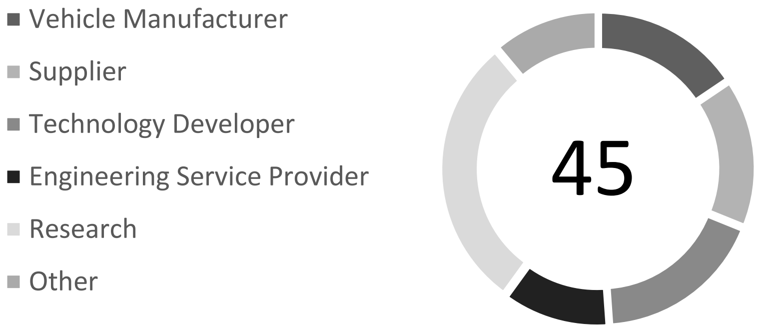
Update process: *The 2017 Lightweight Vehicle and Powertrain Roadmap was updated via a structured consensus-building process involving experts*

- A public workshop was held at the Advanced Propulsion Centre's hub on the 13th April 2017

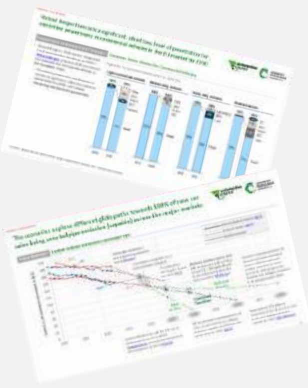
- The process was co-ordinated by the Advanced Propulsion Centre on behalf of Automotive Council

- The Advanced Propulsion Centre was supported by an expert Steering Group, which shaped the roadmap before and after the workshop.

Lightweight Vehicle and Powertrain Workshop and Steering Committee Attendees



Pre-Event Email — 1 day workshop with 40 attendees — Post-Event Email

Pre-event Common Assumptions Briefing	Collective Briefing Process	Breakout Sessions	Post-Event Debrief
			

Technical targets: *Mass market adoption of ultra low emission vehicles drives challenging performance targets for lightweight solutions*

Drivers of change

- **CO_2 targets and requirements for improved air quality have pushed OEMs towards increased energy efficiency**. Reducing energy demand through weight reduction is a logical means to lower CO_2 in conventional ICE vehicles, offering secondary benefits since elements such engines and brakes can also be made smaller as vehicle mass reduces.
- Vehicle weight has been **increasing for a number of years due to greater inclusion of vehicle safety, comfort and entertainment** content. In the past decade lightweighting has been applied to compensate this, resulting in broadly stable weight in most vehicle classes.
- In the short term, electrification poses additional challenges for vehicle weight. In PHEVs and BEVs, the **larger batteries and electrified propulsion components** make these vehicles heavier than conventional ICE vehicles. However in the long term, the **introduction of connected and autonomous vehicles and geo-fenced zones will radically influence vehicle designs** irrespective of powertrain
- **Life cycle considerations** pose challenges for new materials and manufacturing choices, often narrowing options
- Meeting the need for steep CO_2 reductions will require further weight reductions, many of which cannot be achieved through incremental changes. **Targets have been set to drive innovation in vehicle materials, design and manufacturing**, in support of overall CO_2 goals and emission reduction.
- A further challenge for weight reduction is that it should not be achieved at the detriment of unreasonable cost, safety or emissions reduction.

Passenger Car	2015	2025	2035
Conventional vehicle weight decrease (%)[1]	Baseline	10 -> 15%[2]	25 -> 30%[2]
xEV vehicle weight decrease[3]	Baseline	5 -> 7.5%	25 -> 30%
Recyclability of material (%)	85%	85%[4]	95%

1. Some components will be untouched during this period, so those which are redesigned must have a higher % saving than the vehicle % saving required
2. Future vehicle weight reductions will need to counter weight gains from e.g. ADAS, infotainment, NVH, safety systems, refinement solutions (weight gain estimated to be around 5% in 2025 and up to 10% by 2035)
3. The target for 2025 is lower than conventional ICE because larger batteries will increase the weight of next generation xEVs. However the improved energy density of batteries, as well lighter motor and power electronics solutions, are keeping weight increases as small as possible.
4. Number remains the same to reflect the inclusion of battery packs in end of life regulations

Technology categories: *Parallel innovation is needed in design, materials and manufacturing in order to meet targets*

DRIVERS

Smaller vehicle designs, tailpipe CO_2 emissions, recycling

Strong influence of LCA, autonomous vehicles

TARGETS*

Vehicle weight saving vs 2015 (%)

	2025 targets	2035 targets
Conventional	**10-15 %**	**25-30 %**
xEV	**5-7.5 %**	**25-30 %**

DESIGN LED

Innovative vehicle and component design is crucial to engineering structurally efficient vehicles that also meet sustainability targets

Note that the roadmap does not list *all* design, material and manufacturing technologies that will be applied. For clarity the emphasis is upon those where significant innovation is anticipated.

MATERIALS LED

Body, chassis, closures and glazing

Powertrain

Electrical

Interior

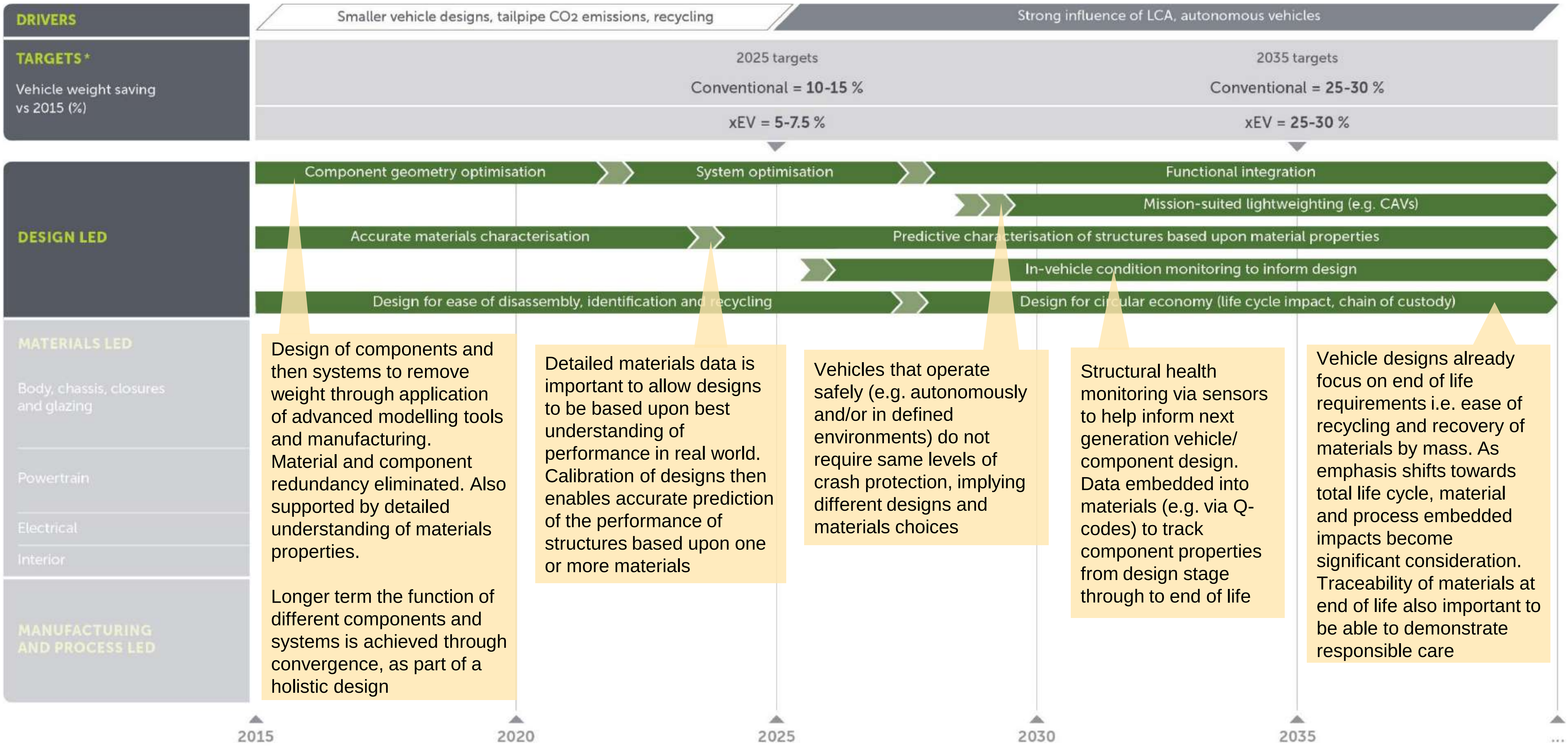
There are a wide range of different materials OEMs can use to reduce weight across the vehicle. The applicability of these materials varies by vehicle area and materials innovation (supported by design and manufacturing) can expand the options for many materials

MANUFACTURING AND PROCESS LED

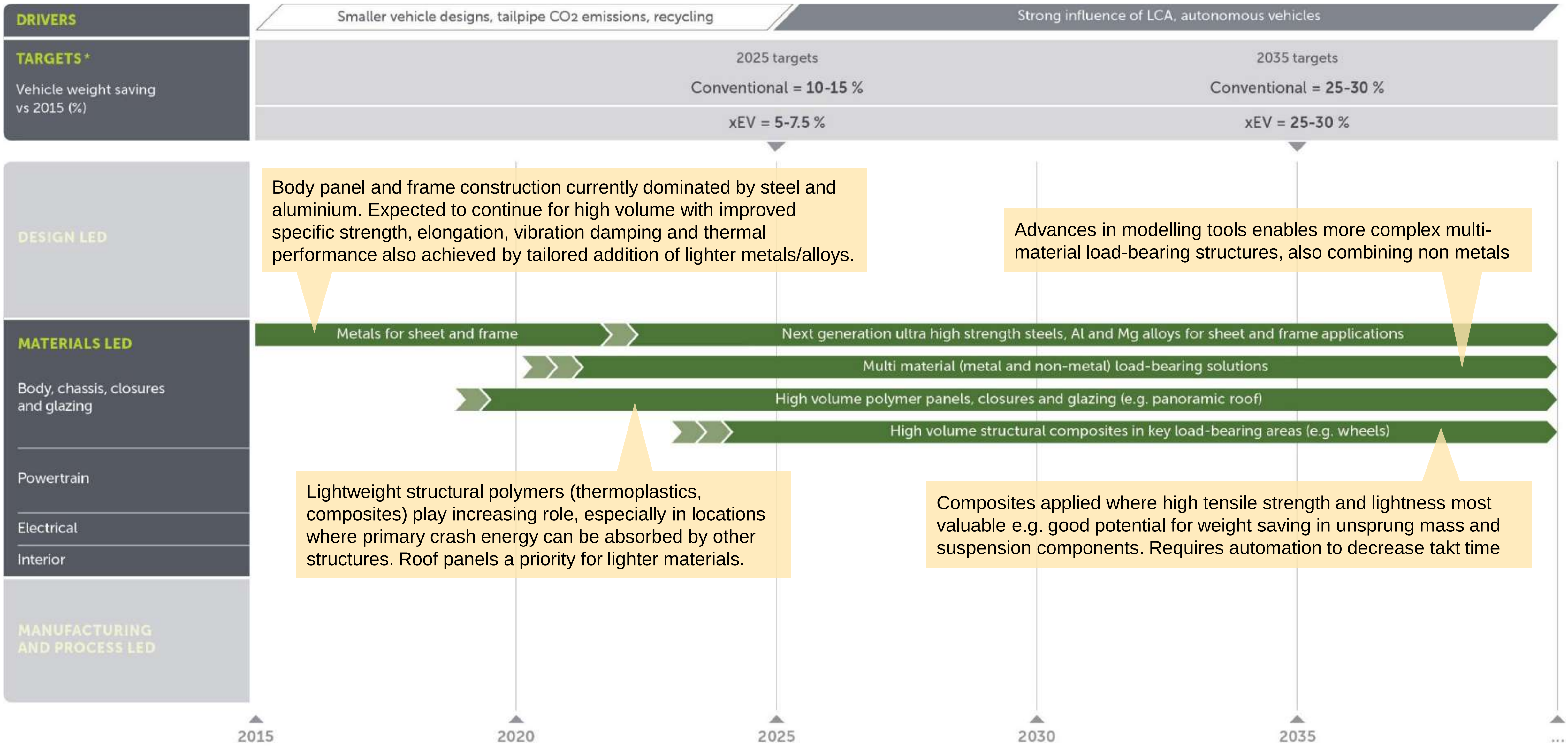
Improvements in manufacturing processes are required to support new lightweight materials and designs

2015 2020 2025 2030 2035 ...

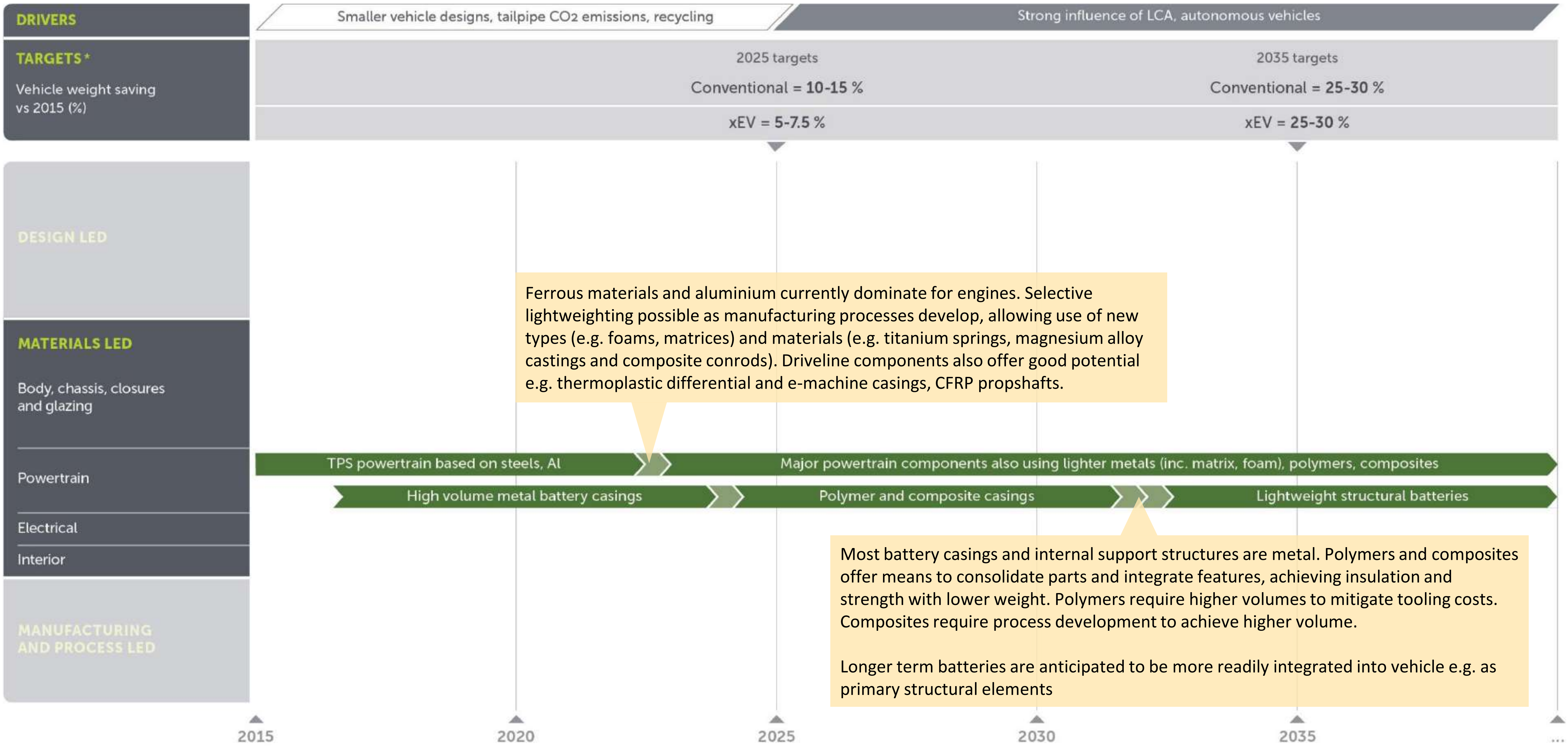
Design led: *Design innovation enables weight to be saved by avoiding unnecessary mass and applying the right materials*



Materials led: *Lighter metals and non traditional materials can reduce weight of body structures, leading to a more mixed material future*



Materials led: *Thermal propulsion systems and electrified powertrains offer strong potential for selective use of lighter materials*

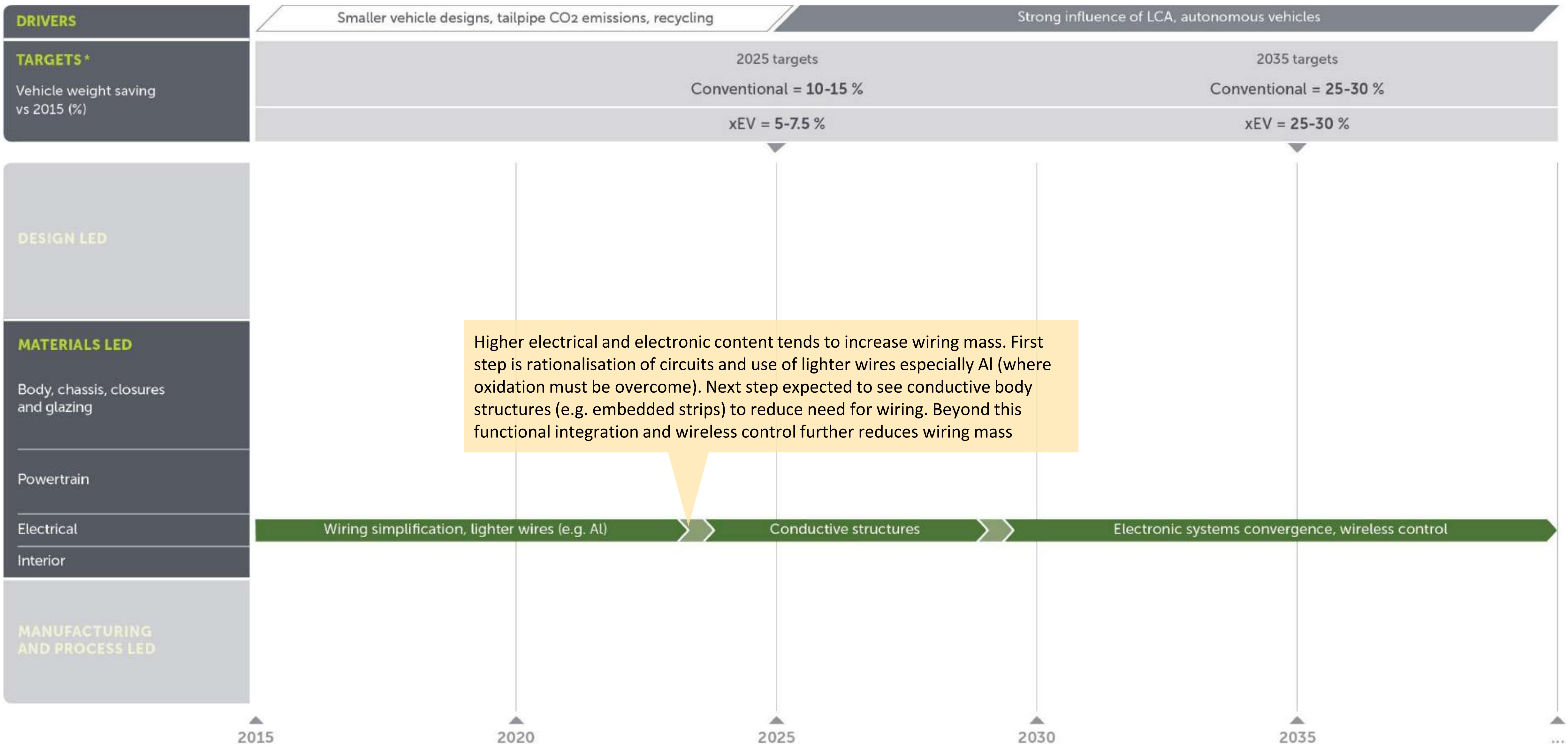


Ferrous materials and aluminium currently dominate for engines. Selective lightweighting possible as manufacturing processes develop, allowing use of new types (e.g. foams, matrices) and materials (e.g. titanium springs, magnesium alloy castings and composite conrods). Driveline components also offer good potential e.g. thermoplastic differential and e-machine casings, CFRP propshafts.

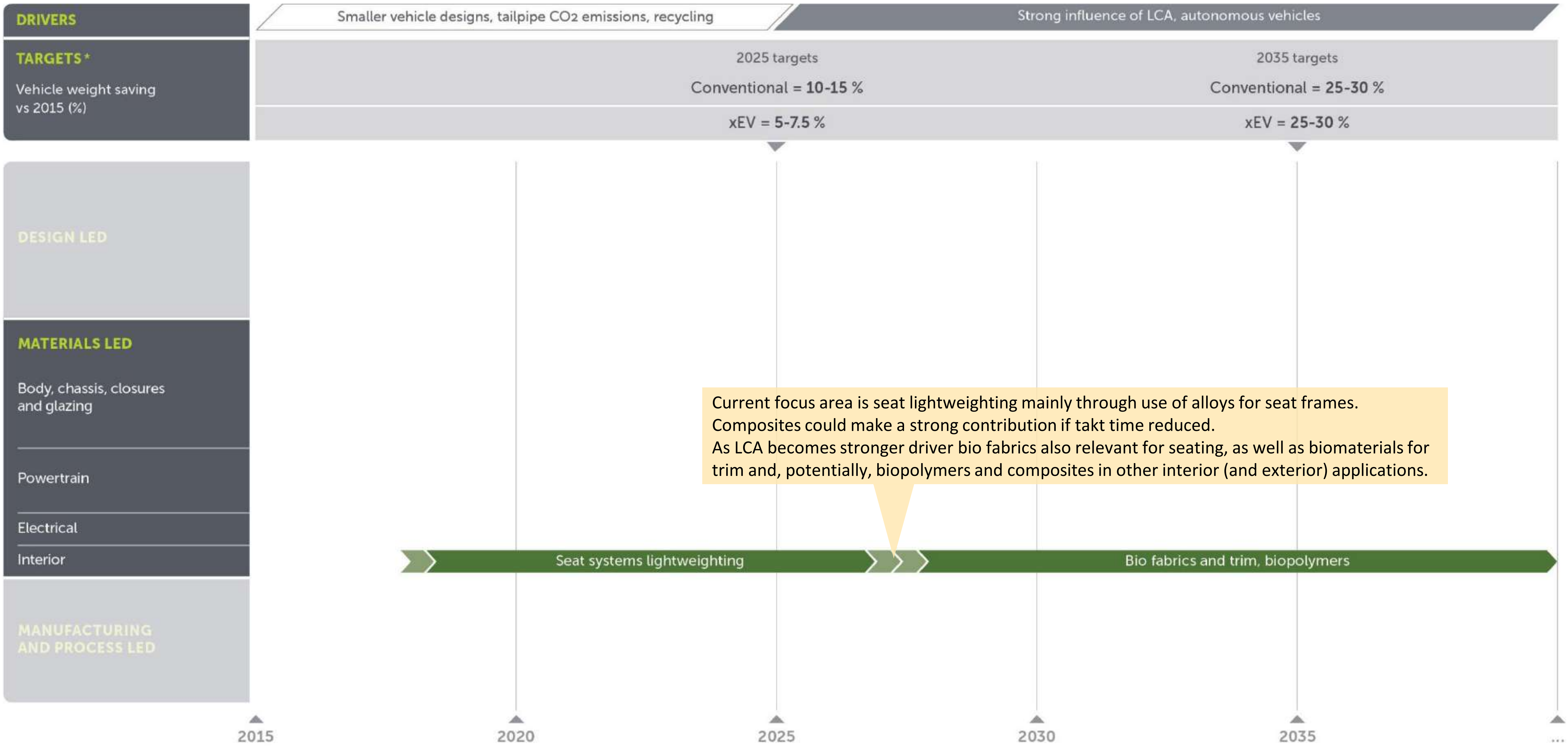
Most battery casings and internal support structures are metal. Polymers and composites offer means to consolidate parts and integrate features, achieving insulation and strength with lower weight. Polymers require higher volumes to mitigate tooling costs. Composites require process development to achieve higher volume.

Longer term batteries are anticipated to be more readily integrated into vehicle e.g. as primary structural elements

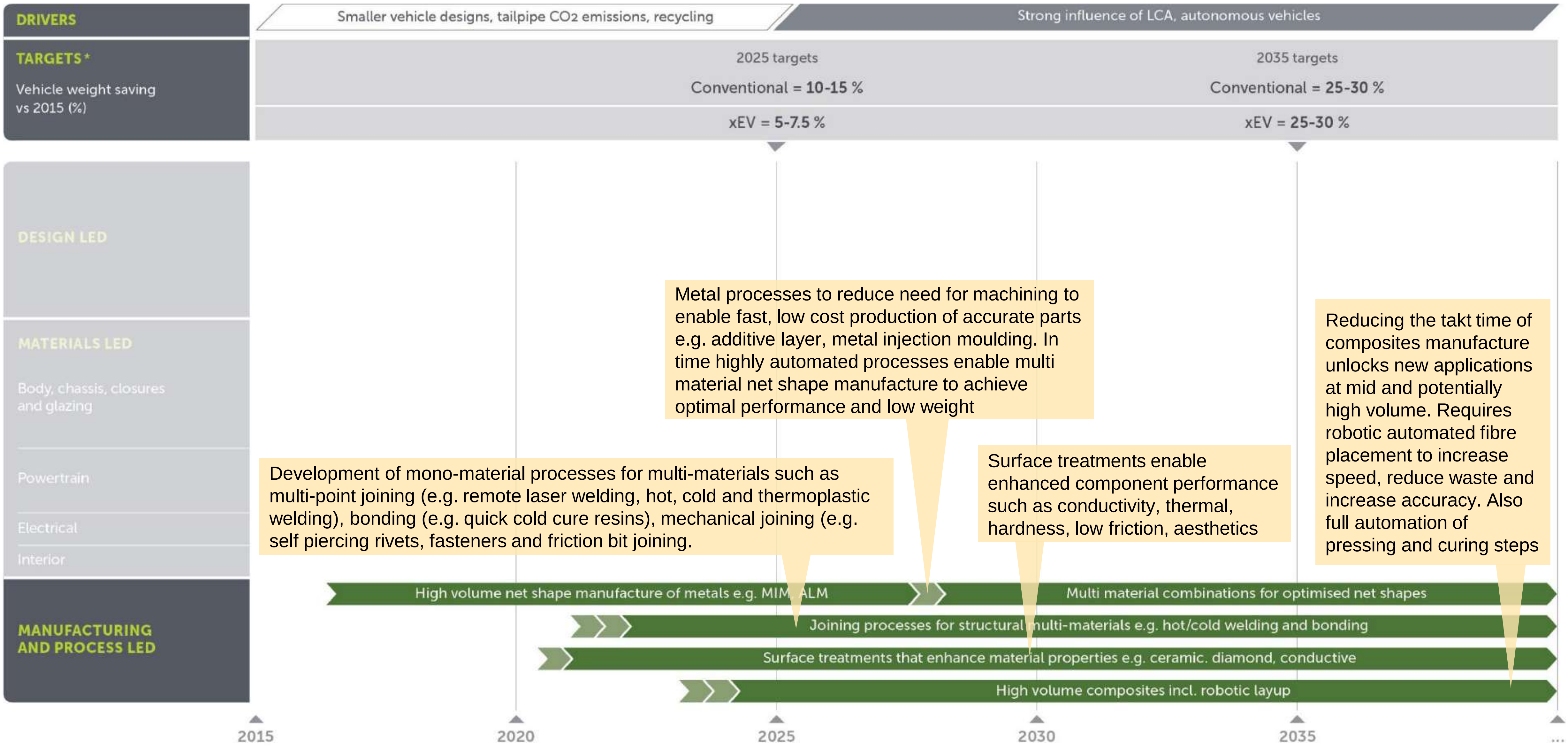
Materials led: *Electrical systems and interiors can benefit from lighter and more sustainable approaches*



Materials led: *Electrical systems and interiors can benefit from lighter and more sustainable approaches*



Manufacturing and process led: *Many of the new component designs and material applications can only be achieved through innovation in manufacturing processes*



TECHNOLOGY ROADMAP 2017: **LIGHTWEIGHT VEHICLE AND POWERTRAIN STRUCTURES**

Roadmap developed by the Automotive Council and the Advanced Propulsion Centre

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DRIVERS

- Smaller vehicle designs, tailpipe CO_2 emissions, recycling
- Strong influence of LCA, autonomous vehicles

TARGETS *

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DESIGN LED

- Component geometry optimisation → System optimisation → Functional integration
- Mission-suited lightweighting (e.g. CAVs)
- Accurate materials characterisation → Predictive characterisation of structures based upon material properties
- In-vehicle condition monitoring to inform design
- Design for ease of disassembly, identification and recycling → Design for circular economy (life cycle impact, chain of custody)

MATERIALS LED

Body, chassis, closures and glazing

- Metals for sheet and frame → Next generation ultra high strength steels, Al and Mg alloys for sheet and frame applications
- Multi material (metal and non-metal) load-bearing solutions
- High volume polymer panels, closures and glazing (e.g. panoramic roof)
- High volume structural composites in key load-bearing areas (e.g. wheels)

Powertrain

- TPS powertrain based on steels, Al → Major powertrain components also using lighter metals (inc. matrix, foam), polymers, composites
- High volume metal battery casings → Polymer and composite casings → Lightweight structural batteries

Electrical

- Wiring simplification, lighter wires (e.g. Al) → Conductive structures → Electronic systems convergence, wireless control

Interior

- Seat systems lightweighting → Bio fabrics and trim, biopolymers

MANUFACTURING AND PROCESS LED

- High volume net shape manufacture of metals e.g. MIM, ALM → Multi material combinations for optimised net shapes
- Joining processes for structural multi-materials e.g. hot/cold welding and bonding
- Surface treatments that enhance material properties e.g. ceramic, diamond, conductive
- High volume composites incl. robotic layup

2015 2020 2025 2030 2035 ...

** Challenges for reducing weight differ between xEVs and conventional powertrains*

1 chevron = some uncertainty around timing of mass market adoption or phase out 2 chevrons = considerable uncertainty around timing of mass market adoption or phase out

Glossary: *Explanation of acronyms and terms not described in the roadmap due to space constraints*

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- **CAVs (Connected and autonomous vehicles) –** *Connected and autonomous vehicles is an umbrella term to capture the varying levels of autonomy and technologies relating to self-driving vehicles.*
- **LCA (Life cycle analysis)** – *Identifying the total environmental impact of a given product.*
- **MIM (Metal injection moulding) –** *Metal injection moulding (MIM) 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.*
- **ALM (Additive layer manufacturing) –** *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.*
- **TPS (Thermal propulsion systems)** – *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)*
- **V2X (Vehicle-to-X)** – *Vehicle-to-X refers to an intelligent transport system where all vehicles and infrastructure systems are interconnected with each other.*

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