Automotive Australia 2020

# TECHNOLOGY ROADMAP

AutoCRC
Smarter Safer Cleaner

AUTOMOTIVE AUSTRALIA
2020

The automotive world is changing. Concerns about global warming, the emergence of low-cost competitors, and higher fuel prices have altered the landscape in which our vehicle and component makers operate. Adaptation will require significant investment in new technologies, new capabilities and new skills. We cannot secure the future of the Australian automotive industry by persisting with the status quo. The Automotive Australia 2020 Roadmap has brought industry stakeholders together to identify green automotive technologies with real commercial potential in Australia. Innovation is the key to putting the industry on an economically and environmentally sustainable footing. It is the only way forward.

**SENATOR THE HON KIM CARR**
Minister for Innovation, Industry, Science and Research

The automotive industry has been a vital part of our manufacturing sector for over a century. To remain at the forefront of technological innovation in the constantly changing global environment, it is crucial that Victoria's automotive industry and research providers continue to build on their competitive advantages. The way motor vehicles are powered, the materials from which they are built and the features and systems they offer will be transformed over the coming decade. The Automotive Australia 2020 Roadmap will guide this transformation by focusing on the technology areas that offer the greatest opportunities for our vehicle producers and component manufacturers.

**JACINTA ALLAN, MP**
Minister for Industry and Trade

# Foreword

**The Australian automotive manufacturing industry is a significant contributor to the Australian economy, exporting in excess of $3 billion in components and vehicles, while providing more than 50,000 jobs. As the global automotive industry evolves, Australian vehicle manufacturing must transform to remain competitive and internationally relevant. This requires a clearly articulated vision and strategic direction.**

To develop this vision and direction, the AutoCRC in partnership with the Australian National University and CSIRO, has undertaken the *Automotive Australia 2020* project (AA2020). This project has been endorsed by the Automotive Industry Innovation Council, and is supported by the Federal and Victorian State Governments.

Roadmapping has been used to develop strategy and manage change in a variety of countries and industries around the world. Best practice in the field has seen the development of a roadmapping culture characterised by an ongoing process of planning and communication followed by implementation and review. It is this process that creates an environment of collaboration and focus, which fosters industry development, transformation and growth.

AA2020 utilises a roadmapping approach developed by the University of Cambridge to define a future direction for the Australian automotive industry. By drawing on industry expertise, the process examines the trends, drivers, needs and capabilities influencing the industry to facilitate an informed decision making process and identify opportunities and obstacles in the short, medium and long term.

The involvement of industry in the AA2020 project has been significant, with over 160 organisations contributing in excess of 2500 hours. This has included organisations from within the automotive sector as well as non-automotive manufacturing companies, universities, research organisations, and state and federal governments.

Success of the roadmapping process can be measured in two ways: firstly by industry involvement and secondly by the ongoing implementation of a roadmapping culture. International studies have shown that successful industry roadmapping programs engage broadly with all relevant communities and stakeholders during their development, with outputs disseminated widely through multiple channels. Early implementation of key recommendations, such as defining implementation plans, forming collaborations and commissioning research, serve to build momentum and awareness, and to establish the roadmap as a common language and reference point. Importantly, the roadmap is a living document that will be enhanced incrementally by the industry and refreshed periodically.

The Automotive Australia 2020 project has identified a number of key areas where the Australian automotive industry can be globally competitive. These areas build on current strengths and capabilities to make Australia attractive to international car manufacturers and their investors. Building on these strengths the Australian automotive industry has identified a path to become larger, more productive and provide more jobs for Australians.

**Dr Matthew Doolan**
Project Manager
Automotive Australia 2020

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# Executive Summary

**The Automotive Australia 2020 project has developed this technology roadmap for the Australian automotive industry with the vision of a sustainable and profitable industry through 2020 and beyond.**

This roadmap has assessed current and developing Australian capabilities, identified local and international markets, and assessed the trends and drivers affecting the global automotive industry. This process has involved significant contributions from over 160 organisations totalling more than 2500 hours.

The Australian automotive industry is built on a strong foundation of diverse capability and encompasses all of the necessary resources to bring a vehicle from concept, through development, to release. The AA2020 Roadmap recognises the importance of maintaining and strengthening these capabilities while supporting the development of world-leading technology and expertise in a number of key strategic areas. A focus on the four long term priority areas identified in this report will highlight the relevance of the Australian industry to global companies and their investors.

The roadmapping process highlights correlations between local capabilities and future technology needs in the global market, opportunities, at an industry level. Strengths have been identified in more than 300 capability areas, with approximately sixty short term and sixty long term technology needs carried forward for assessment. A complete list is available in the accompanying reports: *Capabilities* and *Technology Needs*. Assessing the size of the global market in each area of need and aligning this with the strength of local capabilities has resulted in 32 long term applications and 15 short term opportunities.

In the short term, these identified opportunities utilise Australia's current automotive capabilities in areas with potential import replacement or export. They were further prioritised by measuring market attractiveness and matching this with the level of Australian capability.

In total 13 export opportunities and 15 targets with import replacement potential or a need to maintain local capability were identified. Collaboration between OEMs, suppliers and government will be required to realise these short term opportunities which are presented in the accompanying *Opportunity Portfolio* report.

Long term opportunities for the Australian automotive industry have been categorised across four broad areas: Vehicle Electrification, Gaseous Fuels, Lightweighting, and Data and Communications. Australian-specific capabilities and technologies have been highlighted that allow the development of strategic applications. Industry stakeholders participating in the AA2020 project have prioritised these applications by identifying 15 high priority applications spanning all four opportunity areas that draw on current and developing Australian knowledge and expertise.

Vehicle Electrification (including hybrid and electric vehicles) was identified as the highest priority area if the Australian automotive industry is to achieve recognition in the future of the global industry.

Six applications were identified as high priority in this area:

- Development and manufacture of supercapacitors for electric vehicles
- Design and local assembly of electric vehicle power electronics modules
- High energy density batteries
- Low cost, robust, efficient electric motors/generators
- Standardised battery packs for large passenger vehicles
- Development of a modular electric vehicle powertrain

The opportunity area of Gaseous Fuels is a segment that leverages local resources and expertise while presenting attractive niche export markets. It includes three applications that can be realised through the design and development of an Australian gaseous fuel vehicle platform:

- Dedicated direct injection system for LPG engines
- Fast filling technology for LPG
- High capacity, low cost, on-vehicle CNG storage tank

In response to current and developing global trends, lighter vehicles will be required to achieve reduced emissions in the short term and are essential in the realisation of electric vehicles in the longer term.

In the lightweighting opportunity area, five applications were identified as high priority for the Australian automotive industry:

- Replacement of traditionally steel components with lightweight alternatives
- Manufacture of light weight body panels
- Commercialisation of lightweight road wheels
- Reduction of vehicle structure weight by 30% while improving safety
- Use of 3D composites for interior structure and seats

The fourth high priority area identified for the Australian automotive industry is Data and Communication Systems. This area addresses the increased availability of in-vehicle information and the growing use of onboard electronic systems such as by-wire systems. In this area one key application was identified:

- Improved human-machine interfaces and driver information systems

Realising these priority applications and short term opportunities will require enabling actions from various industry stakeholders. These actions are captured in 32 recommendations classified in five categories: industry collaboration, science and research, government action, education and training and short term action plan. There are also three recommendations for next steps forward to sustain momentum and implement the outcomes of the Automotive Australia 2020 Roadmap.

The AA2020 Roadmap presents a direction for the strategic growth of the Australian automotive industry, which has been developed with significant stakeholder contribution and involvement. Through continued engagement and collaboration between stakeholders, the opportunities outlined in this roadmap can be realised, leading to a larger and more productive Australian automotive industry to 2020 and beyond.

# VISION

Australia's automotive industry must achieve recognition as a strategic element of the global automotive industry to be attractive to global companies and their investors.

Australia must have a sustainable, profitable vehicle manufacturing industry with global reach that maximises opportunities in local and international markets.
The industry must be bigger, more productive, and provide more jobs in the manufacturing and supply sectors.

This can be achieved through leveraging existing strengths and building new capabilities.

# Introduction

**The global automotive industry is experiencing a period of significant change, with emerging Asian markets, competition from developing economies, and a move toward new technologies. It sets the context for the Australian industry where production is valued at approximately $7.5 billion annually, with an increasing trend toward export markets from both the OEM and component sectors. This trend can be seen in Figures 1 and 2.**

Change presents challenges that must be addressed for the Australian automotive industry to remain competitive, and the Automotive Australia 2020 project aims to provide a process for the industry to articulate a vision and define a future direction.

The Vision, defined by industry stakeholders through the early stages of the AA2020 project, is for a competitive Australian automotive industry, achieving recognition as a strategic element from the global perspective. The industry must be attractive to global companies and their investors. By leveraging existing strength, it must become larger, more productive and create more jobs. This vision is captured in the interim report *Automotive Australia 2020 – Vision*.

Realising this vision requires an industry-wide strategy, that must be effectively communicated within the Australian automotive industry, to government, and to other stakeholders. Development of this strategy can be achieved through a transparent and inclusive process that aggregates knowledge and evidence from all stakeholders to provide a firm base for decision making.

Through extensive consultation with industry, government and research representatives including nine workshops, the AA2020 project has developed this roadmap for the Australian automotive industry.

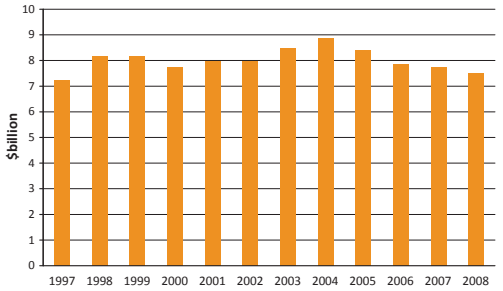



FIGURE 1 – **VALUE OF PRODUCTION OF LOCALLY MADE PASSENGER MOTOR VEHICLES AND DERIVATIVES**[1]

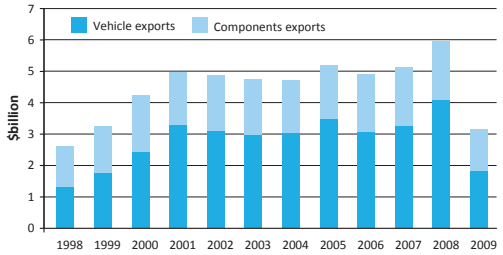



FIGURE 2 – **VALUE OF VEHICLE AND COMPONENT EXPORTS, 2009**[2]

1 Department of Industry Innovation Science and Research. *Key Automotive Statistics*, 2008. Accessed April 2010 from: http://www.innovation.gov.au/Industry/Automotive/Documents/Key%20Automotive%20Statistics%202008.pdf

2 Ibid.

# Mapping Australia's Automotive Future

**Roadmapping is a tool used to define future market opportunities and match these with existing capabilities. The Automotive Australia 2020 process utilised this tool to define and communicate a direction for the industry. Building on the vision, development of the AA2020 Roadmap has involved 6 phases, which are presented graphically in Figure 3.**

**PHASE 1**
Define the Vision

**PHASE 2**
Identify Market Need

**PHASE 3**
Understand National Capability

**PHASE 4**
Identify Opportunities

**PHASE 5**
Develop Opportunity Roadmaps

**PHASE 6**
Prioritise the Opportunities

In Phase 2 the market need was defined in response to the trends and drivers affecting the automotive industry both locally and globally. These trends and drivers included social pressures, technology developments, economic concerns, and environmental awareness. Identification of these trends and drivers provided the context for future demand.

The AA2020 project used stakeholder interviews and surveys to understand the trends and drivers in the local context. This engagement with stakeholders in the industry, including manufacturers, government and component suppliers identified the technology needs within the automotive sector through 2020 and beyond. This work was supplemented with a survey of published literature to determine the trends and drivers affecting the global industry. Through a workshop involving significant industry stakeholders, these trends and drivers were prioritised highlighting those with the greatest impact on the Australian automotive industry.

In the short term, the Australian automotive industry can respond to current local and global market demand. Working with the local vehicle manufacturers, specific short term needs were identified in the area of import replacement. A survey of global short term export demand was undertaken by Deloitte Touche Tohmatsu, accounting for the accessibility of markets to imported products, highlighted short term need in representative markets of Asia, America and Europe. These local and international surveys of market needs also determined critical success factors in each market.

In the longer term the automotive industry will need applications that respond to global and local trends and drivers. Alignment of the local industry with these applications will realise benefits in both domestic and export markets. Identification of long term market need has been achieved through interviews, surveys and workshops with automotive industry experts, government representatives and research organisations.

Phase 3 developed an understanding of current and developing Australian capability. The capabilities are drawn from three different areas: current automotive supplier capabilities, current non automotive supplier capability and developing capability in the science and research sectors. Each of these can be realised in different time frames: in the short term current automotive supplier capability can be utilised; in the longer term, current research capability is the first step in developing new commercial solutions in industry. Capability from outside the automotive sector can be adapted and applied to automotive applications in the medium to long term. The capabilities of each stakeholder group were measured through workshops, surveys and interviews. Current capability was identified in the automotive and non-automotive sectors, while developing capability was identified in commercial firms and research organisations.

Phase 4 draws on the outputs of the preceding two stages, Identify Market Need and Understand National Capability, to identify opportunities for the Australian Automotive Industry in the short and long term. This stage involved a series of workshops, rating potential opportunities against the critical success factors determined by industry stakeholders.

Identified short term opportunities were classified in three categories: import replacement, export potential and those that support long term goals. Import replacement and export opportunities can be realised immediately, and these have been communicated with industry stakeholders, but those with long term relevance have been carried forward. Workshop attendees further classified long term opportunities into four broad categories: Gaseous Fuels; Lightweighting; Data and Communication Systems and Vehicle Electrification. These underlying opportunities are outlined in the interim report: *Automotive Australia 2020 – Opportunities Portfolio*.

Detail has been added to the roadmap in each of the four long term opportunity areas through consultation with stakeholders from automotive suppliers, motor vehicle producers, non-automotive industry, research and government. The four workshops conducted in Phase 5, one targeting each opportunity area, identified specific priority applications for each area.

In order to exploit these applications, a gap analysis was performed. It highlighted *Enablers* – actions that build on the current and developing Australian capability to complete the path to realising each application. These have been captured in detail for each application and define the most detailed level of the roadmap in the four opportunity areas.

The final phase of the project is one of prioritisation. While each opportunity area is a good one, and each includes applications with wide appeal that build on current Australian strengths, prioritisation allows a focus for the subsequent implementation of the roadmap. Stakeholders ranked Vehicle Electrification as the top priority reflecting its long term relevance in the global marketplace.

The area of Gaseous Fuels was second owing to local expertise, availability of fuel resources and applicability in key export markets. Lightweighting, which ranked closely behind gaseous fuels, is seen as a market entry requirement that will see continued adoption regardless of other changes in the industry. Data and Communication Systems will play a supporting role in addressing safety and environmental concerns.

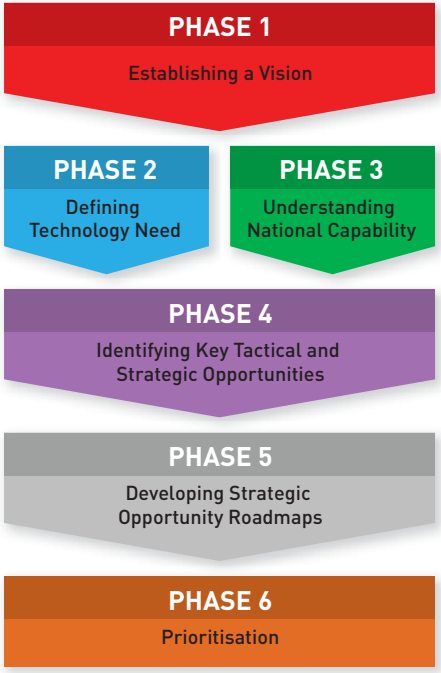



FIGURE 3 – **THE AA2020 ROADMAP PROCESS**

# The Automotive Australia 2020 Roadmap

**The AA2020 Roadmap indicates a direction for the Australian automotive industry, which is defined by mapping Australian capabilities with the future needs of the local and global automotive industry. These needs are shaped by the current trends and drivers.**

Linking capabilities and future needs indicates opportunity areas where Australia can compete in the global automotive industry. Realising these opportunities requires enabling actions from a range of stakeholders in the industry. These form a roadmap which allows the plotting of a course from enabling actions, through the development of capability and technology, to the exploitation of applications in the opportunity areas. The AA2020 Roadmap is presented across three levels of detail, with each level offering a deeper view as shown in Figure 4.

At the highest level, the roadmap is broken into the four sections shown on pages 10 and 11: Trends and Drivers, Opportunity Areas, Technologies and Capabilities, and Enablers. The trends and drivers represented outline many of the challenges being faced by the local and global industry. These define the context in which opportunities for the Australian industry will be recognised.

Enablers are classified into categories, which capture the involvement of different stakeholders in the industry. By carrying out enabling actions, stakeholders will support the development of new and enhanced technologies and capabilities. These are drawn from three different sectors: automotive, non automotive and research. Each of these sectors has a different ability to service the automotive supply chain in the short, medium and long timeframes.

Drawing from the three sectors of capability the automotive industry will be able to exploit applications in Four opportunity areas: Gaseous Fuels; Data and Communication Systems; Lightweighting; and Vehicle Electrification. Each of these opportunity areas has a roadmap containing more detailed information, which is presented in the relevant sections of this report. The roadmaps highlight details including enabling actions and technology development required to realise the applications in each opportunity area. The applications are supported with a detailed examination including a specific strategic path and required actions.

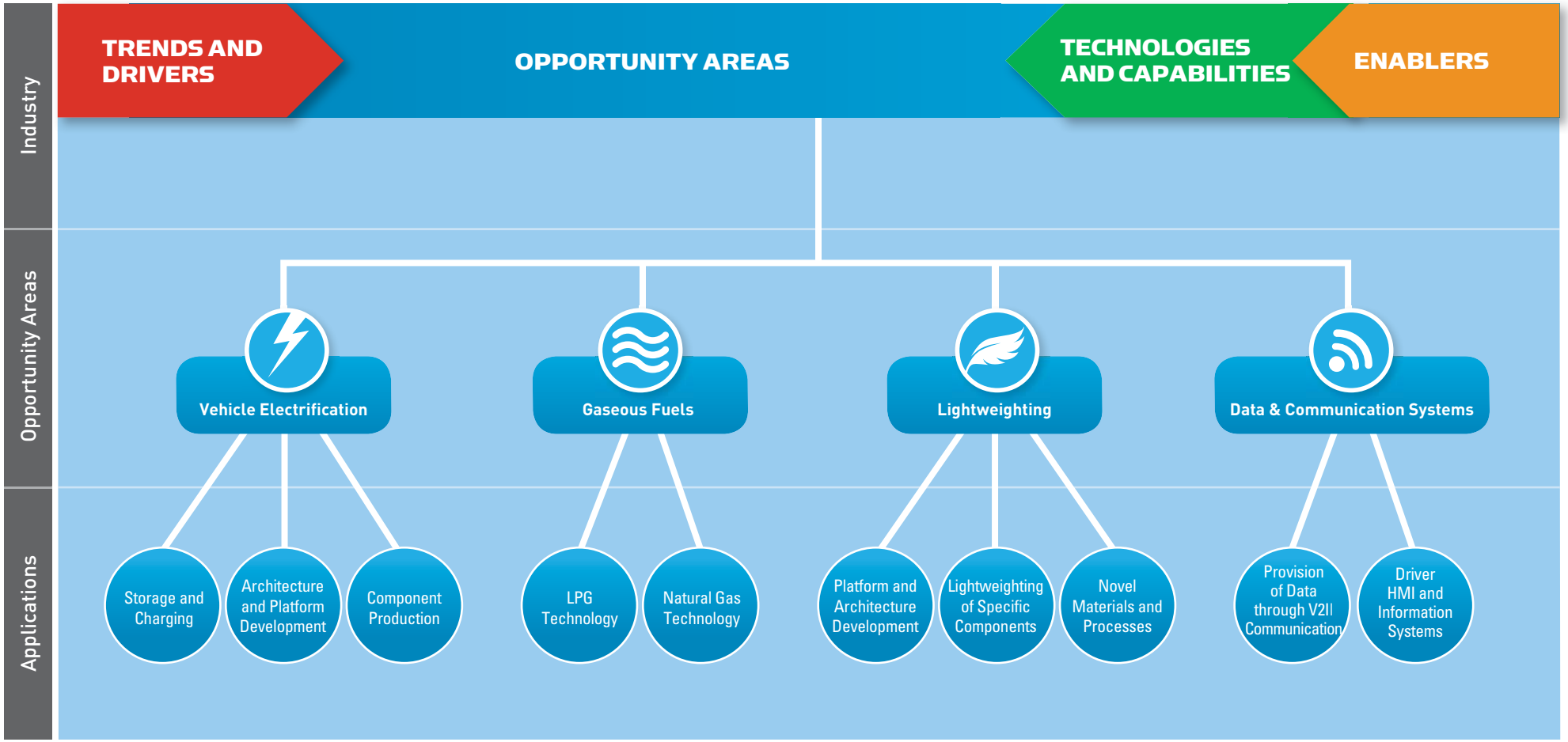



FIGURE 4 – **THREE-LEVEL STRUCTURE OF THE AA2020 ROADMAP REPORT**

# TRENDS AND DRIVERS

Short Term

**2010-2012**

In the short term, increasing oil prices and perceived changes in the environment are driving increased public awareness in both areas. A trend toward smaller, lighter vehicles is already apparent as is a trend toward global automotive platforms. With expanding availability of wireless communications, data is becoming increasingly accessible. Australia has a number of existing strengths that can be leveraged, including a large natural resource endowment and an automotive industry capable of taking a car from concept to release. With significant emerging competition and markets, in countries such as China and Korea, there is a current need for the industry to remain competitive.

Medium Term

**2012-2016**

Beyond 2012, impacts from a changing economic climate are expected to result in some consolidation and restructuring of firms in the Australian industry. Public awareness will drive a coordinated focus on emissions reduction through regulation and policy, with the continuing prevalence of global automotive platforms allowing harmonisation of legislation. Environmental credentials will make electric vehicles highly marketable to early adopters. Safety, however, is a key influence for consumer buying decisions and will remain the primary driver in the mass market through all timeframes. This is particularly relevant to an aging population.

Long Term

**2016-2020**

Competition from low cost countries like Brazil, India, Thailand and Russia with large local markets and developing economies will continue to put pressure on the local industry. Advances in information and computer technology will allow smaller, less expensive, more capable and better integrated electronics. Alternative fuels and electricity generated by less carbon intensive means will see increasing availability making them viable alternatives to conventional fuels. As the economics of vehicle purchases become driven by energy efficiency, alternative vehicles with mass market appeal (featuring low cost of ownership and high amenity) will be demanded.

Vision 2020+

**2020+**

Beyond 2020, many trends and drivers relating to environmental and safety concerns will continue to have relevance. New economic concepts may monetise the value of energy storage and distributed energy generation. In addition, there are loftier goals that will only be achievable given sufficient time. A transportation system with zero net emissions and zero road fatalities are two examples. These goals will require novel technologies, like intelligent roads and vehicles. By addressing these trends and drivers, a sustainable, competitive Australian automotive industry can be achieved.

# OPPORTUNITY AREAS

**2012-2020+**

## Vehicle Electrification

The progressive shift from internal combustion to electric technologies is considered a major theme in the future of automotive technology. Driven by a desire to reduce emissions from transportation, future applications were highlighted in three areas: specific technologies, design services and underlying needs. Services included expertise in design, integration and platforming, and deployment of charging infrastructure. Some specific technologies were electric motors, batteries, modular battery packs, power electronics, driver interface, drive modules and supercapacitors. Finally, a need was highlighted for finance models to encourage adoption, applications for end-of-life batteries, and deployment of electrified fleets.

**2012-2016**

## Gaseous Fuels

Transition from diesel and petrol to LPG or natural gas is influenced by three factors: economics, energy security and the environment. The relative price of liquid fuels is on the rise with an additional benefit that vehicles powered by natural gas and LPG emit substantially lower quantities of $CO_2$. In Australia, local reserves of gaseous fuels improve the security of fuel supply. There are opportunities for specific technology development in areas such as direct injected LPG systems, natural gas drivetrains and gas storage tanks. Perception issues relating to the safety and convenience of gaseous fuels, can be addressed through expansion of infrastructure, improving the refuelling experience, improving the standard of aftermarket installations, and public education.

**2010-2020+**

## Lightweighting

The Lightweighting application area aims to address energy scarcity and environmental drivers by reducing consumption of vehicle fuel and resources. It leverages Australian strengths in two ways: by taking advantage of abundant mineral resources, and by developing applications for those resources through research and development. Two themes, of underlying technology and specific applications, emerged from the lightweighting workshop. Underlying technology applications included: recyclable materials, foam and adhesives, structural design processes, and modular platform design. Specific parts identified for lightweighting were: wheels, door and body panels, seats, and other steel components.

# TECHNOLOGIES AND CAPABILITIES

2010-2020+

## Data & Communication Systems

Developments in Data and Communications Systems will find application in all timeframes. Currently, the majority of new developments in passenger vehicles are dependant on electrical and electronic technology and this trend is expected to continue. Applications identified for data and communications can be grouped into two broad categories: provision of information, and specific technology development. Information suitable for integration into driver information systems is needed for dynamically updating speed limits, congestion information, and traffic incident warning. Opportunities for technology development were highlighted in HMI and driver information systems, and next generation vehicle navigation systems with improved resolution.

2010-2020+

## Automotive

In the short term, only capability currently existing in the automotive sector can be used to realise the opportunities that have been identified. This reflects the lead times to mass production associated with developing or adapting technology for manufacture. The Australian automotive industry is highly capable, with the ability to develop a vehicle from concept to release. Even future applications, of sufficient relevance to the Australian industry to be presented here, will build on existing capability in the manufacturing and supply base. For this reason, automotive capability remains relevant as it develops across all timeframes.

2012-2020+

## Non-Automotive

There are complementary technologies and capabilities that are fully production proven, but have not yet been transferred for application in the automotive industry. Because the technology development and commercialisation work has already been completed, the transfer process is much simpler than for ground up development of new technology. One example is the use of lightweight materials in the defence and aerospace industries, while the trucking industry has experience in gaseous fuel technology and complementary capability in the development and implementation of fleet monitoring and communications systems. By leveraging these technologies and capabilities, lead times for automotive technology development can be substantially reduced.

2016-2020+

## Science and Research

There are many examples where a future need can be identified, but underlying technology has not reached the level needed to realise the opportunity presented. In these cases, new technology will need to be developed and related applications will have the longest lead times. Development can take place in industry directly, but often requires collaboration with organisations such as CSIRO, universities, cooperative research centres (CRCs) and centres of excellence. By identifying technology gaps now, development programs can realise commercial capabilities in the long-term and vision timeframes.

# ENABLERS

### Feasibility and Planning

An immediate need was identified in all areas for targeted feasibility studies and business planning. The level of detail proposed varies by application: from establishing a business case for the development of lightweight road wheels, through the production of a roadmap specifically targeting an Australian electric vehicle industry.

### Industry Collaboration

A coordinated approach from all stakeholders was another recurring theme. Proposed mechanisms for collaboration included the formation of cooperative research centres (CRCs), the re-targeting of existing CRCs, and development of joint venture partnerships to ensure broad industry engagement. Regardless of the suggested method, it is clear that a collaborative approach and aligned objectives can be considered very important factors.

### Education and Training

Focussed education programs can be used to facilitate the development and uptake of identified applications. Poor public perception of gaseous fuel technology is based largely on misinformation and this can be addressed through an education campaign. Beyond public education, training and certification of aftermarket installers can improve real and perceived public safety of gaseous fuels. In other application areas, a need for graduates and professionals with expertise in emerging technologies was identified.

### Government Support

Required action by government was identified in three broad support areas: financial, infrastructure, and standards. While the predominant method of financial support mentioned was the existing Green Car Innovation Fund (GCIF), other mechanisms proposed include incentive programs and the purchase of locally produced electric vehicles for government fleets. Infrastructure is required for some applications in the gaseous fuels, electrification and communications areas, while adjustment of Australian Design Rules (ADRs) and other standards will facilitate the development and uptake in all application areas.

### Science and Research

Beyond the few short term opportunities identified, collaboration with the science and research sector to support technology development will be required by applications in all areas. Particular need for research programs was noted in areas requiring world-leading technology development, like the development of novel battery technology or the design of a lightweight modular vehicle platform. It is critical that research programs be aligned with programs in industry to ensure a coordinated approach.

# Priority Opportunity Areas

**The top four opportunity areas were identified that build on Australian strengths to address global market trends and drivers. As shown in the preceding section, the opportunity areas have global relevance.**

Applications in each area were assessed by industry experts against a series of five critical success factors: Environmental Impact, Social Impact, Economic Benefit, Investment Cost, and Likelihood of Success. Using this assessment as a guide, a panel of stakeholders representing vehicle producers, component suppliers, industry bodies, research organisations and government prioritised the applications and their opportunity areas.

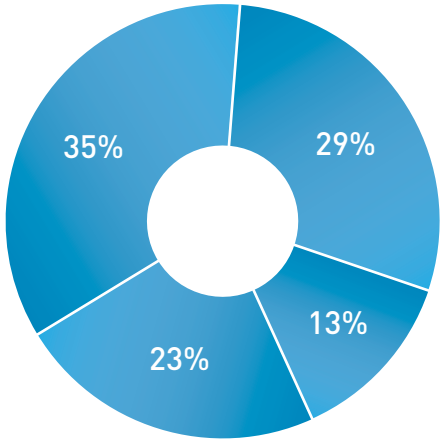
Prioritisation of the top four opportunity areas was measured as a percentage share of available resources – termed *Resource Allocation*. The average of all participant scores was calculated (as shown in Figure 5) to determine an overall resource allocation score for each area. The figure shows Vehicle Electrification as a clear priority, with Gaseous Fuels receiving a slightly smaller allocation. Lightweighting was allocated a 23 percent share, and Data and Communication Systems was the area with the lowest overall allocation at 13 percent.

**Vehicle Electrification 35%**

Vehicle Electrification, in some form, will have to play a key role in future efforts to address fuel cost and scarcity, and emissions from transport. It is critically important that a globally competitive automotive industry participates in this sector.

**Lightweighting 23%**

Lightweighting leverages natural Australian metals resources and strong material development capabilities. Reduced vehicle weight reduces fuel usage and resource consumption – irrespective of powertrain technology.




**Gaseous Fuels 29%**

Gaseous Fuels builds on local expertise and availability of LPG and natural gas to provide an alternative fuel for passenger transport. Gaseous fuel is currently available at lower cost and its local abundance addresses energy security concerns, while its cleaner burning nature allows reduced emissions.

**Data and Communication 13%**

Data and Communications Systems integrate vehicle data with information about the surrounding environment, presenting the information to vehicle systems and directly to drivers. Efficient delivery of information can improve safety, while reducing congestion, which leads to reduced fuel consumption and pollution.

FIGURE 5 – **PERCENTAGE RESOURCE ALLOCATION FOR EACH OF THE PRIORITY OPPORTUNITY AREAS**

This prioritisation is strengthened by considering the overall ranking of participant preferences. Electrification was ranked first or second by a large majority of stakeholders, with gaseous fuels also receiving a number of first-placed rankings. Lightweighting was consistently rated second or third, while more than half of participants ranked Data and Communication Systems with the least priority.

Participant feedback in the workshop reflected a desire to pursue applications with a strong local market, and sales potential in export markets. These applications will present a compelling business case and justify the investment required to compete globally. Stakeholders presented a view describing how each opportunity area meets these criteria:

- Gaseous fuel technology is a strong niche market where Australia has strategic advantage in raw materials. Building on global recognition as a technology leader and an existing local market, there is potential to develop true innovation in the segment, improving energy security and reducing emissions. The opportunity is strengthened by limited competition internationally, and market potential in key export markets.
- Electrification is the focus of attention in a global automotive industry's efforts to address fossil fuel availability and emissions. To compete effectively in the global vehicle marketplace with an expanding proportion of electrified vehicles, competitive technology and capability in the sector will be essential. Significant opportunity exists for energy storage and power systems solutions that address outstanding gaps in technology and provide Australia with a unique competitive position. The increasing prevalence of global platforms presents increased risk through international competition, but equally presents increased opportunity to secure a position for locally developed technology in international markets.
- Lightweighting will be a key technology in attaining goals of increasing fuel efficiency and emissions reduction, regardless of fuel and propulsion system. Advancements in lightweight components will likely become competitive requirements for suppliers. Benefits can be further increased by expanding local capability to transform raw materials into manufacturing inputs.
- Advances in Data and Communications will be applied to provide benefits in safety, convenience, emissions reduction, and entertainment whether future vehicles are powered by petrol, natural gas, or electricity.

These opportunity areas address global trends and drivers, so on their own do not provide a competitive edge for the Australian industry. Through identifying applications that align with local skills and capabilities, Australia can become attractive as a strategic element of the global automotive industry. The priority applications identified for Australia in each area are the focus of the four detailed sections of the roadmap, with an overview presented in the following four pages.

# PRIORITY APPLICATIONS

Specific applications were identified by workshop participants in each of the four opportunity areas. Each has been assessed based on relative merits against five critical success factors relating to: environmental performance, social benefit, profit potential, investment cost and risk. These factors informed resourcing recommendations from industry stakeholders to define the following prioritised lists, with further information presented in the four detailed sections of the roadmap.

# VEHICLE ELECTRIFICATION

## FOREMOST PRIORITIES

1. **Supercapacitors for Electric Vehicles** can be applied as a primary energy storage solution, or to balance peak loads on battery storage options. Locally developed technology and capability will provide Australia with a competitive position as the electric vehicle market expands.
2. **Design and Assembly of Power Electronics Modules** will build on complementary expertise in power electronics from industries outside automotive. Australia has the capacity to develop and supply power electronics modules to domestic and export electric vehicle markets.
3. **High Energy Density Batteries (including Metal-Air)** technology leads to improved electric vehicle range and performance. As electric vehicles see widespread adoption, the demand for high performance, lightweight, compact batteries will increase substantially.
4. **Low Cost, Robust and Efficient Electric Machines** are the core propulsion component of electric vehicles. Competitive electric motor technology will have global appeal as the market for electric vehicles expands.
5. **Modular, Standardised Battery Packs** for electric vehicles will simplify vehicle development while easing future maintenance, replacement and disposal challenges. In addition, it permits alternative vehicle and charging concepts – like swap-and-go at service stations.
6. **Modular Electric Vehicle Platform** presents fundamental changes in vehicle architecture by taking advantage of new design opportunities provided by electric propulsion. Modular designs have potential advantages in shortening development cycles, and reducing manufacturing and maintenance costs.

## SUPPORTING PRIORITIES

7. **Expertise in Solutions for Electric Vehicle Architectures and Technologies** leverages future local capability in automotive engineering and design that could be applied to electric vehicles. This capability can be leveraged to establish a global reputation for expertise in vehicle electrification technology.
8. **Seamless Integrated Charging Infrastructure** provides customers with equal or better convenience compared to liquid refuelling to support the widespread adoption of electric vehicles.
9. **Software and Hardware for Electric Vehicle Specific Driver Interface** present different vehicle information to electric vehicle drivers and this can be optimised through specific display strategies. Electric drive also presents opportunities to change the fundamental interface (steering, braking and acceleration), or make it adaptable to different drivers.

## ANCILLARY PRIORITIES

10. **A Utility-Level Energy Grid Management System** leverages electric vehicles and plug-in hybrid vehicles as particularly attractive as it provides a distributed electricity storage system. This new resource can be leveraged to smooth peak electricity demands and profit from variability in supply costs.
11. **Hybrid and Electric Vehicle Production for Fleets and Taxis** promotes the mass market uptake of electric vehicles through demonstration programs in government and private fleets. By stimulating local production, fleet purchases increase production volumes and provide economies of scale.
12. **Market for Used Electric Vehicle Batteries** improves the value proposition for vehicle electrification by developing end-of-life applications for used vehicle batteries. In that way, vehicles will retain residual value with batteries being refurbished, recycled, or repurposed for applications that do not require peak battery performance.
13. **Innovative Finance Models for Electric Vehicles** encourage broad market appeal for electric vehicles by facilitating lower cost barriers to entry through development of models that recognise future potential of electric vehicle technology.

# GASEOUS FUELS

## FOREMOST PRIORITIES

1. **Dedicated LPG System for Direct Injected Engines** captures the market for fitment of LPG technology to current generation direct injection petrol engines through the development of a dedicated aftermarket LPG system.
2. **Fast Fill Solutions for LPG** improves customer perceptions of gaseous fuel technology by developing on-vehicle and infrastructure capacity to consistently fill LPG passenger vehicles in the same time as petrol or less.
3. **High Capacity, Low Cost, On-Vehicle Storage Tanks for CNG** allows widespread deployment of natural gas vehicles by developing cost effective technology for on-vehicle gas storage including lightweight, conformable tanks and the possible addition of a gas adsorbent.

## SUPPORTING PRIORITIES

4. **Increased Availability of Natural Gas Refuelling** provides infrastructure to support an expanding natural gas vehicle fleet builds on existing gas distribution networks. Compressors for refuelling from the existing supply can be installed at-home or centrally located in service stations.
5. **A Public Education Campaign** can improve the perception of gaseous fuel vehicles by addressing both real and perceived problems. Real safety and amenity can be improved through training of industry personnel, while perception is addressed through a targeted marketing and public relations campaign.
6. **Natural Gas Vehicle Technology** includes the development of world leading technology for natural gas powered passenger vehicles with $CO_2$ emissions reduced by 25% over currently available solutions.

## ANCILLARY PRIORITIES

7. **Expansion of the LPG Retrofit Market** changes the public perception of gaseous fuels through lifting the standard of retrofit and after-OE LPG installations to be internationally consistent with *OEM-style* fitment and performance.

# LIGHTWEIGHTING

## FOREMOST PRIORITIES

1. **Replacement of Steel Components with Aluminium, Titanium, Magnesium and Composites** will extend beyond the specific components mentioned in this opportunity area to reduce vehicle weight 10-15%. Some remaining steel components in the driveline and running gear systems can be readily replaced with lightweight alternatives.
2. **Lightweight, High Volume, Class-A Body and Door Panels** shows lightweighting potential because, like the vehicle structure, the vehicle body contributes significantly to the overall vehicle weight. Currently, lightweight non-appearance parts are produced in high volume using metal and composite technology, but capacity for high volume production of appearance parts remains to be developed.
3. **Lightweight Road Wheels** build on existing local technology for casting lightweight metals. Weight reduction in wheels will have a proportionately larger benefit than removing mass from stationery components.

FOREMOST PRIORITIES continued

4 **Vehicle Structure with 30% Weight Reduction and Improved Crash Performance** contributing significantly to overall vehicle weight reduction due to the large potential, for weight reduction in those systems. Safety remains the primary factor in customer buying decisions, so crash performance must improve continually.

5 **Novel 3D Knitted Composite Applications for Interior Structure and Seats** leverages emerging composites technology to achieve similar production volumes to metal alternatives with equivalent investment costs. Cost savings are realised through reduced production lead times and component weight.

## SUPPORTING PRIORITIES

6 **Materials and Processes for Advanced Recycling** are required because modern cars are largely recyclable and, as environmental consciousness continues to rise, recyclability will be increasingly important. Lightweighting and recyclability factors must be balanced in the development of novel materials and processes.

7 **Lightweight Modular Vehicle Platform** takes advantage of the physical properties of materials designed for lightweighting, which are different to those of metals. This allows rethinking of traditional design concepts to allow further weight reduction through a targeted vehicle architecture.

8 **Energy Absorbing Foams and Adhesives** will form hybrid metal-foam systems that can be used to replace heavy structural components, like impact beams, with lightweight alternatives. Development of foams and adhesives must take place to ensure safety is maintained, while recyclability of multi-material structures is considered.

# DATA AND COMMUNICATIONS

## FOREMOST PRIORITIES

1 **Improved HMI and Driver Information** reduce the cognitive burden on drivers to address challenges associated with increasing availability of data and more complex vehicle systems. Interfaces and delivery of information can be improved to manage the load as different driving situations demand.

## SUPPORTING PRIORITIES

2 **Next Generation Car Navigation Systems** will increase the resolution of existing mapping and positioning systems to the 0.5-1 metre level and provide drivers and vehicle systems with high precision information about their location. Integration with other data sources and autonomous systems will improve safety.

3 **Provision of Real-time Traffic, Congestion and Incident Information** allows the driver and vehicle systems to adapt to changing conditions, reducing travel times, lowering pollution and improving road safety.

4 **Provision of Dynamic Speed Limit Information** allows driving speed to be limited according to traffic, road and environmental conditions. Centrally adjustable limits are commonplace on some motorways, but there is a need to facilitate wider adoption and better communication of limits to drivers.

# VEHICLE ELECTRIFICATION

- Supercapacitors for Electric Vehicles
- Design and Assembly of Power Electronics Modules
- High Energy Density Batteries (including Metal-Air)
- Low Cost, Robust and Efficient Electric Machines
- Modular, Standardised Battery Packs
- Modular Electric Vehicle Powertrains
- Expertise in Solutions for Electric Vehicle Architectures and Technologies
- Seamless Integrated Charging Infrastructure
- Software and Hardware for Electric Vehicle Specific Driver Interface
- Utility-Level Energy Grid Management System
- Hybrid and Electric Vehicle Production for Fleets and Taxis
- Market for Used Electric Vehicle Batteries
- Innovative Finance Models for Electric Vehicles

# VEHICLE ELECTRIFICATION

## Vehicle electrification can be defined as a progressive shift in vehicle propulsion technology from traditional internal combustion (IC) to a combination of electric drive and accompanying electrical storage or generation systems.

These systems are used in both electric and hybrid vehicles. The vehicle electrification concept is not new; in fact models with comparable performance to IC vehicles were available in the early 20th century, but widespread adoption has been prevented by limitations of battery storage.

Recently, rising petroleum costs, awareness of environmental issues and advances in storage technology have improved the commercial potential of electric vehicles (EVs). The Garnaut Climate Change Review reported:

***The early emergence of a low-cost electric car, alongside the decarbonisation of the electricity sector, would secure a large place for the private car.***[3]

The widespread adoption of electric vehicles has immense potential for social and environmental benefit including: increased efficiency of transport, lower traffic noise, reduced maintenance requirements, and reduced urban pollution. Well-to-wheel $CO_2$ emissions have been estimated at 115g/km compared with 252g/km for an equivalent petrol vehicle[4], and as an added benefit, it is predicted that total cost of ownership for a mass produced electric vehicle will be lower than that of equivalent IC vehicles.

Australia has existing advantages that give the country a compelling competitive position in the area of vehicle electrification.

These include:

### Lithium Supply

Australia is the second largest producer of lithium, having produced approximately 6,280 tonnes in 2009. Lithium reserves are currently estimated at 580,000 tonnes.[5] Lithium is an important component in current state of the art battery technologies.

### Rare Earth Metal Reserves

These materials are widely used to produce permanent magnets for electric motors, with smaller quantities used in semiconductors, catalysts and exotic alloys. While not a significant producer of rare earth metals, Australian reserves are estimated at 5.4 million tonnes and account for approximately 5% of available global supply.[6]

### Availability of Green Energy

Electric vehicles with onboard electricity storage have a requirement for recharging. Australia's well connected, robust electricity grid will facilitate the rollout of charging infrastructure and the uptake of electric vehicles. In addition, with increasing pressure to reduce carbon emissions, the availability of low emissions energy from wind, wave, solar and nuclear, will be important.

### Automotive Research and Development

Australian industry, both in and outside the automotive sector, has global strengths in research and development that can be used to leverage resource strengths.

With the fundamental shift in core propulsion technology, electric vehicles need not directly replicate the layout, interface or subsystems of IC vehicles. Broader changes have been proposed in the way cars are designed and used. These might include the integration of on-vehicle storage systems with the electricity grid to smooth load during peak hours, the development of a driver interface specific to EVs, or a shift in vehicle platform architecture to maximise the benefit of changed design requirements.

Other technical challenges remain in achieving market penetration for electrified vehicles. Battery technology continues to advance, with improved performance at reduced cost, but energy storage density remains substantially lower that that of fossil fuels. Alternatives to battery storage, such as supercapacitors and fuel cells, are also being explored to solve the energy density challenge. As new technology becomes available, consumers will be increasingly able to do without IC engines enabling widespread adoption of electrified vehicles.

3 Garnaut, R. *The Garnaut Climate Change Review: Final Report*. 2008. P 503.
4 Komer, M and Heywood, J. *Electric Powertrains: Opportunities and Challenges in the US Light-Duty Vehicle Fleet*. Sloan Automotive Laboratory, MIT. May 2007.
5 US Geological Survey. *Mineral Commodity Summaries 2010*. January, 2010. p92.
6 Ibid. p128.

# VEHICLE ELECTRIFICATION APPLICATIONS

The trend toward vehicle electrification is driven primarily by the desire to improve energy efficiency and reduce pollution. These desires, in turn, are driven by the increasing relative cost of traditional energy and public awareness of environmental issues. This combination of factors makes electric vehicles highly marketable.

Performance and cost concerns still exist, however. Low ownership costs and improved battery performance (yielding longer range and shorter recharge times) are important market considerations.

Additionally, consumers continue to demand high levels of amenity and this is enhanced by design flexibility brought about by the fundamental shift from internal combustion to electric propulsion. Options for increased personalisation through mass customisation are also desirable.

A strong influence on the Australian industry will be the integration of technologies into the global vehicle platforms of parent companies. This will increase the competition for design and supply contracts, but also increase the rewards of a successful bid.

As with all fundamental changes in technology, enthusiastic early adopters drive technology uptake and will be the focus of initial sales and marketing efforts.

## Short Term

**2010-2012**

The market for electric vehicles is currently emerging and this departure from conventional vehicles limits applications in the short term.

## Medium Term

**2012-2016**

**Supercapacitors for Electric Vehicles**
Increase the energy density of existing battery chemistries, see page 28.

**Seamless Integrated Charging Infrastructure**
Improves the convenience and availability of electric vehicle power, see page 35.

**Hybrid and Electric Vehicle Production for Fleets and Taxis**
Demonstrates the viability of alternative vehicles to encourage their widespread adoption by the public, see page 38.

## Long Term

**2016-2020**

**Modular Electric Vehicle Powertrains**
Development realises the gains in functionality and efficiency enabled by the shift to electric vehicle technology, see page 33.

**Modular, Standardised Battery Pack**
Manufacturing improves the efficiency of vehicle production and maintenance, see page 32.

**Software and Hardware for EV Specific Driver Interface**
Exploits new concepts to improve vehicle safety and comfort, see page 36.

**Design and Assembly of Power Electronics Modules**
Enhances the efficiency of electric vehicles and increases the local value-add, see page 29.

**Expertise in Solutions for EV Architectures and Technologies**
Accesses a growing global market for EV-specific design and engineering services, see page 34.

## Vision 2020+

**2020+**

**Low Cost, Robust and Efficient Electric Machines**
Reduce EV cost to promote widespread adoption and exploit locally available rare earth resources, see page 31.

**High Energy Density Batteries (including Metal-Air)**
Represent a globally exploitable technology to increase EV performance, see page 30.

## TECHNOLOGIES AND CAPABILITIES

**Automotive Sector**

Vehicle manufacturing capabilities existing in the industry are highly transferrable to early generations of hybrid and electric vehicles. As electric vehicles move to new architectures, related capability will have to be developed in the local industry to respond to gaps including:

- Production of battery modules,
- Efficient, electronic automotive subsystems,
- Recharging electronics,
- Vehicle sensors, and
- Specific interfaces.

**Non-Automotive Sector**

Outside the vehicle industry, complimentary capability exists in a number of sectors. Design and manufacturing of electric motors is one example, as is capability in lightweighting and electric vehicles from in mining and military industries. Non-automotive expertise can help address gaps in areas like:

- High voltage connectors,
- Charging and power control systems,
- Electric motors, and
- Electricity grid technologies.

**Research Sector**

In the R&D sector, there is existing capability and expertise in a number of key areas including: battery research, electrochemical testing, advanced supercapacitor development, EV and hybrid vehicle research, software development, energy economics, battery lifecycle and electric machines. Building on this expertise will allow the industry to address gaps in:

- Second-life battery applications,
- Renewable energy supply modelling,
- Smart grid technologies,
- Expanding lab facilities,
- Advanced battery chemistries, and
- Supercapacitor applications.

## ENABLERS

**Innovative Finance Models for Electric Vehicles**

To encourage broader uptake of electric vehicles, alternative financing concepts could help eliminate barriers to entry by lowering upfront costs, see page 40.

**Utility-Level Energy Grid Management System**

The wide-reaching economic and energy efficiency benefits offered by plug-in electric vehicles can be realised through the development of an intelligent grid to manage available storage for peak loading, see page 37.

**Market for Used Electric Vehicle Batteries**

By increasing the usefulness of batteries through a market for end-of-life vehicle batteries, the environmental and financial cost of EVs can be substantially reduced, see page 39.

**Government Action**

Support for electrification can be achieved by establishing appropriate standards and targeting existing funds, policy and incentives.

**Science and Research**

Targeted research programs will be necessary to specify design requirements, model alternative approaches, and provide lab capabilities.

**Industry Collaboration**

To realise large, complex applications, industry partnerships and strategic alliances will facilitate coordinated technology development.

**Education and Training**

Support through education programs will supply graduates with specific expertise in the new technologies required by electric vehicles.

**Planning and Feasibility**

Business planning is key to securing funding. A technology action plan specifically targeting an electric vehicle industry was also identified.

# VEHICLE ELECTRIFICATION ROADMAP

By considering local and global factors, including those described on page 19, workshop participants highlighted the trends and drivers of particular relevance to vehicle electrification in Australia, including the need to reduce reliance on foreign oil and address emissions. Applications, which address the drivers, were identified and ranged from commercialisation of supercapacitors in the medium term, through development of electric motor and battery technology in the future. Gaps in existing technology and capabilities prevent the realisation of these applications have been identified, along with enabling actions to facilitate their development. The figure at left presents an overview.

# VEHICLE ELECTRIFICATION

## The System Perspective

Vehicle Electrification yielded the most priority applications of any opportunity area with participants identifying 10. Three cross-cutting enablers with impact on a range of applications were also identified. The applications in the sector fit into three categories:

- Storage and Charging
- Architecture and Platform Development
- Component Production

Figure 6 provides a broad view of the interrelationships between vehicle electrification applications and their enablers. By identifying enabler theme areas that participants deemed relevant to each application, enablers with broad impact, like industry collaboration, become apparent reading across the rows.

Equally, applications requiring support from diverse stakeholder groups can be separated from those needing little intervention by reading the columns. For example, the development of an EV specific driver interface requires enabling action in two areas, while action is needed from the majority of stakeholders to realise the production of electrified fleet vehicles. Additional detail for each application was provided by participants and is available at the end of this section.

Also shown in Figure 6 are scores based on predicted performance of each application in five areas: Profit (economic benefit), People (social impact), Planet (environmental benefit), Investment Cost, and Likelihood of Success. High profit potential was indicated across all categories, particularly in applications like battery development, and vehicle architecture development services. Lower potential was identified for the development of a driver interface.

Social and environmental benefits are generally strong, with some applications providing only secondary benefits as component technologies. Wider variation can be seen among scores for investment cost, however, with development in electronic systems being particularly cost effective and longer term research and commercialisation programs indicated as more expensive. Required investments were estimated between $5 and $200 million. Finally, the likelihood of success was assessed with supercapacitor technology and integrated charging infrastructure ranking highly, and development of battery technology rating least likely.

| Key | |
|---|---|
| Low | |
| Medium | |
| High | |

| | | Applications | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Supercapacitors for Electric Vehicles | Design and Assembly of Power Electronics Modules | High Energy Density Batteries (including Metal-Air ) | Low Cost, Robust, Efficient Electric Machines | Modular, Standardised Battery Pack | Modular Electric Vehicle Platform | Expertise in Solutions for EV Architectures and Technologies | Seamless Integrated Charging Infrastructure | Software and Hardware for EV Specific Driver Interface | Hybrid and Electric Vehicle Production for Fleets and Taxis |
| Enablers | Innovative Finance Models for Electric Vehicles | | | | | | ● | ● | | | ● |
| | Electric Vehicle Market for Used Batteries | ● | | ● | | ● | | | | | ● |
| | Utility-Level Energy Grid Management System | | | | | | | | ● | | |
| | Infrastructure Support | | | | | | | | ● | | ● |
| | Government Action | ● | | | | ● | | ● | ● | ● | ● |
| | Industry Collaboration | ● | ● | ● | ● | ● | ● | ● | | | ● |
| | Science and Research | ● | ● | ● | | ● | ● | | | | |
| | Education and Training | | | | ● | ● | ● | ● | ● | | |
| | Planning and Feasibility | | ● | ● | | | | ● | | ● | ● |
| Metric Scores | Profit | | | | | | | | | | |
| | People | | | | | | | | | | |
| | Planet | | | | | | | | | | |
| | Investment Cost* | | | | | | | | | | |
| | Likelihood of Success | | | | | | | | | | |

FIGURE 6 – **INTERRELATIONSHIP OF VEHICLE ELECTRIFICATION PRIORITY APPLICATIONS AND ENABLERS. APPLICATIONS HAVE BEEN SCORED AGAINST FIVE KEY METRICS. *NOTE: APPLICATIONS WITH LOW INVESTMENT COSTS RECEIVE HIGH SCORES.**

### Application Linkages

Within the vehicle electrification area, there are applications that are dependent on one another to achieve success. Workshop participants were asked to identify these linkages and the results are depicted in Figure 7. Participants indicated one particularly strong linkage between the design of power electronics modules and expertise in EV technologies, noting that power electronics are a key competitive element of an electric vehicle design.

Equally interesting are the weak relationships, showing applications that may be effectively realised independently. Charging infrastructure, for example, is shown to be independent of component manufacturing applications. This reflects the view that provision of infrastructure will be required to support electric vehicles whether or not they are driven by locally produced electric motors. The reverse is also true: producing globally relevant power electronic modules can be achieved without a seamless charging infrastructure network.

## Enabling Actions

Workshop participants specified detailed action plans required to realise each of the 13 Vehicle Electrification applications. A summary is presented on the following pages.

### Enabler Linkages

By recording the frequency of enablers appearing together in achieving a particular application, relationships can be identified as shown in Figure 8. The majority of correlations shown in the figure relate to two areas: Government Action, and Industry Collaboration. In the case of their specific combination, government action and industry collaboration are alternative, but complementary methods of achieving the same goals – engaging broad stakeholder support and securing funding.

Industry collaboration also shows strong linkages with science and research enablers. Participants discussed the need to promote collaboration between research and commercial sectors with particular attention required for promotion of commercial outcomes. Planning and feasibility is another collaborative activity that both requires and serves to engage broad stakeholder support from industry, research and government sectors across industry. Other interesting areas of correlation identified include the linkage between the research sector and education programs, a need for government support in applications that require deployment of infrastructure, and a strong correlation between industry collaboration and an end-of-life vehicle battery market.

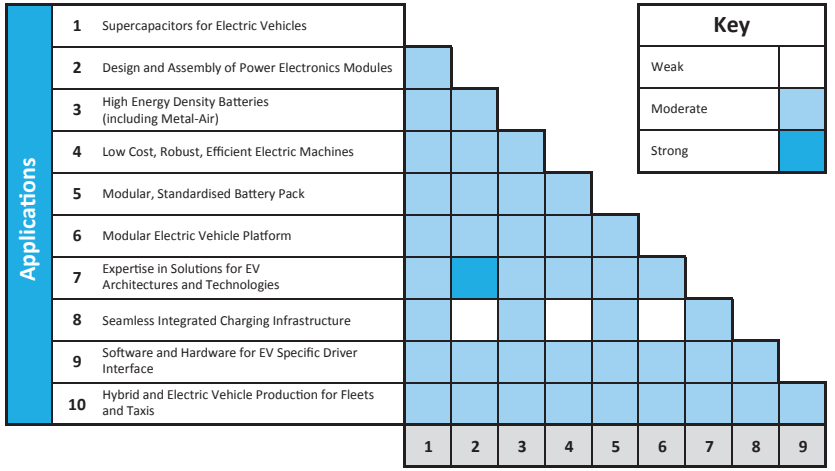



FIGURE 7 – **STRENGTH OF RELATIONSHIP BETWEEN VEHICLE ELECTRIFICATION PRIORITY APPLICATIONS**

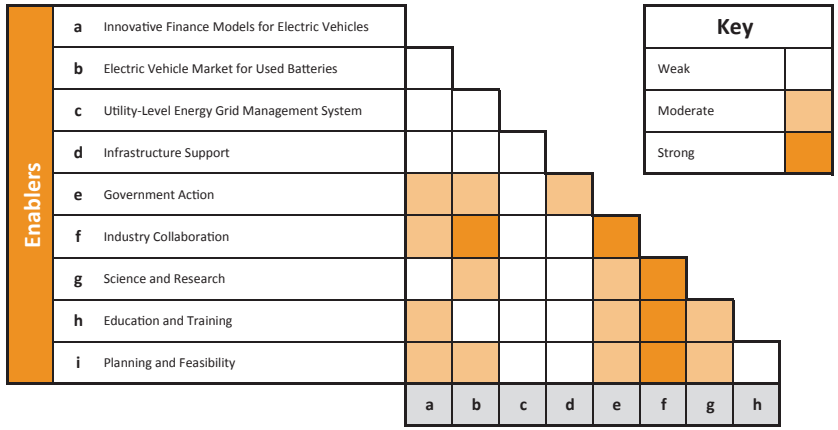



FIGURE 8 – **STRENGTH OF RELATIONSHIP BETWEEN VEHICLE ELECTRIFICATION ENABLERS**

# VEHICLE ELECTRIFICATION

## Supercapacitors for Electric Vehicles

A number of opportunities exist for application of supercapacitors in electric vehicles: as a primary energy storage solution, to manage peak loads from regenerative braking systems and to increase the effective energy density in supercapacitor battery systems. Competitive local technology can be enabled through:

**Setting Strategic Directions** and engaging stakeholder support through meetings to formulate strategy across stakeholders from CSIRO, government and industry.

**Establishment of a Consortium** to support market entry that will undertake the development of pre-production prototypes leading to local assembly of high energy density supercapacitor modules and hybrid battery systems.

**Funding Support for R&D** through existing mechanisms like the Green Car Innovation Fund that supports research initiatives into prototype development and technology integration.

## Design and Assembly of Power Electronics Modules

Vehicle performance will require optimisation for the specific requirements of the Australian climate and local consumer preferences. This optimisation can be undertaken locally and will be supported by enabling actions that include:

**Preparation of a Business Case** to target the requirements of identified customers and justify the investment in development and commercialisation by industry stakeholders.

**A Collaborative Study** between consultants and industry experts will define the requirement for vehicle integration and performance. These requirements will form the design specification that allows development of integrated charger-controller power electronics.

## High Energy Density Batteries (including Metal-Air)

A limiting factor in the widespread adoption of electric vehicles is the energy density of available battery technologies. Improvements in this area will allow increased range and performance while maintaining vehicle mass and size. Key enablers for the development of battery technology include:

**Establishment of Alliances** between industry and research stakeholders to form a centre for excellence for targeted battery technology development.

**Development of a Business Plan** to justify business and research investment and partnerships.

**Securing Funding for R&D** that is delivered to research programs through a centre for excellence in battery technology research. Specific R&D targets have been identified in increased power density and molecular modelling.

**Collaboration among Key Organisations** for business operations that includes the possible formation of joint ventures in the production of battery packs and ancillary processes.

## Low Cost, Robust and Efficient Electric Machines

Electric machines are the core component of electric vehicle powertrains, so increased vehicle electrification will see expanding markets for this technology. Novel concepts to reduce weight or reduce rare earth metal content will have global appeal. Development in the area will depend on enablers including:

**Training of Skilled Undergraduates** by universities that specifically target the design and manufacture of electric machines. Working with research centres of excellence, these graduates will support prototype development and design for manufacture.

**OEM Selection of Local Technologies** for electric motors – instrumental in determining the final production specification and gaining investment in production facilities.

## Modular, Standardised Battery Packs

Battery modules will be required by future electric vehicles and can be assembled cost effectively for local production. In addition, packaging of locally produced advanced battery technology will represent a significant value-add. To realise this application, supporting action will be required in areas such as:

**Expansion of Electrochemical Lab Capabilities** in the science and research base that supports the development of a design and integration specification by allowing full-scale detailed testing and validation of battery modules.

**Establishment of a Company** as the body to undertake module development and commercialisation.

**Funding** through government support schemes like the Green Car Innovation Fund and industry investment that supports the establishment of joint ventures between electric vehicle and battery cell manufacturers to develop a specification for design and integration.

## Modular Electric Vehicle Powertrains

Global platforms are increasingly the focus of major automotive manufacturers, which presents a significant opportunity for the Australian industry. By developing modular powertrain technology that is included in these platforms, significant licensing and export opportunities can be realised. The following key enablers were identified:

**Education and Training** needed to support the development of powertrain technology, provides graduates with directly relevant skills.

**Establishment of Alliances** and consortia to provide a mechanism for undertaking collaborative research and development programs in key areas of powertrain technology.

**Research and Development Programs** which are required to address gaps in areas that include: automotive-specific power electronics, powertrain controls, NVH models and tools, and vehicle integration.

**Commercialisation Funding** from available private sector and government resources to support the establishment of production facilities.

## Expertise in Solutions for EV Architectures and Technologies

Expanding on specific technologies, like batteries and electric machines, there is opportunity to gain recognition as a 'technology integrator' – where technologies can be refined and combined for use in global platforms. Building on existing capability in conventional vehicle design, this application can be realised through key enablers, including:

**An Electric Vehicle-Specific Technology Action Plan** involving stakeholders from universities, industry and government will provide further detail in the understanding of global tends and emerging technologies to target the development of local supply base capability for electric vehicles.

**Development of a Business Plan** to define the case for establishment of core partnerships, founding a business entity and gaining investment. This entity will recruit required partners and resources to offer electric vehicle development solutions.

**Focused Electric Vehicle Education** based on requirements defined by an EV education body will ensure graduates have skills required to offer electric vehicle development solutions.

**Definition of Local Design Standards** by government to provide a base for expansion into overseas markets.

# VEHICLE ELECTRIFICATION

## Seamless Integrated Charging Infrastructure

Electric vehicles will require charging from the electricity grid and their broad adoption will be encouraged through widespread deployment of recharging facilities. Deployment of this infrastructure will be supported by enabling actions and those identified include:

**Policy, Funding and Investment** from government will support the development and rollout of charging infrastructure by targeting secondary factors such as: the renewable energy industry, education and training.

**Targeted Higher Qualifications** through universities will improve engineering skills in automotive and electronics fields, leading to new technologies that support safe, convenient vehicle recharging.

**Standardised International Regulation** across jurisdictions will simplify the design challenges and ensure compatibility of locally developed technology in export markets overseas.

**Removal of Regulatory Barriers** will further simplify the local regulatory environment and encourage swift, widespread deployment of charging technology.

## Software and Hardware for EV Specific Driver Interfaces

Electric vehicles, with widespread adoption of by-wire technologies and multi function displays, present opportunities for new approaches to the human machine interface. This provides an opportunity to develop world-leading technologies that can be applied across global vehicle platforms. To achieve recognition in this sector a number of enabling actions will be required:

**Funding** through the Green Car Innovation Fund if appropriate or other existing support schemes will build novel software, sensors and communication systems into a technology demonstrator.

**Market Research** will determine customer requirements to focus technology demonstration programs. By identifying specific opportunities, the research will support sales and commercialisation efforts.

## Utility-Level Energy Grid Management System

An expanding base of grid-connected electric vehicles presents significant opportunity to capture value from the electricity system. Electrified vehicles provide distributed storage infrastructure for power generated off-peak, which can be returned to the system during periods of high demand. Hybrid vehicles can equally be used to generate electricity to satisfy peak need. Management of this resource can be achieved through:

**Support for Smart-Grid Development and Trials** expands on existing residential smart metering to include support for electric and hybrid vehicles.

**Detailed Modelling** through research institutions, of renewable energy generation and storage solutions to allow the development of a detailed renewable energy supply model and an appropriate Network Operating System.

**Rollout of Broadband Communications** are a backbone technology that facilitates communications between vehicles, smart metering systems and the electricity grid.

**Development of Regulations and Standards** from governments will ensure consistency and reliability of the grid and management system.

## Hybrid or Electric Vehicles for Fleets and Taxis

Affordability of hybrid and/or electric vehicles can be improved by achieving greater economies of scale. In turn, the development of vehicles specifically targeted at fleet sales can provide this increased sales volume. To enable the development of these vehicles a number of proposed actions were identified:

**Clearly Define Objectives** through a clear business plan engaging all stakeholders will justify the case for financial support from governments and OEM investment.

**Financial Support** from government leverages existing capability in automotive component supply, advanced manufacturing and research to support the demonstration of integrated local technology with global OEM platforms.

**Investment and In Kind Support** from OEMs will fund the final stages of commercialisation and lead to the availability of hybrid or electric fleet vehicles.

## Market for Used Electric Vehicle Batteries

Another approach to improving the affordability of electric vehicles is to establish a market for end-of-life vehicle batteries. Likely to be focussed around onsite applications, this residual value for batteries at the end of service life will reduce the overall cost of ownership of electric vehicles. This market can be expanded by:

**Establishing a Cooperative Research Centre** between industry and research sectors to identify and develop applications for used vehicle batteries.

**Government Policy and Regulation** will establish a standard for battery life assessment to regulate and encourage the emerging onsite battery storage market.

**Subsidies for Infrastructure Rollout** from government that will stimulate an expanded deployment of onsite battery storage applications.

**Compilation of a Reuse Portfolio** will leverage cooperative research and supporting performance studies to compile existing and emerging 2nd life battery applications.

**Performance Characterisation** by the science and research base provides real data to support policy, regulation and the portfolio of reuse application.

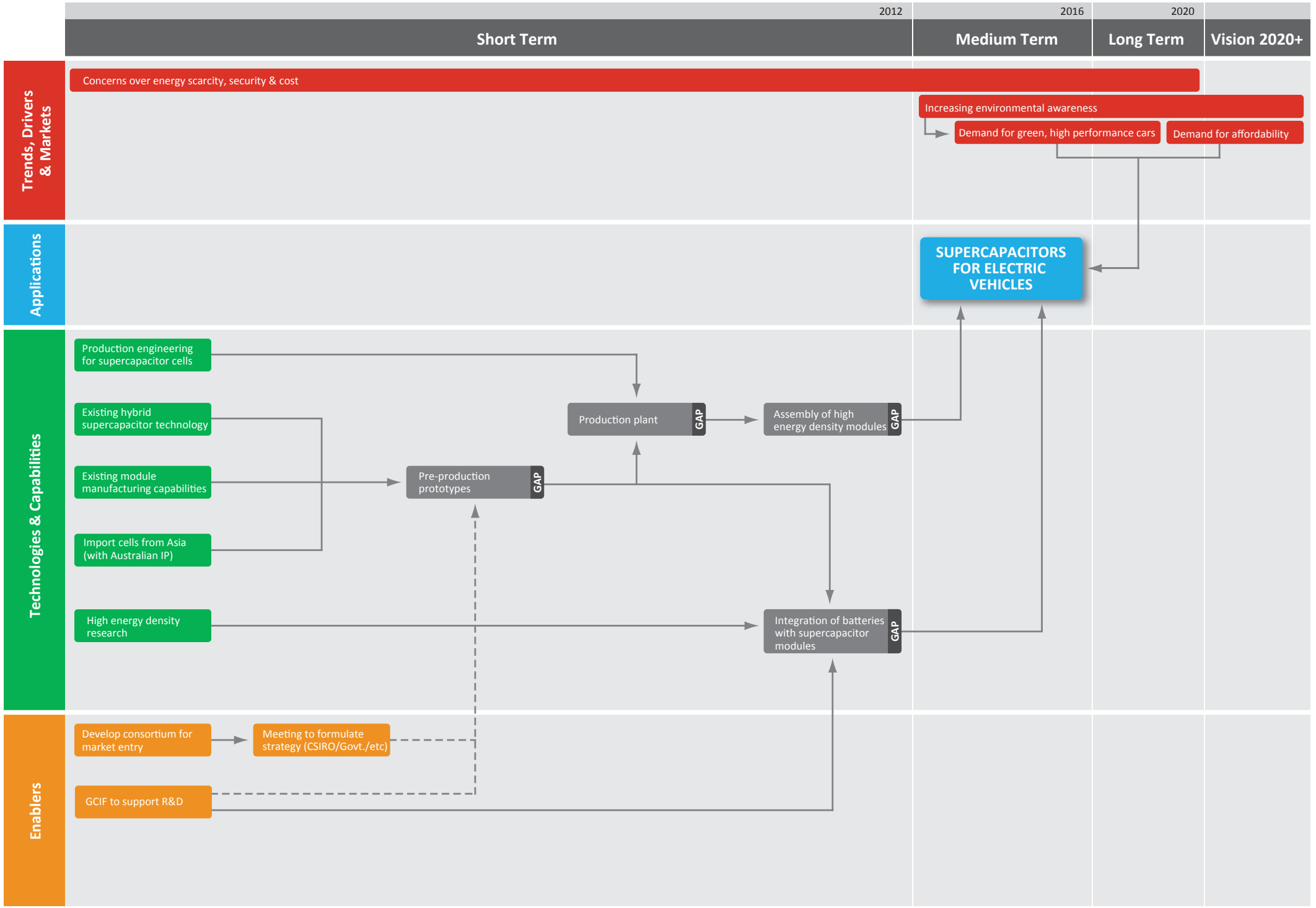
## Innovative Finance Models for Electric Vehicles

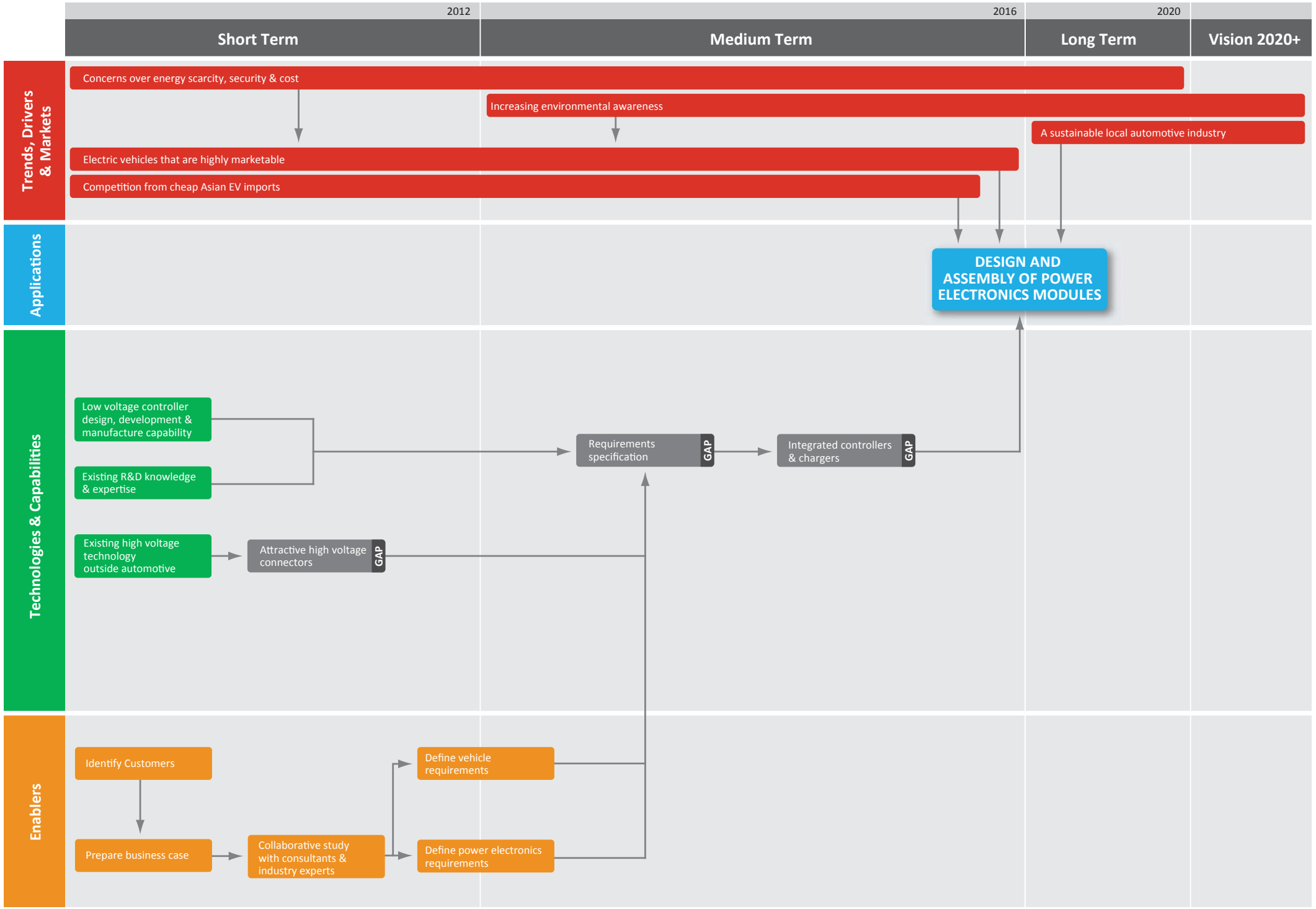
By providing innovative financing options to consumers, the overall cost of electric vehicle ownership can be reduced to encourage widespread adoption of the technology. Deployment of these financing models will require enabling actions, which include:

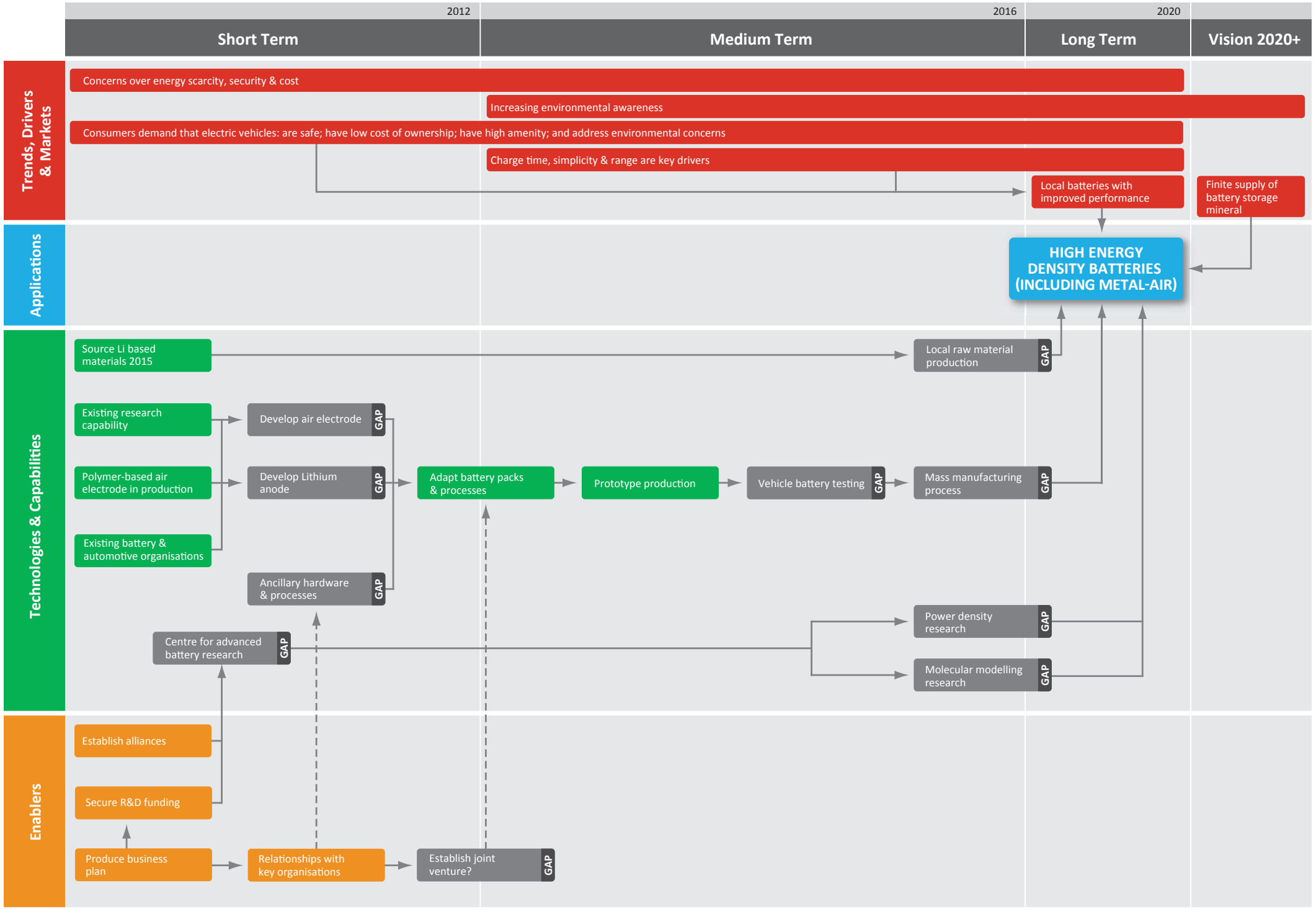
**Supporting Government Policy** is combined with a strong banking sector and existing green car loans to facilitate the establishment of a small scale trial credit union. The credit union will develop and test models including hire purchasing, EV specific leasing and crowd buying.

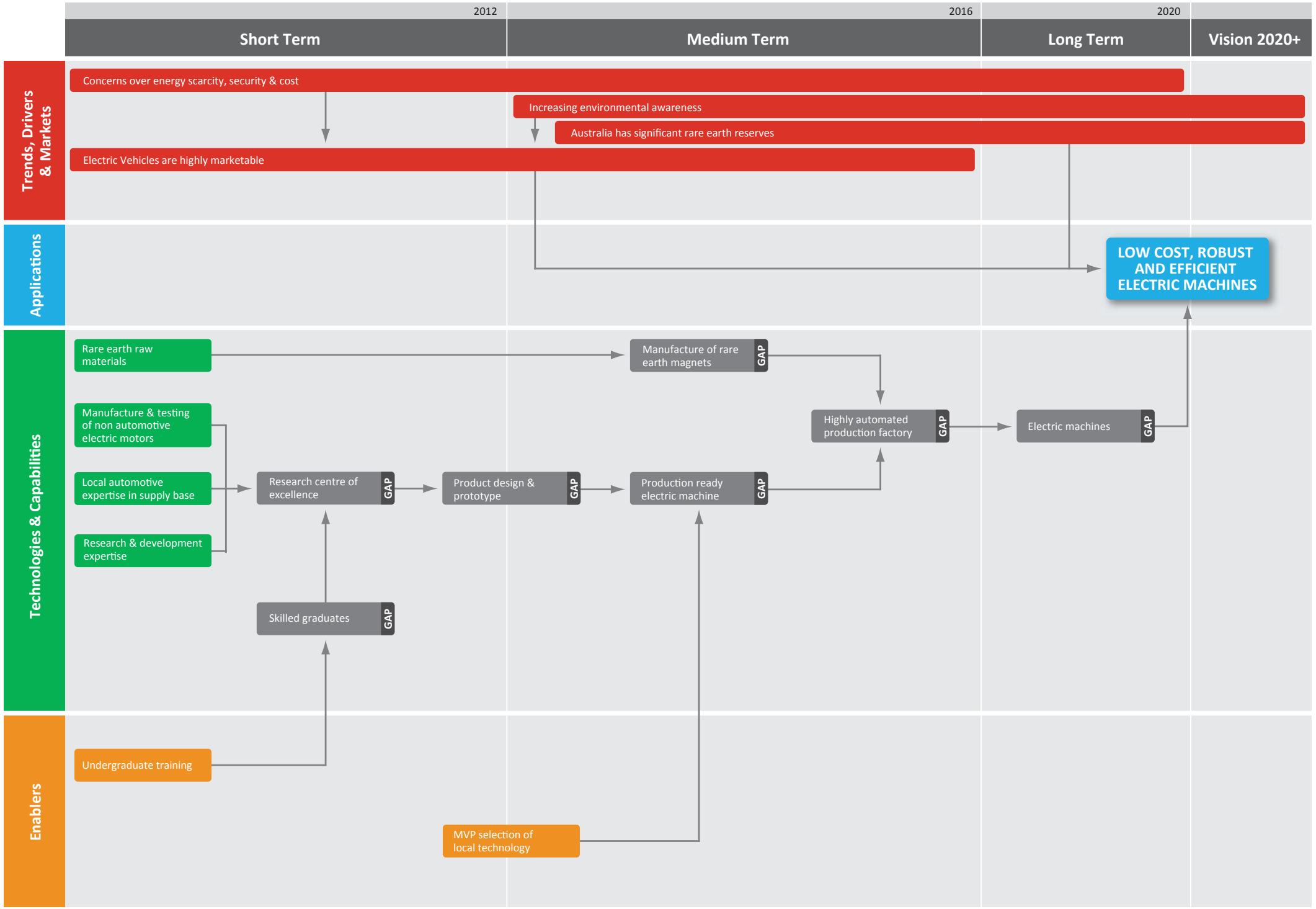
**A Research Study** to determine the lifecycle costs of electric vehicles to support risk mitigation strategies as finance models are tested.

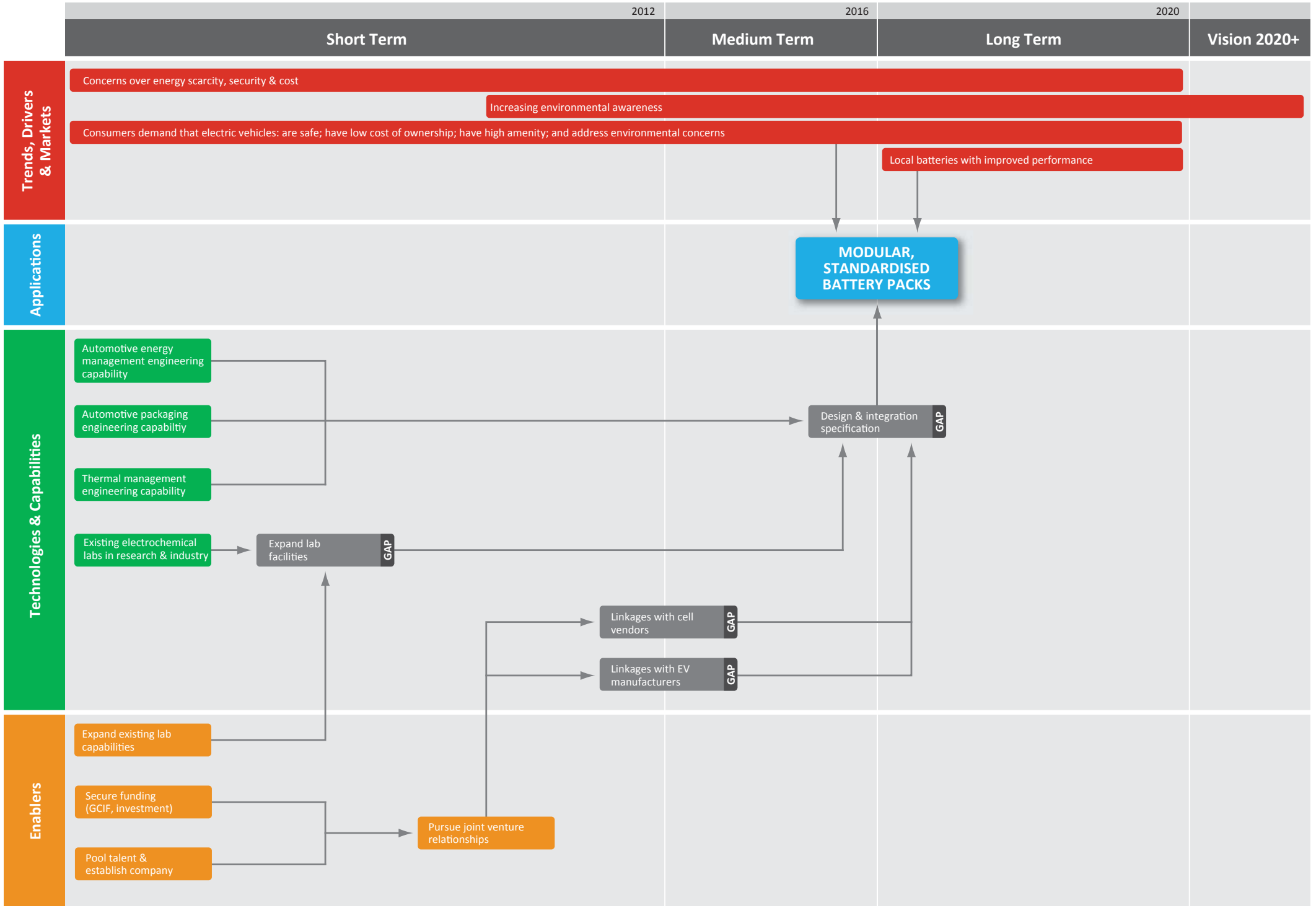
**Establishment of Monitoring and Reporting Mechanisms** to ensure innovative finance models are sustainable for all stakeholders will enable the founding of an EV focussed credit union and the full scale deployment of successful models.

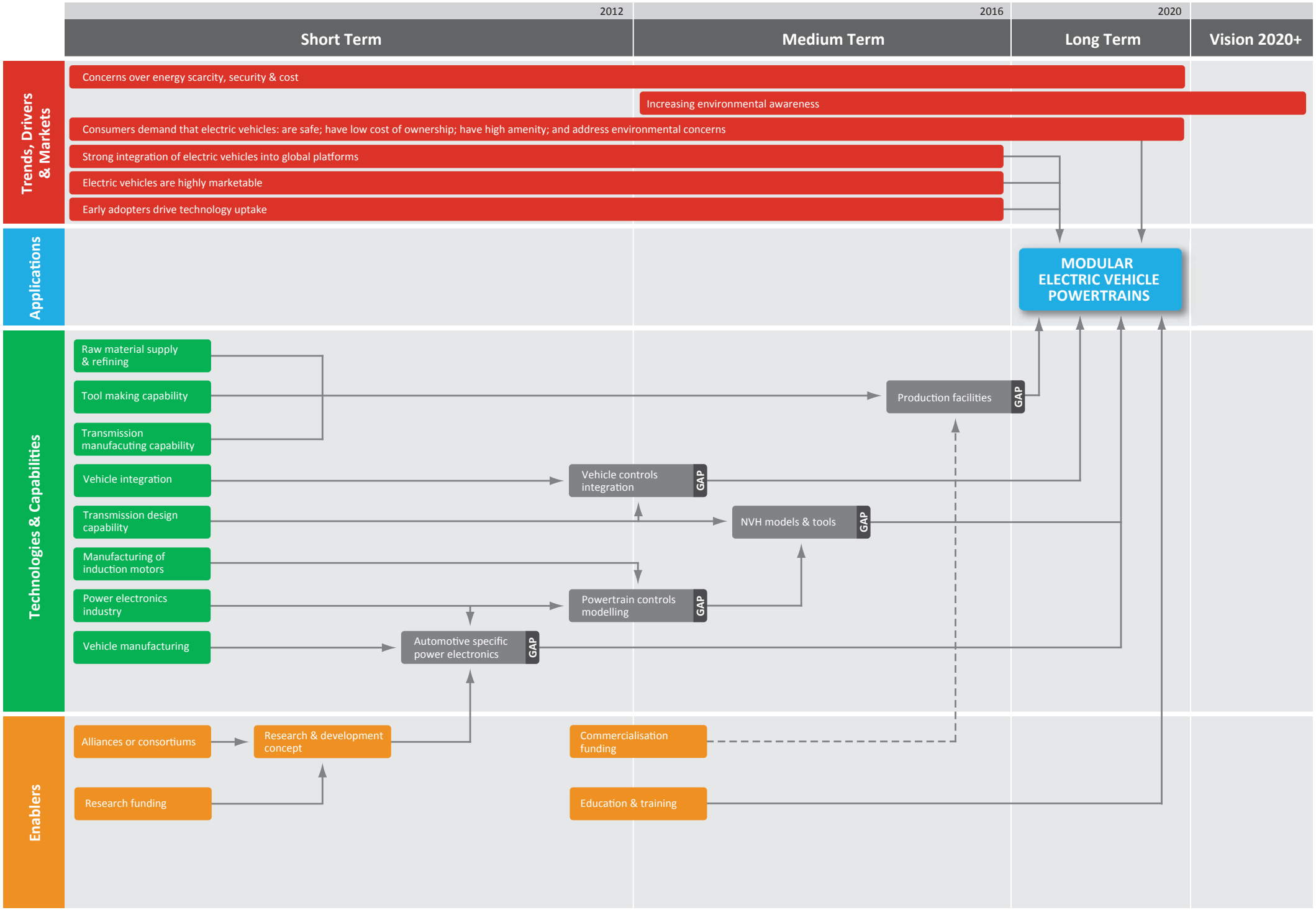

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Demand for green, high performance cars
Demand for affordability
Applications
SUPERCAPACITORS FOR ELECTRIC VEHICLES
Technologies & Capabilities
Production engineering for supercapacitor cells
Existing hybrid supercapacitor technology
Existing module manufacturing capabilities
Import cells from Asia (with Australian IP)
High energy density research
Pre-production prototypes
GAP
Production plant
GAP
Assembly of high energy density modules
GAP
Integration of batteries with supercapacitor modules
GAP
Enablers
Develop consortium for market entry
Meeting to formulate strategy (CSIRO/Govt./etc)
GCIF to support R&D

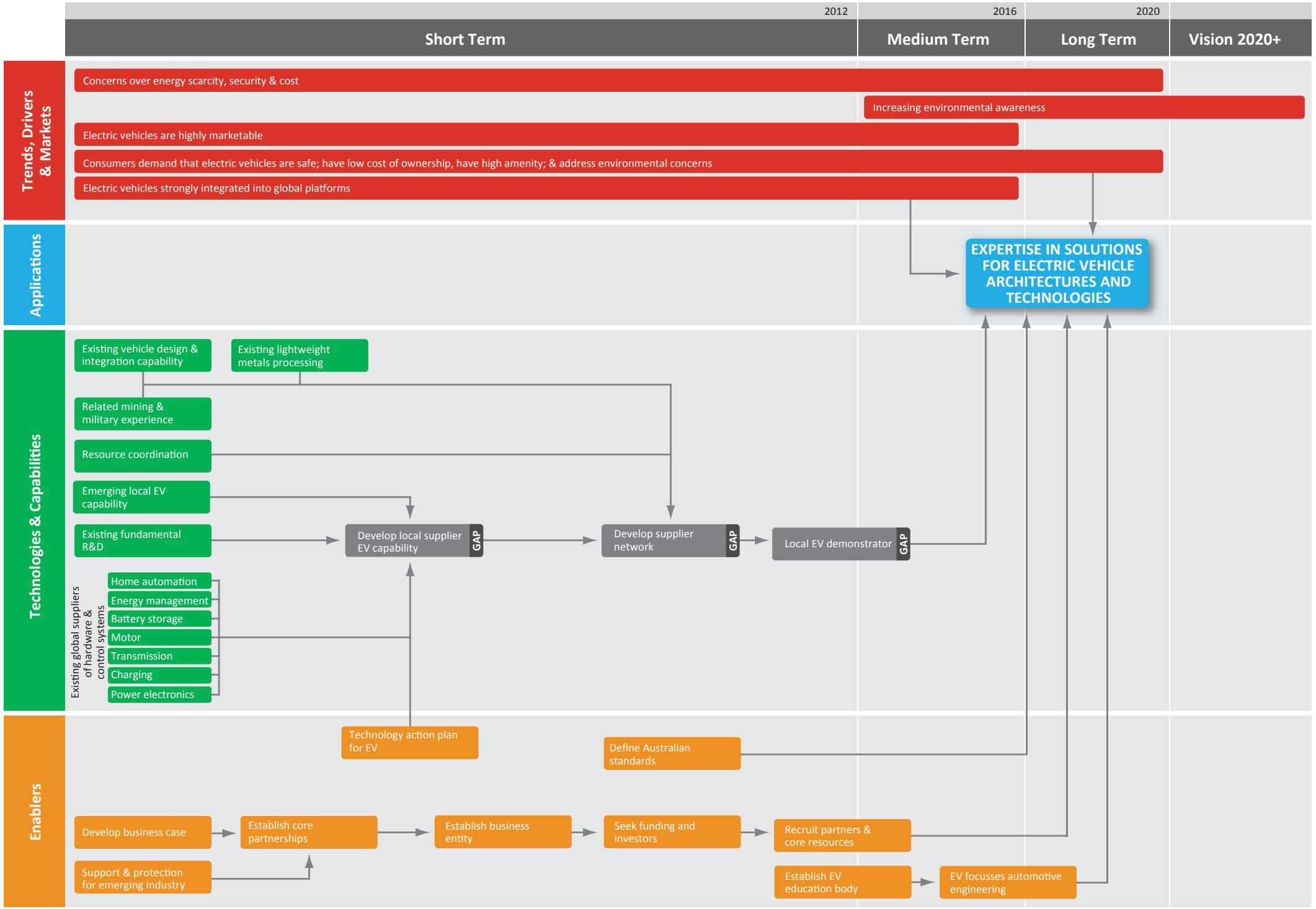

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
A sustainable local automotive industry
Electric vehicles that are highly marketable
Competition from cheap Asian EV imports
Applications
DESIGN AND ASSEMBLY OF POWER ELECTRONICS MODULES
Technologies & Capabilities
Low voltage controller design, development & manufacture capability
Existing R&D knowledge & expertise
Existing high voltage technology outside automotive
Attractive high voltage connectors
GAP
Requirements specification
GAP
Integrated controllers & chargers
GAP
Enablers
Identify Customers
Prepare business case
Collaborative study with consultants & industry experts
Define vehicle requirements
Define power electronics requirements

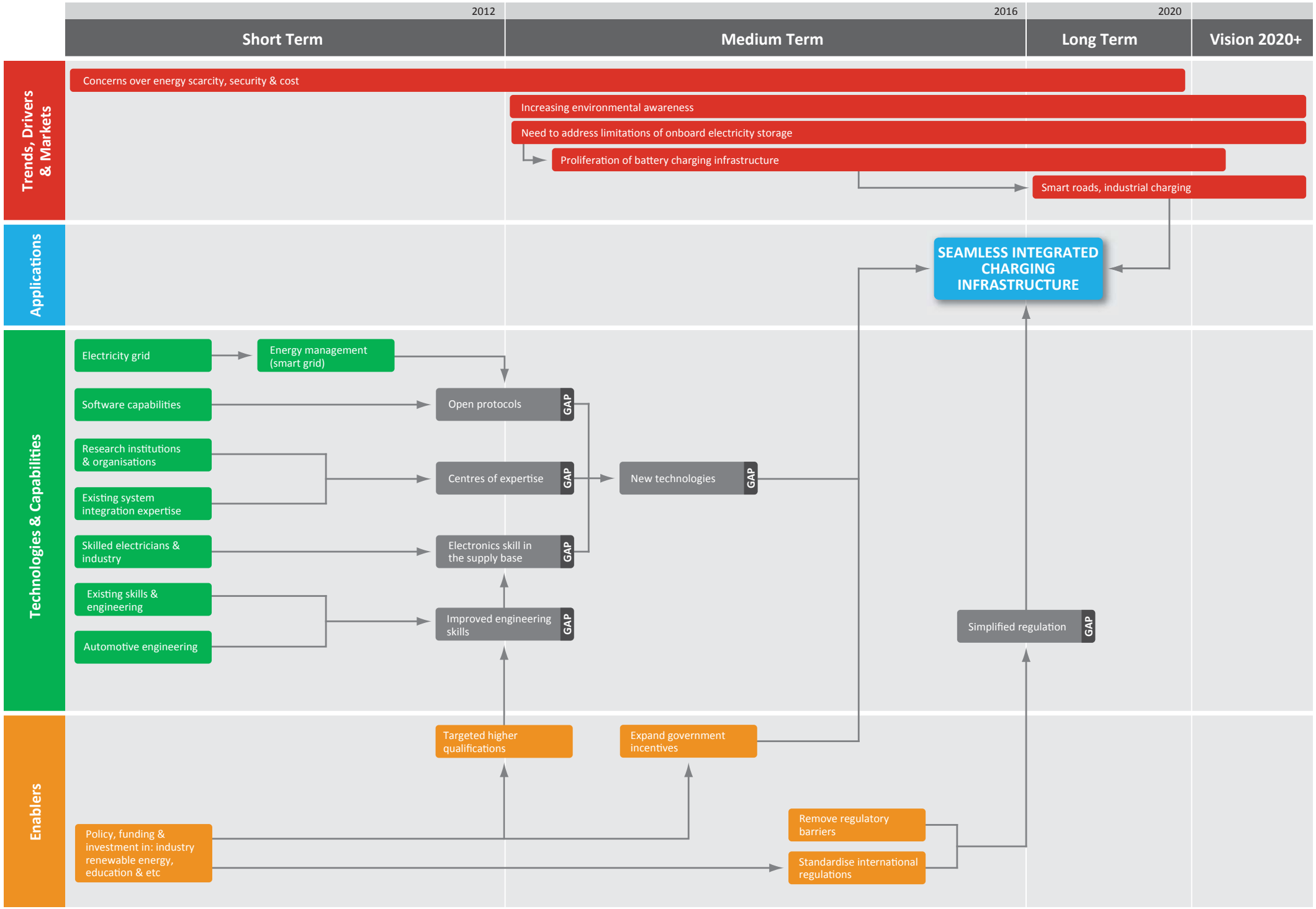

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Consumers demand that electric vehicles: are safe; have low cost of ownership; have high amenity; and address environmental concerns
Charge time, simplicity & range are key drivers
Local batteries with improved performance
Finite supply of battery storage mineral
Applications
HIGH ENERGY DENSITY BATTERIES (INCLUDING METAL-AIR)
Technologies & Capabilities
Source Li based materials 2015
Local raw material production
GAP
Existing research capability
Develop air electrode
Polymer-based air electrode in production
Develop Lithium anode
Adapt battery packs & processes
Prototype production
Vehicle battery testing
Mass manufacturing process
Existing battery & automotive organisations
Ancillary hardware & processes
Power density research
Centre for advanced battery research
Molecular modelling research
Enablers
Establish alliances
Secure R&D funding
Produce business plan
Relationships with key organisations
Establish joint venture?

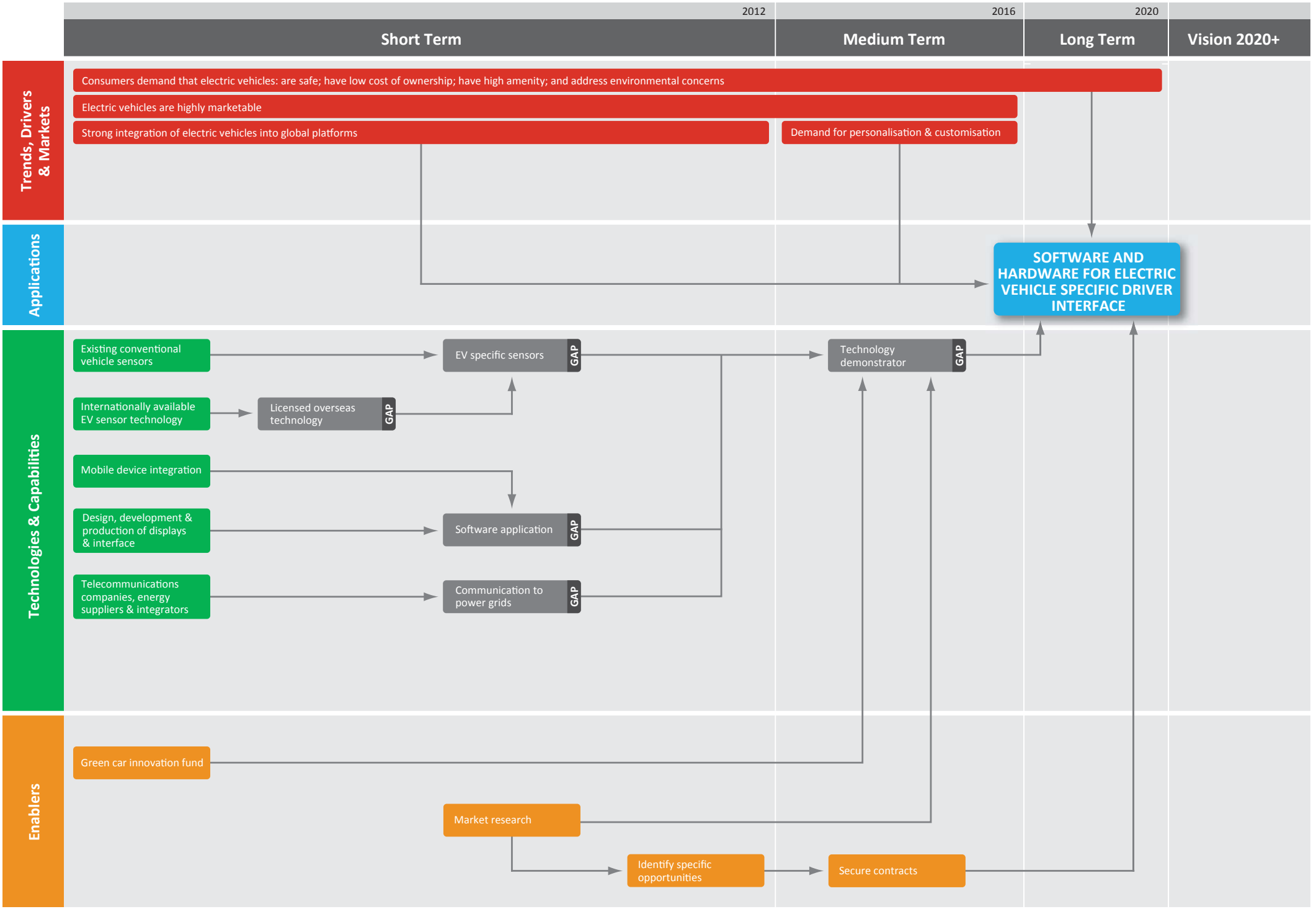

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Australia has significant rare earth reserves
Electric Vehicles are highly marketable
Applications
LOW COST, ROBUST AND EFFICIENT ELECTRIC MACHINES
Technologies & Capabilities
Rare earth raw materials
Manufacture of rare earth magnets
GAP
Manufacture & testing of non automotive electric motors
Highly automated production factory
GAP
Electric machines
GAP
Local automotive expertise in supply base
Research centre of excellence
GAP
Product design & prototype
GAP
Production ready electric machine
GAP
Research & development expertise
Skilled graduates
GAP
Enablers
Undergraduate training
MVP selection of local technology

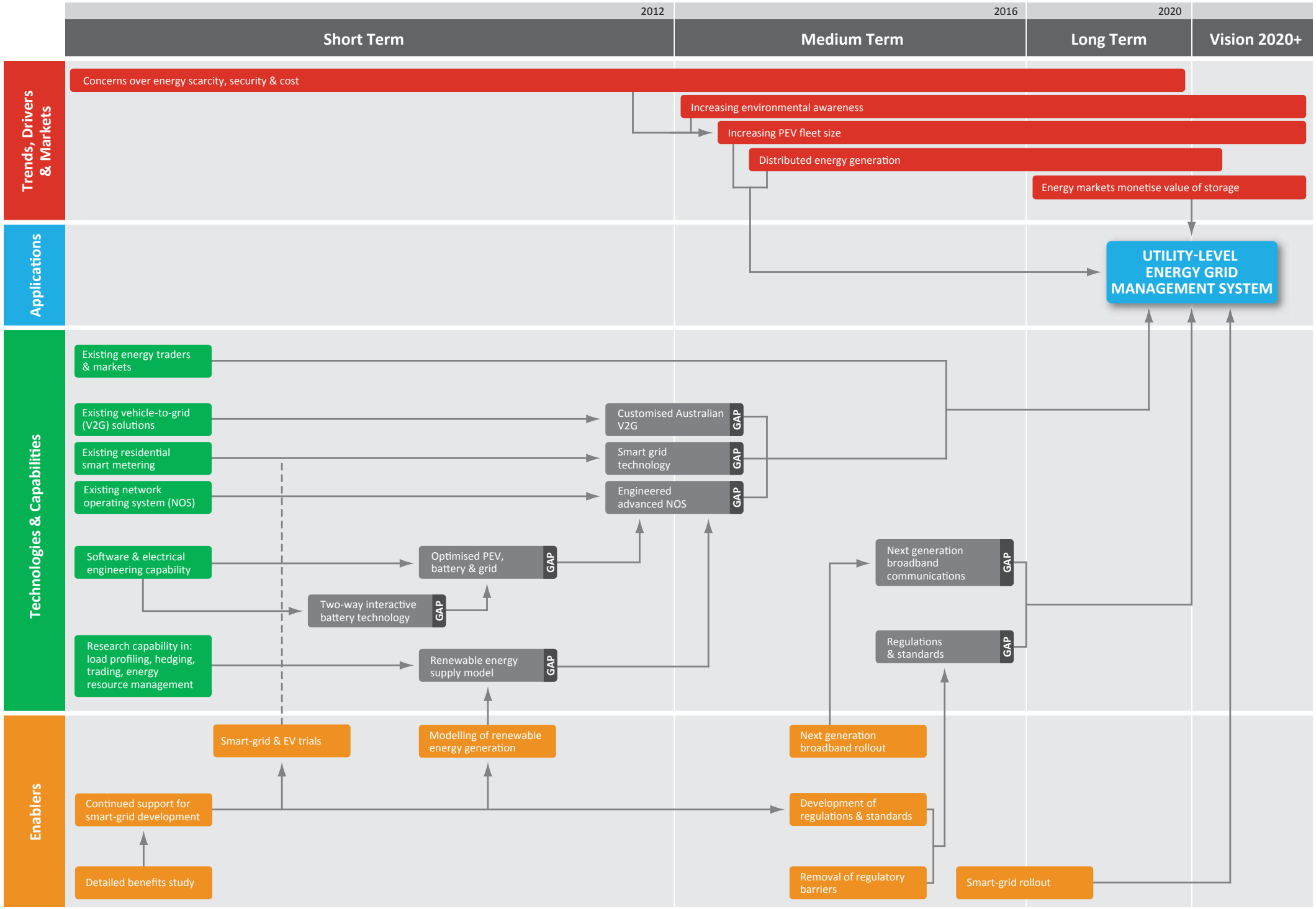

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Consumers demand that electric vehicles: are safe; have low cost of ownership; have high amenity; and address environmental concerns
Local batteries with improved performance
Applications
MODULAR, STANDARDISED BATTERY PACKS
Technologies & Capabilities
Automotive energy management engineering capability
Automotive packaging engineering capabiltiy
Thermal management engineering capability
Design & integration specification
GAP
Existing electrochemical labs in research & industry
Expand lab facilities
GAP
Linkages with cell vendors
GAP
Linkages with EV manufacturers
GAP
Enablers
Expand existing lab capabilities
Secure funding (GCIF, investment)
Pool talent & establish company
Pursue joint venture relationships

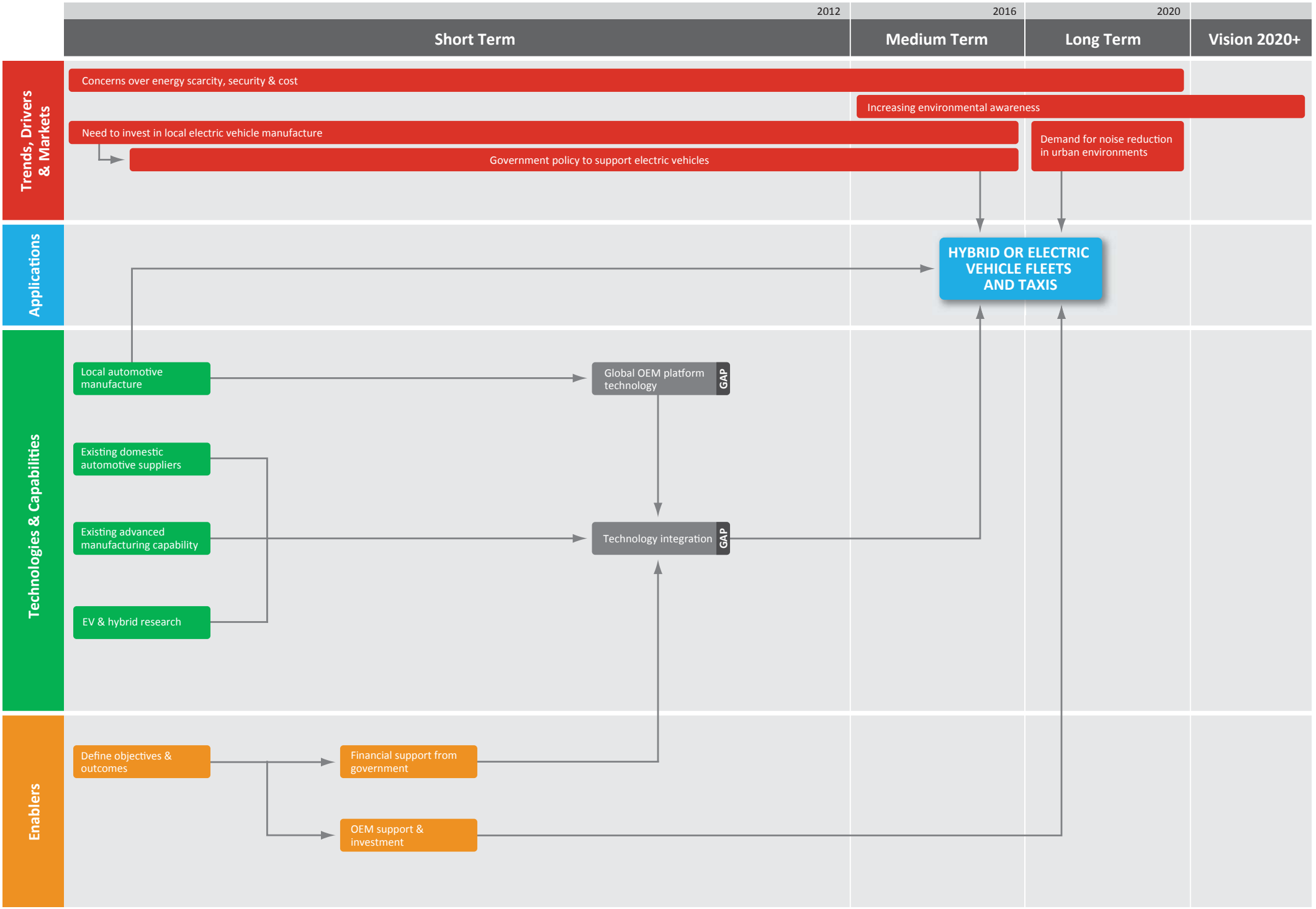

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Consumers demand that electric vehicles: are safe; have low cost of ownership; have high amenity; and address environmental concerns
Strong integration of electric vehicles into global platforms
Electric vehicles are highly marketable
Early adopters drive technology uptake
Applications
MODULAR ELECTRIC VEHICLE POWERTRAINS
Technologies & Capabilities
Raw material supply & refining
Tool making capability
Transmission manufacuting capability
Vehicle integration
Transmission design capability
Manufacturing of induction motors
Power electronics industry
Vehicle manufacturing
Production facilities
GAP
Vehicle controls integration
GAP
NVH models & tools
GAP
Powertrain controls modelling
GAP
Automotive specific power electronics
GAP
Enablers
Alliances or consortiums
Research & development concept
Research funding
Commercialisation funding
Education & training

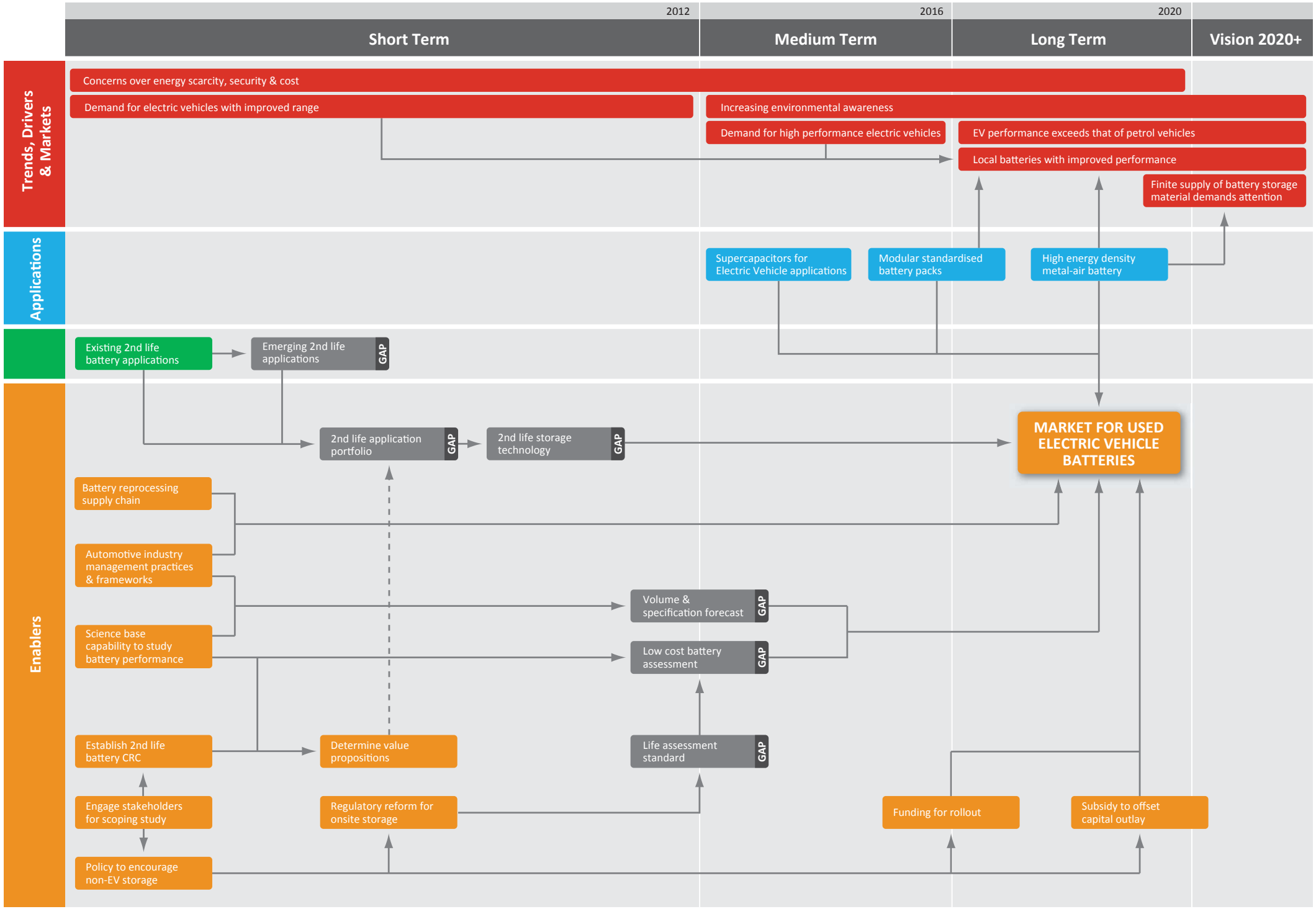

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Electric vehicles are highly marketable
Consumers demand that electric vehicles are safe; have low cost of ownership, have high amenity; & address environmental concerns
Electric vehicles strongly integrated into global platforms
Applications
EXPERTISE IN SOLUTIONS FOR ELECTRIC VEHICLE ARCHITECTURES AND TECHNOLOGIES
Technologies & Capabilities
Existing vehicle design & integration capability
Existing lightweight metals processing
Related mining & military experience
Resource coordination
Emerging local EV capability
Existing fundamental R&D
Develop local supplier EV capability
GAP
Develop supplier network
GAP
Local EV demonstrator
GAP
Existing global suppliers of hardware & control systems
Home automation
Energy management
Battery storage
Motor
Transmission
Charging
Power electronics
Enablers
Technology action plan for EV
Define Australian standards
Develop business case
Establish core partnerships
Establish business entity
Seek funding and investors
Recruit partners & core resources
Support & protection for emerging industry
Establish EV education body
EV focusses automotive engineering

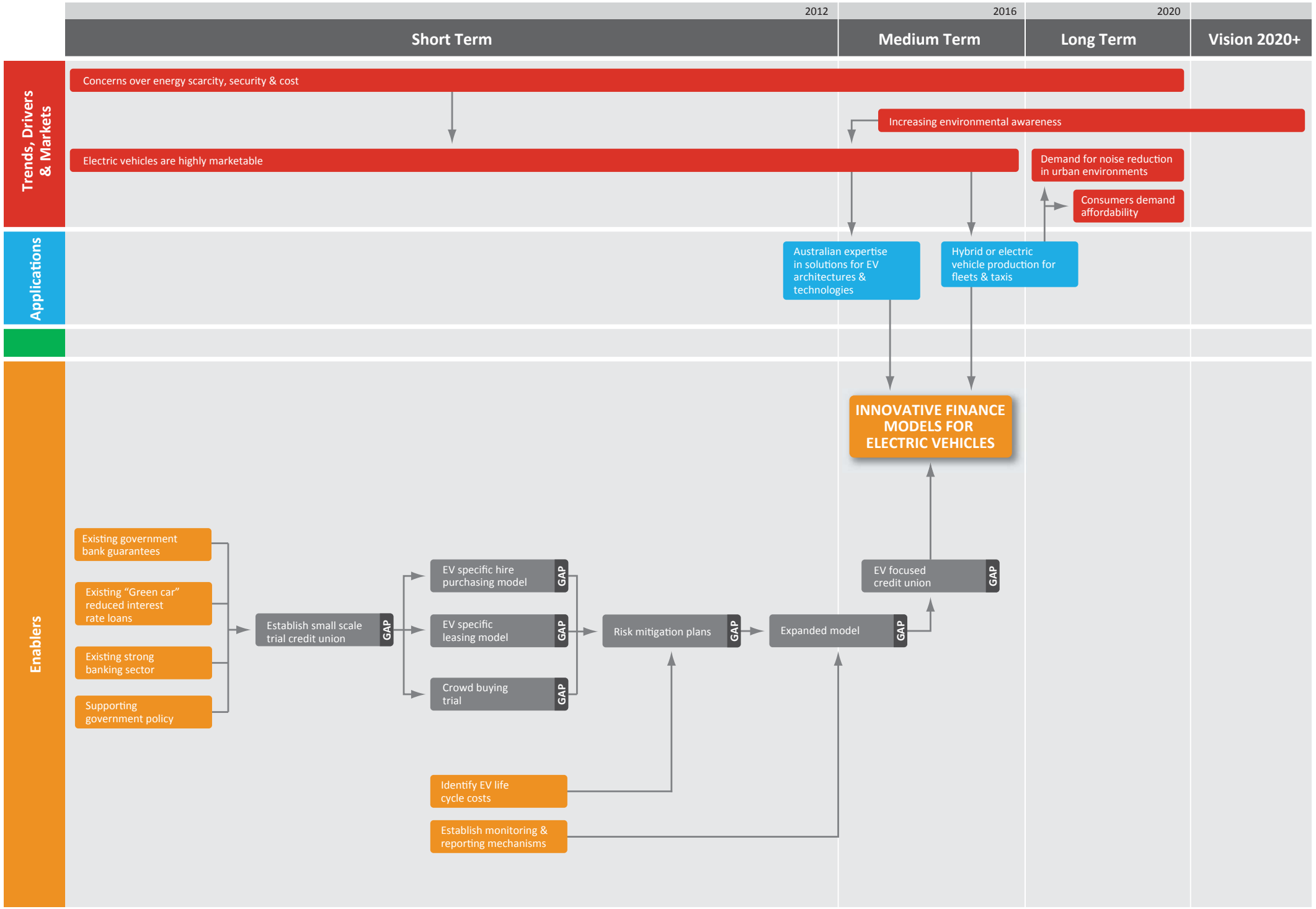

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Need to address limitations of onboard electricity storage
Proliferation of battery charging infrastructure
Smart roads, industrial charging
Applications
SEAMLESS INTEGRATED CHARGING INFRASTRUCTURE
Technologies & Capabilities
Electricity grid
Energy management (smart grid)
Software capabilities
Open protocols
GAP
Research institutions & organisations
Existing system integration expertise
Centres of expertise
GAP
New technologies
GAP
Skilled electricians & industry
Electronics skill in the supply base
GAP
Existing skills & engineering
Automotive engineering
Improved engineering skills
GAP
Simplified regulation
GAP
Enablers
Targeted higher qualifications
Expand government incentives
Policy, funding & investment in: industry renewable energy, education & etc
Remove regulatory barriers
Standardise international regulations


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Consumers demand that electric vehicles: are safe; have low cost of ownership; have high amenity; and address environmental concerns
Electric vehicles are highly marketable
Strong integration of electric vehicles into global platforms
Demand for personalisation & customisation
Applications
SOFTWARE AND HARDWARE FOR ELECTRIC VEHICLE SPECIFIC DRIVER INTERFACE
Technologies & Capabilities
Existing conventional vehicle sensors
EV specific sensors
GAP
Technology demonstrator
GAP
Internationally available EV sensor technology
Licensed overseas technology
GAP
Mobile device integration
Design, development & production of displays & interface
Software application
GAP
Telecommunications companies, energy suppliers & integrators
Communication to power grids
GAP
Enablers
Green car innovation fund
Market research
Identify specific opportunities
Secure contracts


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Increasing PEV fleet size
Distributed energy generation
Energy markets monetise value of storage
Applications
UTILITY-LEVEL ENERGY GRID MANAGEMENT SYSTEM
Technologies & Capabilities
Existing energy traders & markets
Existing vehicle-to-grid (V2G) solutions
Existing residential smart metering
Existing network operating system (NOS)
Customised Australian V2G
GAP
Smart grid technology
GAP
Engineered advanced NOS
GAP
Software & electrical engineering capability
Optimised PEV, battery & grid
GAP
Two-way interactive battery technology
GAP
Research capability in: load profiling, hedging, trading, energy resource management
Renewable energy supply model
GAP
Next generation broadband communications
GAP
Regulations & standards
GAP
Enablers
Smart-grid & EV trials
Modelling of renewable energy generation
Next generation broadband rollout
Continued support for smart-grid development
Development of regulations & standards
Detailed benefits study
Removal of regulatory barriers
Smart-grid rollout


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Need to invest in local electric vehicle manufacture
Demand for noise reduction in urban environments
Government policy to support electric vehicles
Applications
HYBRID OR ELECTRIC VEHICLE FLEETS AND TAXIS
Technologies & Capabilities
Local automotive manufacture
Global OEM platform technology
GAP
Existing domestic automotive suppliers
Existing advanced manufacturing capability
Technology integration
GAP
EV & hybrid research
Enablers
Define objectives & outcomes
Financial support from government
OEM support & investment


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Demand for electric vehicles with improved range
Increasing environmental awareness
Demand for high performance electric vehicles
EV performance exceeds that of petrol vehicles
Local batteries with improved performance
Finite supply of battery storage material demands attention
Applications
Supercapacitors for Electric Vehicle applications
Modular standardised battery packs
High energy density metal-air battery
Existing 2nd life battery applications
Emerging 2nd life applications
GAP
Enablers
2nd life application portfolio
GAP
2nd life storage technology
GAP
MARKET FOR USED ELECTRIC VEHICLE BATTERIES
Battery reprocessing supply chain
Automotive industry management practices & frameworks
Science base capability to study battery performance
Volume & specification forecast
GAP
Low cost battery assessment
GAP
Establish 2nd life battery CRC
Determine value propositions
Life assessment standard
GAP
Engage stakeholders for scoping study
Regulatory reform for onsite storage
Funding for rollout
Subsidy to offset capital outlay
Policy to encourage non-EV storage


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Concerns over energy scarcity, security & cost
Increasing environmental awareness
Electric vehicles are highly marketable
Demand for noise reduction in urban environments
Consumers demand affordability
Applications
Australian expertise in solutions for EV architectures & technologies
Hybrid or electric vehicle production for fleets & taxis
INNOVATIVE FINANCE MODELS FOR ELECTRIC VEHICLES
Enablers
Existing government bank guarantees
Existing "Green car" reduced interest rate loans
Existing strong banking sector
Supporting government policy
Establish small scale trial credit union
GAP
EV specific hire purchasing model
EV specific leasing model
Crowd buying trial
Risk mitigation plans
Expanded model
EV focused credit union
Identify EV life cycle costs
Establish monitoring & reporting mechanisms

> The opportunity areas identified through the Automotive Australia 2020 Roadmap capture the significant areas of change for the global automotive industry. The prioritisation of the applications in these areas is specific to Australia and will allow development of strategic capability and a competitive edge in the global automotive industry.

**PROFESSOR ALEKS SUBIC**

Head of School, School of Aerospace, Mechanical and Manufacturing Engineering
RMIT University

# GASEOUS FUELS

- Dedicated LPG System for Direct Injected Engines
- Fast Fill Solutions for LPG
- High Capacity, Low Cost, On-Vehicle Storage Tanks for CNG
- Increasing Availability of Natural Gas Refuelling
- Public Education Campaign
- Natural Gas Vehicle Technology
- Expansion of the LPG Retrofit Market

# GASEOUS FUELS

## When considering passenger vehicles, there are two gaseous fuels with significant penetration in the global market: Liquefied Petroleum Gas (LPG), and Compressed Natural Gas (CNG).

CNG is the same fuel as that delivered for heating and cooking, and is predominantly methane. LPG, however, is a mixture of butane and propane – the exact composition varies with source and refining methods.

The trend toward increased use of LPG and CNG is, from the global perspective, driven by two primary factors: increasing public awareness of environmental issues like green house gas emissions, and the increasing cost of liquid fuels. In terms of environmental performance, a US study of a CNG taxi fleet found:

***operating costs for CNG cabs were 25 percent less than the gasoline-powered cabs... Tailpipe emissions tests on 14 of the 20 vehicles indicated that CNG exhaust emissions were significantly lower than their gasoline counterparts for non-methane hydrocarbons and carbon monoxide.***[7]

In Australia, there are specific factors significantly increasing the appeal of gaseous fuels over petrol and diesel:

### Cost of Liquid Fuels

Currently, gaseous fuels enjoy lower prices and attract lower excise rates than diesel and petrol alternatives.

### Local Supply of LPG and CNG

Australian annual production of LPG is approximately equivalent to 152 petajoules (PJ) and is projected to grow to about 230PJ by 2020.[8] Natural gas also contributes significantly to the economy ($21 billion in 2006-07) with proved and probable reserves estimated at 173,000PJ.[9]

### Existing Gaseous Fuels Expertise

LPG is currently available as an OEM option on some Australian manufactured vehicles, with aftermarket fitment available for LPG and natural gas. Beyond the passenger market, both fuels are commonly fitted to heavy fleet vehicles.

Although gaseous fuel technology already has some presence in the consumer vehicle market, there are a number of opportunities for technological development to improve performance and public perception. Expanded availability of infrastructure, OEM-style integration and performance, an improved refuelling experience and perceived safety have been highlighted as areas that limit widespread appeal.

Other technical challenges limit the extent to which the benefits of gaseous fuels can be realised without the development of specialised technology. Existing engines are not universally suited to gas conversion.

For example, the efficient use of LPG and CNG requires higher running temperatures and, combined with the elimination of lubricating fuel additives, this requires different valve and valve seat materials to be used. Gaseous fuel engines, when compared with equivalent gasoline alternatives, exhibit lower power and torque outputs that can be exacerbated by weather. For this reason, all current aftermarket conversions use petrol until the engine reaches an appropriate temperature.

A number of other key issues present opportunities to increase uptake of LPG and CNG vehicles. Gas cylinders add up to 100kg to vehicle weight that must be taken into account when designing ride, handling and braking equipment. The requirement for two tanks also present packaging and integration issues for conversion of petrol and diesel vehicles.

By developing dedicated gas bi-fuel engines and systems, optimised to gain the most advantage from gaseous fuels, significant benefit can be realised: oil dilution or contamination can be eliminated, allowing for longer oil drain intervals; thermodynamic efficiency can be achieved through higher compression ratios and boosting; and emissions, including $CO_2$ and toxic substances, can be reduced. The development of advanced gas-specific technology will further increase these benefits.

7 United States Environmental Protection Agency. *Clean Alternative Fuels: Compressed Natural Gas*. Retrieved April 2010 from: http://www.afdc.energy.gov/afdc/pdfs/epa_cng.pdf.
8 LPG Australia. *Industry Data*. Retrieved January 11, 2010 from: http://www.lpgaustralia.com.au/index.php?option=com_content&view=article&id=50&Itemid=55
9 Energy Networks Australia. *CEO Message – Its all about Gas, Gas, Gas!*. Retrieved January 11, 2010 from: http://www.ena.asn.au/?tag=australian-gas-industry-trust

# GASEOUS FUELS APPLICATIONS

A shift to gaseous fuel technologies is being driven primarily by two factors: concerns over security and cost of conventional fuels; and the increasing pressure of environmental issues. An increase in the relative price of conventional liquid fuels with respect to gaseous alternatives was identified as a key underlying driver, while improved fuel security, based on large reserves of natural gas, was also cited as important.

Growing awareness of environmental concerns is increasing the public pressure to be 'green', but the need to address emissions will extend beyond social forces. The drive to reduce $CO_2$ through ultra-low emissions will see continued adoption of standards in Australia, while global platforming may lead to harmonisation with international standards (including Euro V and VI).

Complementing these global drivers is the availability of gas reserves and an existing base of LPG passenger vehicles that make the technology more attractive for Australia than for other markets.

There are public perception issues with gaseous fuels, however. Poor availability of CNG refuelling for passenger vehicles is indicated as a major drawback along with low public opinion of LPG overall. Participants indicated that consumers demand an improved overall LPG experience, including: improved refuelling speed, more convenient vehicle connection, improved range, increased performance and more integrated design. Beyond convenience, perceptions of the safety of gaseous fuels (whether justified or not) need to improve before mass uptake can be realised.

## Short Term

**2010-2012**

**Fast Fill Solutions for LPG**
Address consumer perceptions of refuelling convenience with faster, more convenient fuelling. see page 51.

**Expansion of the LPG Retrofit Market**
Is achieved by lifting the standard of LPG fitment to provide 'OEM-style' performance and integration, see page 56.

**High Capacity, Low Cost, On-Vehicle Storage Tanks for CNG**
Integrate easily into vehicle designs, increasing the viability of natural gas solutions for passenger vehicles, see page 52.

## Medium Term

**2012-2016**

**Natural Gas Vehicle Technology**
Provides a competitive advantage over existing technology by reducing $CO_2$ by 25%, see page 55.

**Dedicated LPG System for Direct Injected Engines**
Allow attachment of gaseous fuel systems to the latest generation of internal combustion engines, see page 50.

**Increased Availability of Natural Gas Refuelling**
Supports the adoption of natural gas vehicles through at-home or centralised filling stations, see page 53.

## Long Term

**2016-2020**

In the longer term, LPG and CNG technology will be largely mature. Applications realised in the short term will continue to provide benefit as transitional technologies between conventional vehicles and fuels, and those of the future.

## Vision 2020+

**2020+**

Beyond 2020, the transition away from fossil fuels will be complete. Gaseous fuel technologies will be progressively replaced by newly developed zero emission alternatives.

## TECHNOLOGIES AND CAPABILITIES

### Automotive

Gaseous fuel applications build on existing Australian capabilities in vehicle and parts manufacturing, and automotive engineering. Passenger vehicles powered by LPG are available directly form Australian vehicle manufacturers and as aftermarket conversions. Significant technology gaps for LPG technology relate to:

- OEM-style equipment integration,
- Aftermarket installation standards,
- Industry expertise in CNG technology,
- LPG refuelling speed, and
- Local availability of LPG systems for direct injected engines.

### Non-Automotive

There is an existing natural gas distribution network, with existing technology for compressing the supply and refuelling vehicles. CNG has seen broad application as a fuel for large commercial fleet vehicles. In these applications, size and weight is not a primary concern and vehicles are refuelled at central depots. This highlights key gaps in CNG technology for passenger vehicles including:

- Widespread availability of CNG refuelling, and
- Lightweight tanks.

### Science and Research

Gaps in scientific and research knowledge can be addressed by building on established capability in thermodynamic modelling, fluid modelling, lightweight materials research and gas adsorbents. Key technology gaps to be addressed through research include:

- Conformable tank technology,
- Gas adsorbent materials, and
- Alternative refuelling strategies (Swap-and-Go).

## ENABLERS

### Public Education Campaign

A program designed to change consumer perceptions of gaseous fuels was consistently identified as a critical enabler. Participants found the issue so compelling that it is treated separately in this section, see page 54.

### Harmonisation of Standards

Consistent standards were identified as important in a number of areas. These include: the characteristics of supplied fuels, the quality of aftermarket systems fitment, and volumetric versus energy-based fuel pricing.

### Infrastructure Support

LPG infrastructure is widespread, but needs to be upgraded to improve fill times and customer perceptions. CNG infrastructure must be more widely deployed to encourage technology uptake.

### Government Action

The enablers highlighted here can be encouraged through supporting policy. Realignment of existing programs and consumer incentives are indicated.

### Industry Collaboration

Significant capability in gaseous fuels exists outside the passenger vehicle industry and in aftermarket conversion providers. This can be captured through cooperative development.

### Education and Training

Beyond market education as described above, training for industry personnel to ensure standards are consistently applied was highlighted as key to maintaining safety.

### Science and Research

A number of areas were indicated as requiring research attention. Solving the problem of LPG filling speed (specifically in hot temperatures) is one example. Another is the development of lightweight conformable CNG tank technology.

### Planning and Feasibility

All commercial applications have proposed feasibility studies to engage stakeholders.

# GASEOUS FUELS ROADMAP

Workshop participants highlighted trends and drivers particularly relevant to Gaseous Fuels in Australia, including a desire to reduce emissions and concerns over the security of imported fuels. Applications, to address the drivers, were identified in LPG and natural gas sectors and ranged from the development of a fast fill LPG solution in the short term, to commercialisation of novel natural gas vehicle technology in the long. Critical gaps in technology and capabilities from all sectors are required before applications can be realised, so enablers were identified to facilitate their development. The figure at left presents an overview

## The System Perspective

Workshop participants identified six priority applications in the area of gaseous fuels. Additionally, participants highlighted a need for consumer education to enable widespread adoption of gaseous vehicle technologies. The priority applications can be grouped by fuel type into two categories:

- LPG Technology, and
- CNG Technology

Aggregation of enablers identified by participants into broad categories and plotting their relevance to particular applications allows interrelationships between gaseous fuels applications and enablers to be shown clearly. This can be seen in Figure 9.

By reading the application columns, applications requiring enabling action across a range of stakeholder groups can be easily identified. Fast fill solutions for LPG, for example, is indicated as requiring enabling action indicated in six of eight areas. By contrast, expansion of the LPG retrofit market has relationship indicated in two areas – government action, and industry collaboration. This reflects a simple need to establish standards and monitoring to improve the consistency of aftermarket installations.

To complement this information, enabling actions with broad impact on a number of priority applications can be identified by reading across the rows. One enabler with a broad impact is a market education program to improve overall public perception of gaseous fuel vehicles.

In the lower section of the interrelationships table, Figure 9 shows scores based on workshop participant views of predicted performance in five areas: Profit (economic benefit), People (social benefit), Planet (environmental benefit), Investment Cost, and Likelihood of Success. High performance was indicated broadly by scores across social, economic and environmental benefit. Fast fill LPG is notably lower ranked in planet and profit metrics, while the social impact of both CNG tanks and the development of an advanced CNG driveline have ranked more highly.

Investment cost has rated poorly by comparison, particularly in relation to natural gas applications. In a similar manner to Vehicle Electrification, this reflects the infrastructure investment in areas with higher cost estimates. These estimates range from the order of $1 million to hundreds of millions for widespread infrastructure rollout. Risks and costs associated with LPG are lower due to its established market position.

| Key | |
|---|---|
| Low | |
| Medium | |
| High | |

| | | Applications | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dedicated LPG Systems for Direct Injected Engines | Fast Fill Solutions for LPG Vehicles | High Capacity, Low Cost, On-Vehicle Storage Tanks for CNG | Increased Availability of Natural Gas Refuelling | Natural Gas Vehicle Technology | Expansion of the LPG Retrofit Market |
| Enablers | Public Education Program | ● | | ● | ● | ● | |
| | Harmonisation of Standards | | ● | ● | | | |
| | Infrastructure Support | | ● | | ● | ● | |
| | Government Action | | ● | ● | ● | ● | ● |
| | Industry Collaboration | ● | ● | | | | ● |
| | Science and Research | ● | ● | ● | | | |
| | Education and Training | | | | | | |
| | Planning and Feasibility | | ● | ● | ● | | |
| Metric Scores | People | | | | | | |
| | Planet | | | | | | |
| | Profit | | | | | | |
| | Investment Cost* | | | | | | |
| | Likelihood of Success | | | | | | |

FIGURE 9 – **INTERRELATIONSHIP OF GASEOUS FUELS PRIORITY APPLICATIONS AND ENABLERS. APPLICATIONS HAVE BEEN SCORED AGAINST FIVE KEY METRICS. * NOTE: APPLICATIONS WITH LOW INVESTMENT COST RECEIVE HIGH SCORES.**

### Application Linkages

Linkages between applications must be considered as the effective realisation of some applications is dependent on developments in other related areas. Workshop participants were asked to identify complementary applications, and the results have been presented in Figure 10. Two particularly strong linkages were identified between applications relating to each of the locally available fuels: LPG and CNG.

The development of a dedicated LPG system for direct injection engines is strongly linked to a solution allowing convenient LPG refuelling. Both will increase consumer demand for LPG technology. In a similar manner, the development of competitive technology for natural gas vehicles will require development in tank design. Flexible, lightweight tank design will allow better vehicle integration and increase the consumer appeal of the natural gas vehicle platform.

## Enabling Actions

Gaseous Fuels workshop participants identified the enabling actions required to address key gaps in technology and capability needed to realise the seven applications. A summary is presented on the following pages.

### Enabler Linkages

Figure 11 presents the strength of correlation between pairs of enablers in the gaseous fuels opportunity area. The relative scores, presented on a 3-point scale, were calculated from workshop output by recording the frequency at which pairs of enablers are indicated together in achieving a particular application. Two particularly strong relationships have been identified.

Government involvement was highlighted as an important element of consumer education programs aimed at changing the public perception of LPG and CNG vehicles. Government support for expanded availability of refuelling infrastructure was also indicated in large proportion of applications. This reflects the need for a structured program to encourage widespread deployment of CNG infrastructure to support CNG vehicles.

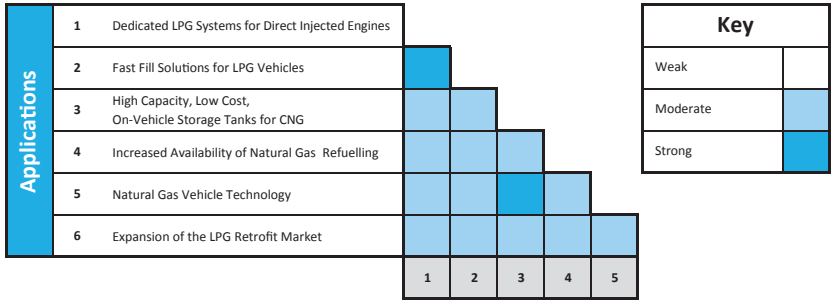



FIGURE 10 – **STRENGTH OF RELATIONSHIP BETWEEN GASEOUS FUELS PRIORITY APPLICATIONS**

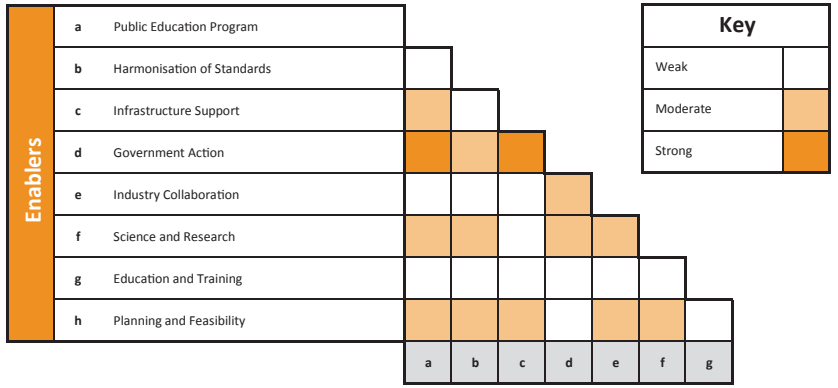



FIGURE 11 – **STRENGTH OF RELATIONSHIP BETWEEN GASEOUS FUELS ENABLERS**

# GASEOUS FUELS

## Dedicated LPG System for Direct Injected Engines

Current generation petrol and diesel engines are turning toward direct injection technology for improved efficiency and reduced emissions. An LPG system tailored to these engines will capture this expanding market. Key enablers include:

**Advertising and Public Relations Campaigns** by government and industry to improve perceptions through enhanced recognition of benefits and dispelling of misconceptions.

**A Fuel Standards Study** of compatibility between Australian and international standards leading to harmonised regulation and consistent vehicle performance across global markets.

**A Shared Technology Centre** supporting prototyping, demonstration and field testing, which leads to a final validated product specification.

## Fast Fill Solutions for LPG

A key factor limiting the market penetration of LPG is consumer perception of convenience. Refuelling speed has been highlighted as an area in particular need of a solution. Improving the filling experience will facilitate uptake of LPG vehicles and can be achieved through:

**Applied Research Programs** including thermodynamic and fluid modelling, to increase available tank volume and refuelling speed utilising updated tank, sensor and line designs.

**A Review of Infrastructure and Fuel Specifications** to establish a standardised supply pressure and fuel formulation.

**Alternative Technology Research** examining possible options for novel refuelling strategies, such as swap-and-go services.

**Business Case Development** engaging broad stakeholder and government support to justify technology development and infrastructure development.

**An Infrastructure Upgrade Program** to rollout improved technology and standards across the refuelling network.

## High Capacity, Low Cost, On-Vehicle Storage Tanks for CNG

The weight and size of tanks for natural gas storage limit their scope for passenger vehicle applications. Novel technologies, like gas adsorbents, will allow lightweight, conformable tanks to be integrated into vehicles. These developments can be facilitated through:

**Public Education** by government and industry about safety and benefits of CNG technology will stimulate market acceptance and demand for natural gas vehicles.

**Feasibility Studies** of technical and market factors to justify investment in technology and standards development.

**Government Funding** through the Green Car Innovation Fund, that will stimulate tank technology development.

**Research Programs** targeting lightweighting of tank materials and developments in gas adsorbent technologies.

**Standards Harmonisation** across design, installation and servicing promotes safety and convenience for consumers.

## Increasing Availability of Natural Gas Refuelling

Natural gas infrastructure for vehicle refuelling is currently limited. There is an existing gas distribution infrastructure for domestic and commercial applications that could be leveraged for vehicle refuelling. Enablers include:

**Excise Policy** clearly articulated by government, to provide certainty over future natural gas pricing in the transportation sector.

**A Business Case** to justify support for conversion programs, infrastructure investment and research.

**Market Education** that challenges public perception of refuelling convenience, CNG availability and safety.

**Infrastructure Support** for the rollout of at-home refuelling and distributed solutions leveraging the existing natural gas supply network.

**CNG Vehicle Retrofit Program** that creates market demand and a customer base for the expanding refuelling network.

## Public Education Campaign

Highlighted as an enabling action across many gaseous fuels applications, public education is essential in challenging consumer perceptions of safety and convenience, while drawing attention to economic and environmental benefits of natural gas and LPG. This can be enabled by:

**A Stakeholder Collaboration Plan** between government and industry identifying roles and funding responsibilities.

**Establishing Uniform National Curricula** to ensure rigorous training of industry personnel and improve real safety.

**A Rigorous Safety Study** allowing updated messaging to be effectively communicated to consumers.

**Rigorous Environmental Study** that expands existing knowledge of environmental benefits to support messaging.

**A Marketing and Public Relations Campaign** jointly funded by industry and government, allows engagement of marketing agencies for wide distribution of key messages.

## Natural Gas Vehicle Technology

By reducing $CO_2$ emissions from natural gas vehicles by 25% over current technology, the local industry can gain significant competitive advantage in the global marketplace. This technology development is supported by:

**Strategy for Gaseous Fuels Transition** from government to facilitate a structural transition from petrol and diesel to natural gas.

**Market Education** that improves consumer perceptions of safety while highlighting environmental benefits to stimulate customer demand.

**Support for Research & Commercialisation** that expands CNG knowledge across all industry sectors.

**Support for Infrastructure** that combines with an expanded retrofit market for existing natural gas vehicle technology to increase fuel accessibility and encourage consumer adoption of the technology.

## Expansion of the LPG Retrofit Market

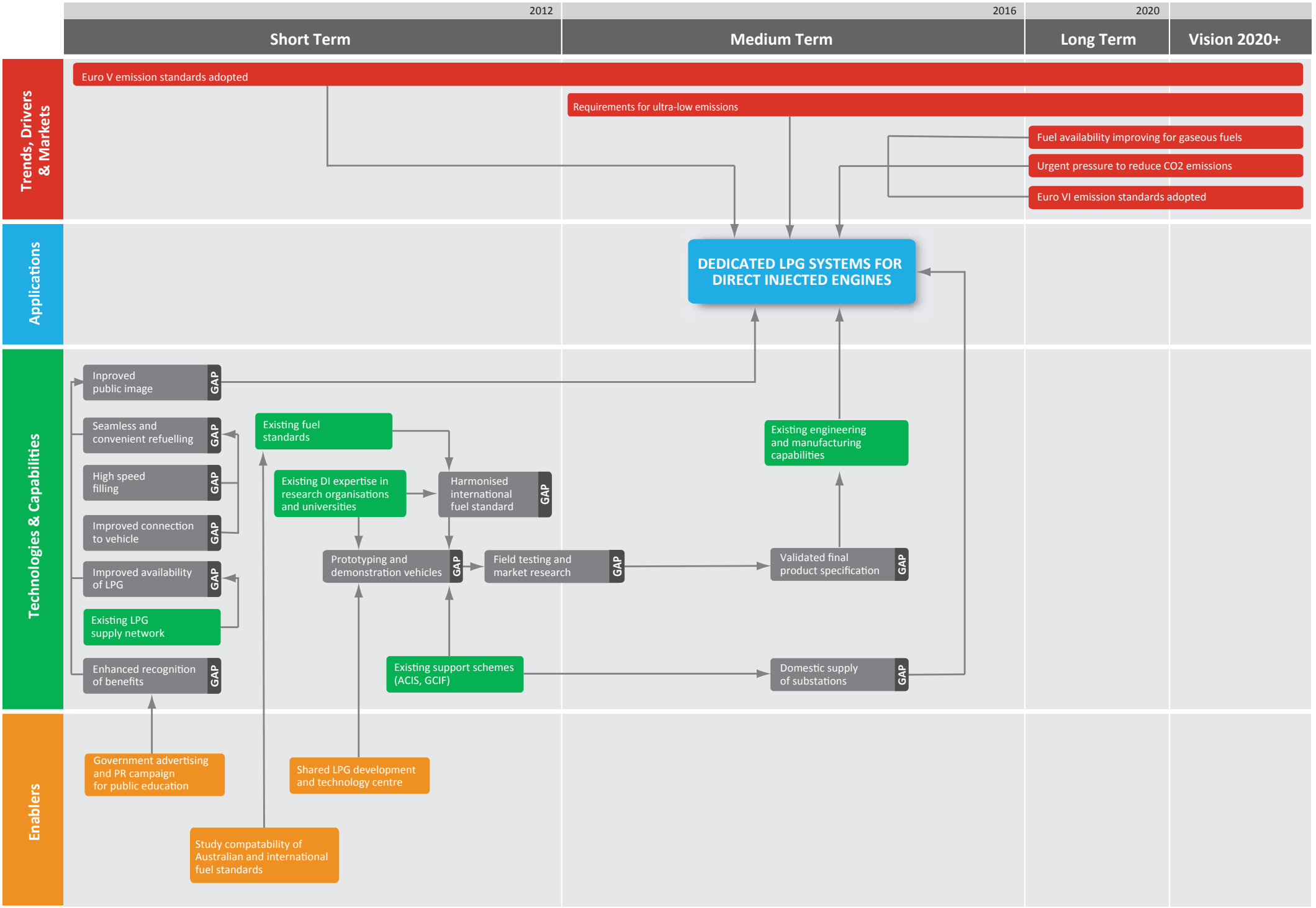
Improved availability of LPG refuelling infrastructure can also be achieved by increasing the installed base of LPG vehicles and consequent demand for local filling stations. By improving the standard of LPG retrofit installations to reflect OEM levels of integration and performance, market penetration will be increased. This can be supported through:

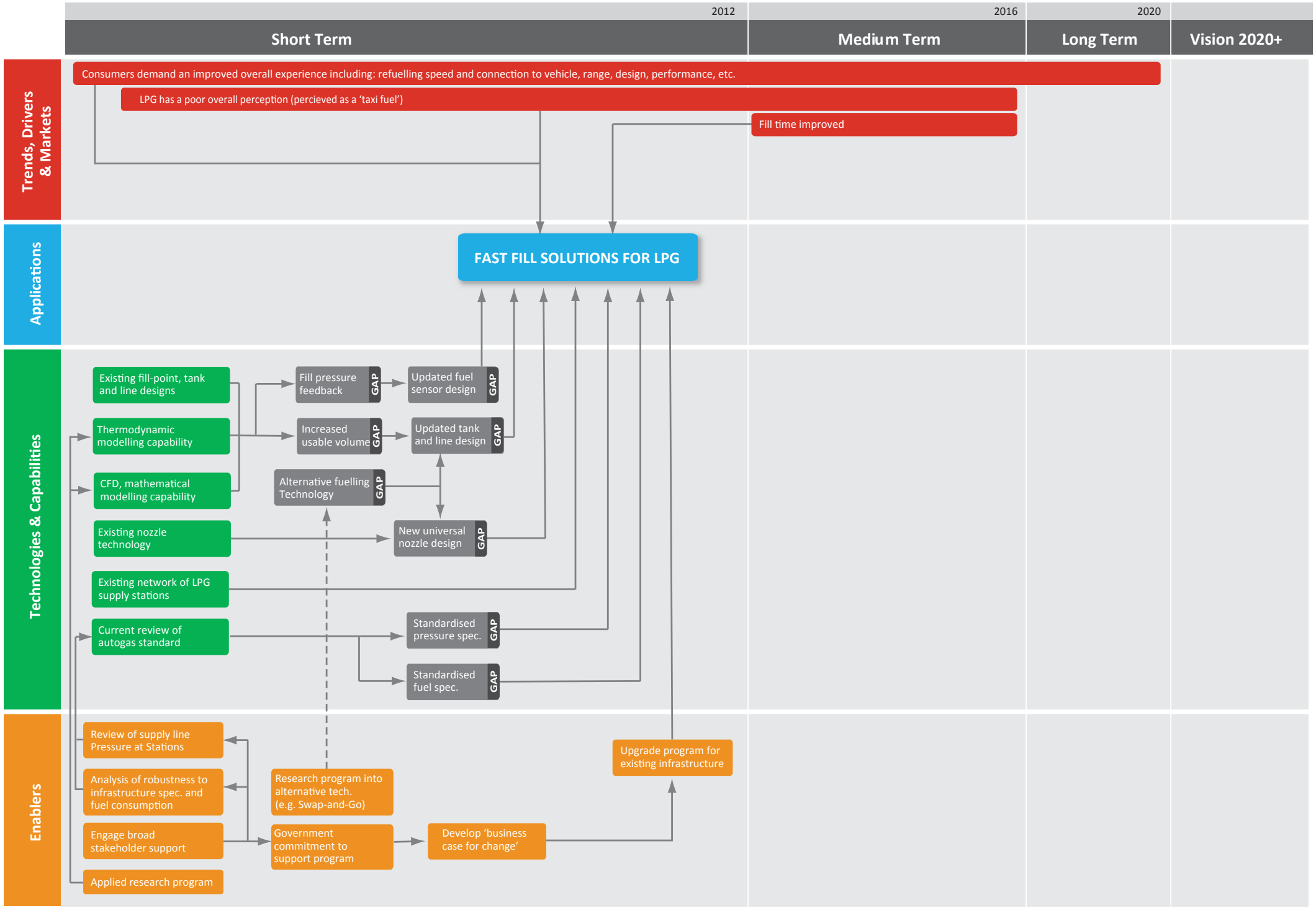
**Government Support Policies** that can be realigned to encourage expansion of local engineering, manufacturing, development and support services.

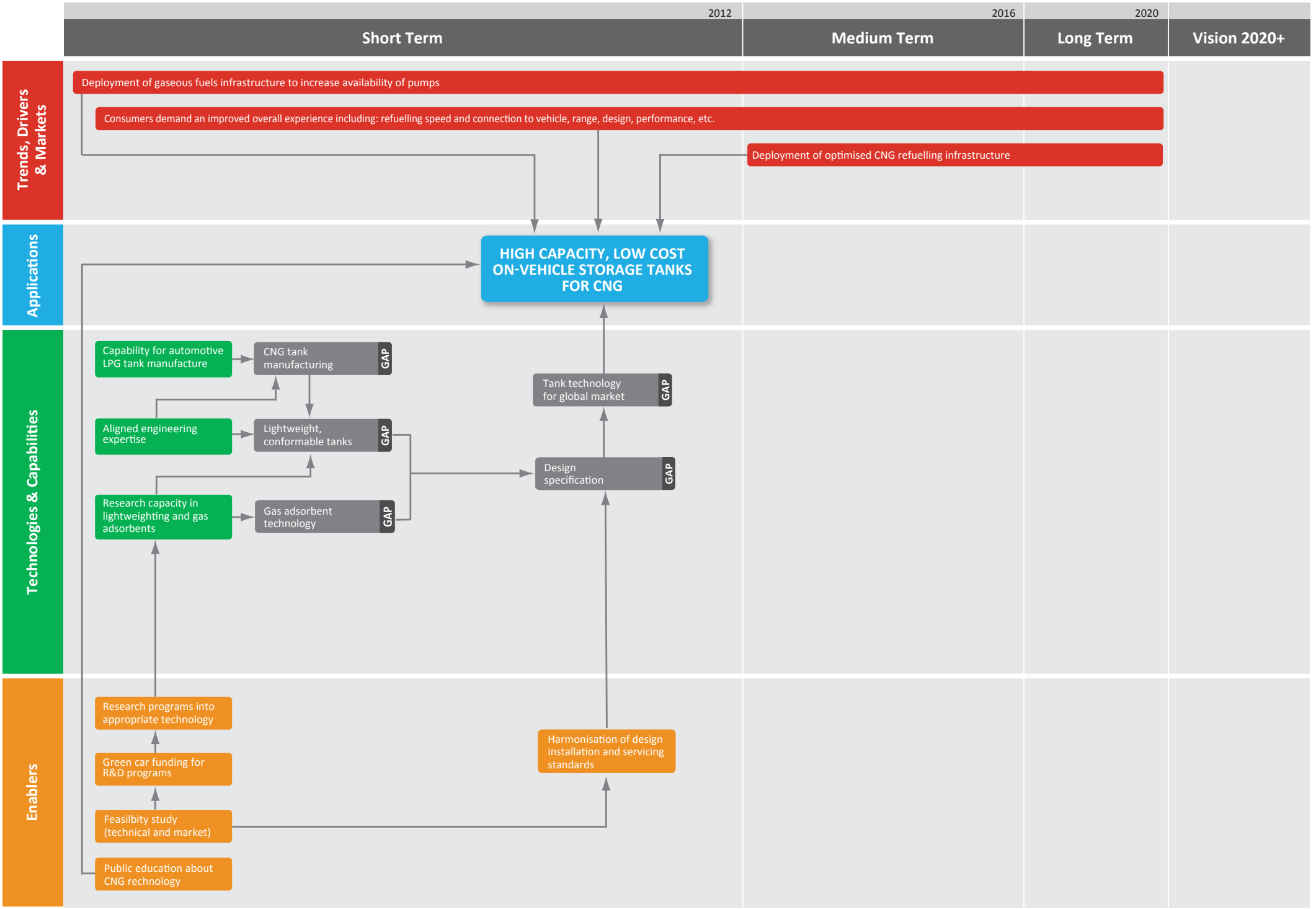
**Review of Autogas Standards** combined with implementation of updated fuel and infrastructure standards to ensure consistent performance throughout Australia and in export markets.

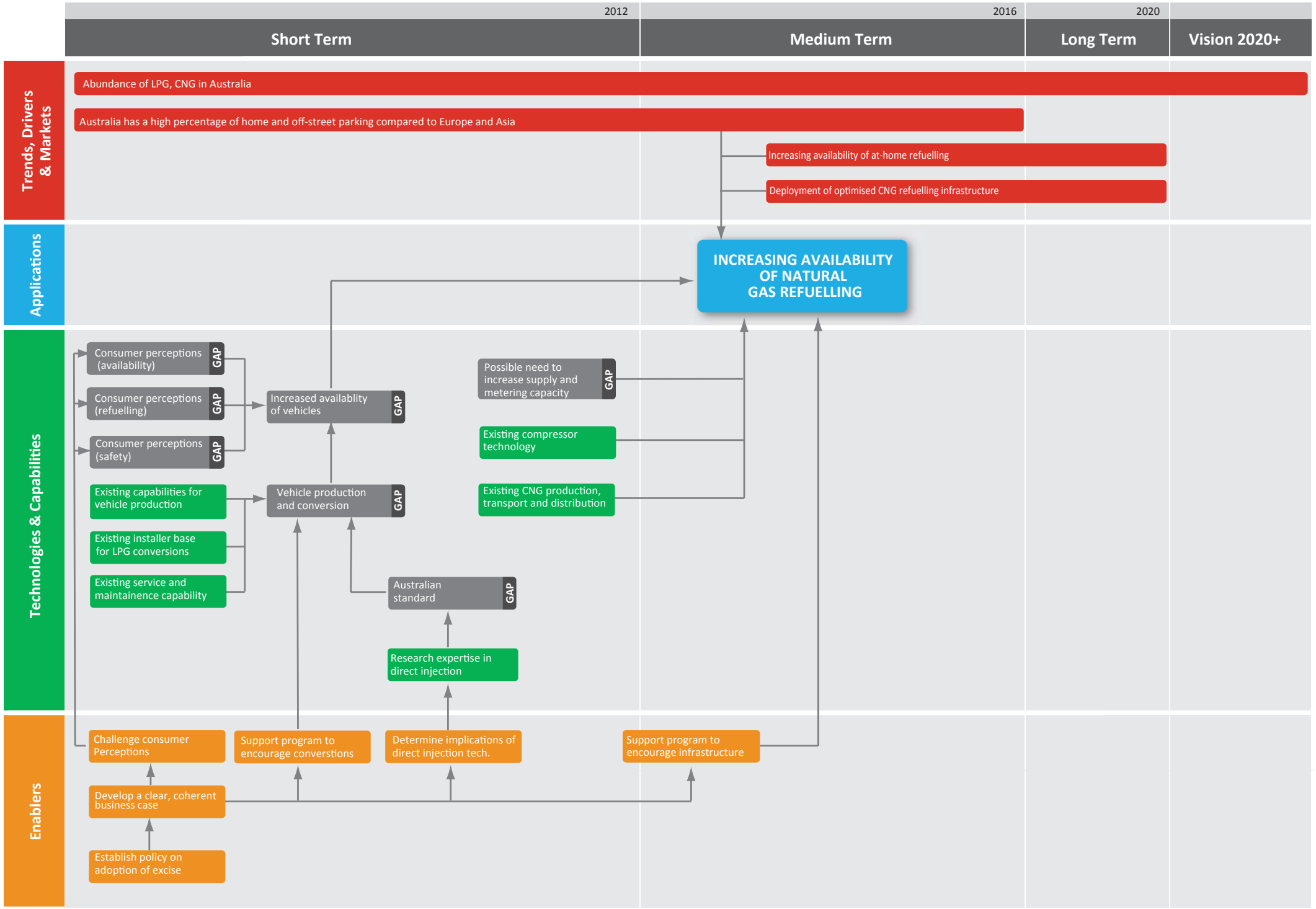
**Review of Retrofit Standards** relating to aftermarket installations to ensure, a safe consistent customer experience.

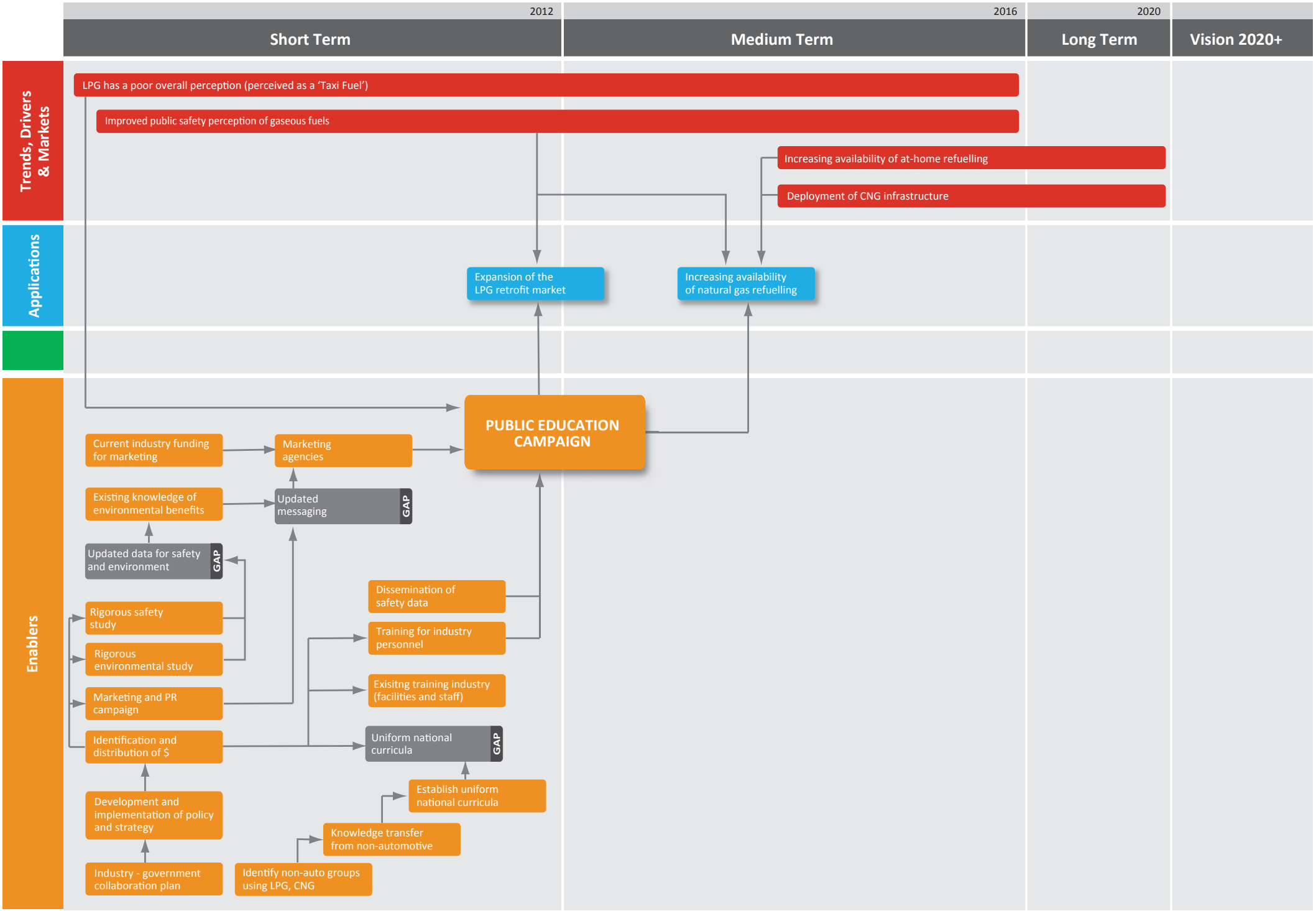
**Mandated Universal LPG Compatibility** in all new vehicles that greatly expands the available base of retrofit opportunities and lowers retrofit costs.

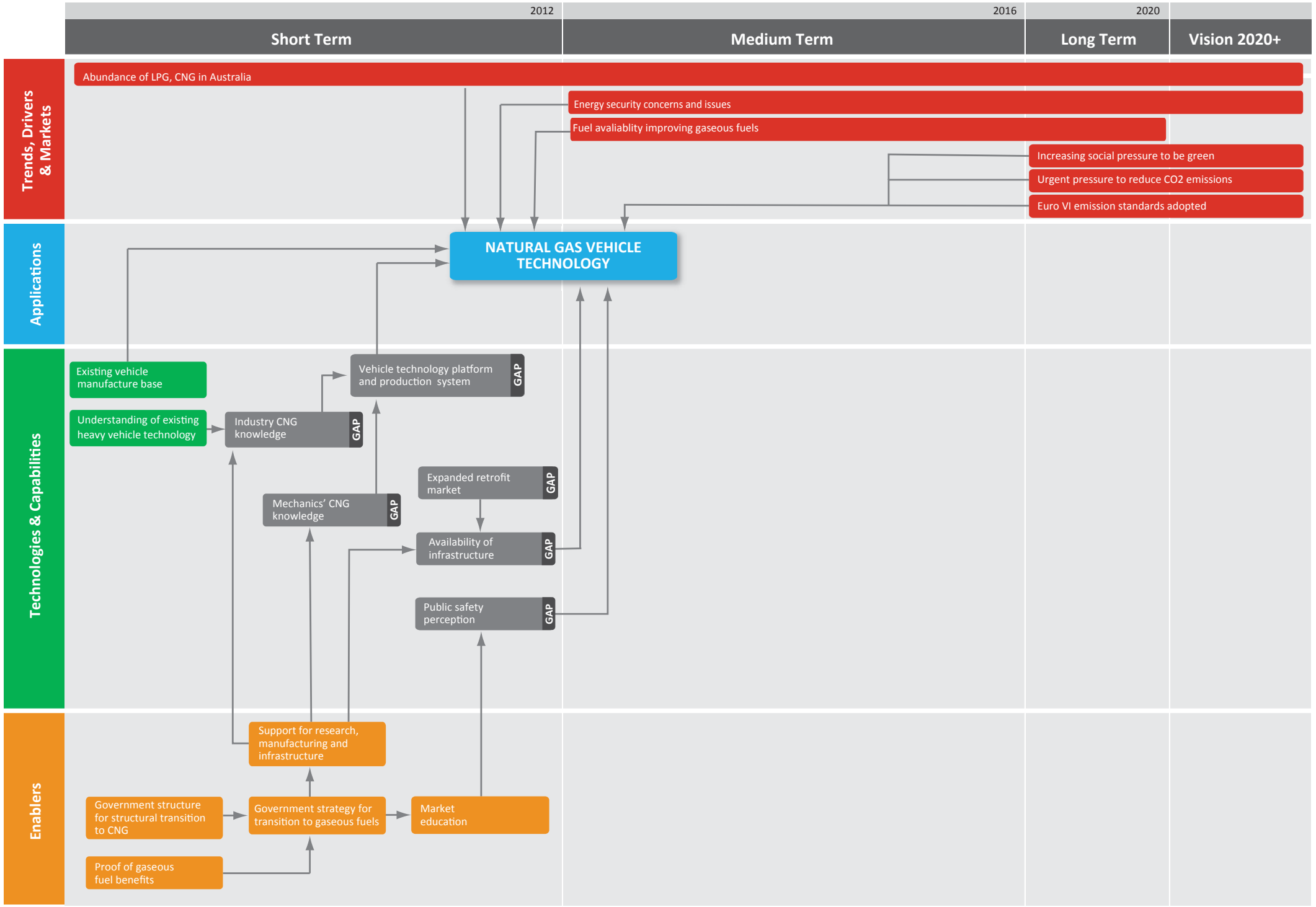

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Euro V emission standards adopted
Requirements for ultra-low emissions
Fuel availability improving for gaseous fuels
Urgent pressure to reduce CO2 emissions
Euro VI emission standards adopted
Applications
DEDICATED LPG SYSTEMS FOR DIRECT INJECTED ENGINES
Technologies & Capabilities
Inproved public image
GAP
Seamless and convenient refuelling
GAP
High speed filling
GAP
Improved connection to vehicle
GAP
Improved availability of LPG
GAP
Existing LPG supply network
Enhanced recognition of benefits
GAP
Existing fuel standards
Existing DI expertise in research organisations and universities
Harmonised international fuel standard
GAP
Prototyping and demonstration vehicles
GAP
Field testing and market research
GAP
Existing support schemes (ACIS, GCIF)
Existing engineering and manufacturing capabilities
Validated final product specification
GAP
Domestic supply of substations
GAP
Enablers
Government advertising and PR campaign for public education
Shared LPG development and technology centre
Study compatability of Australian and international fuel standards

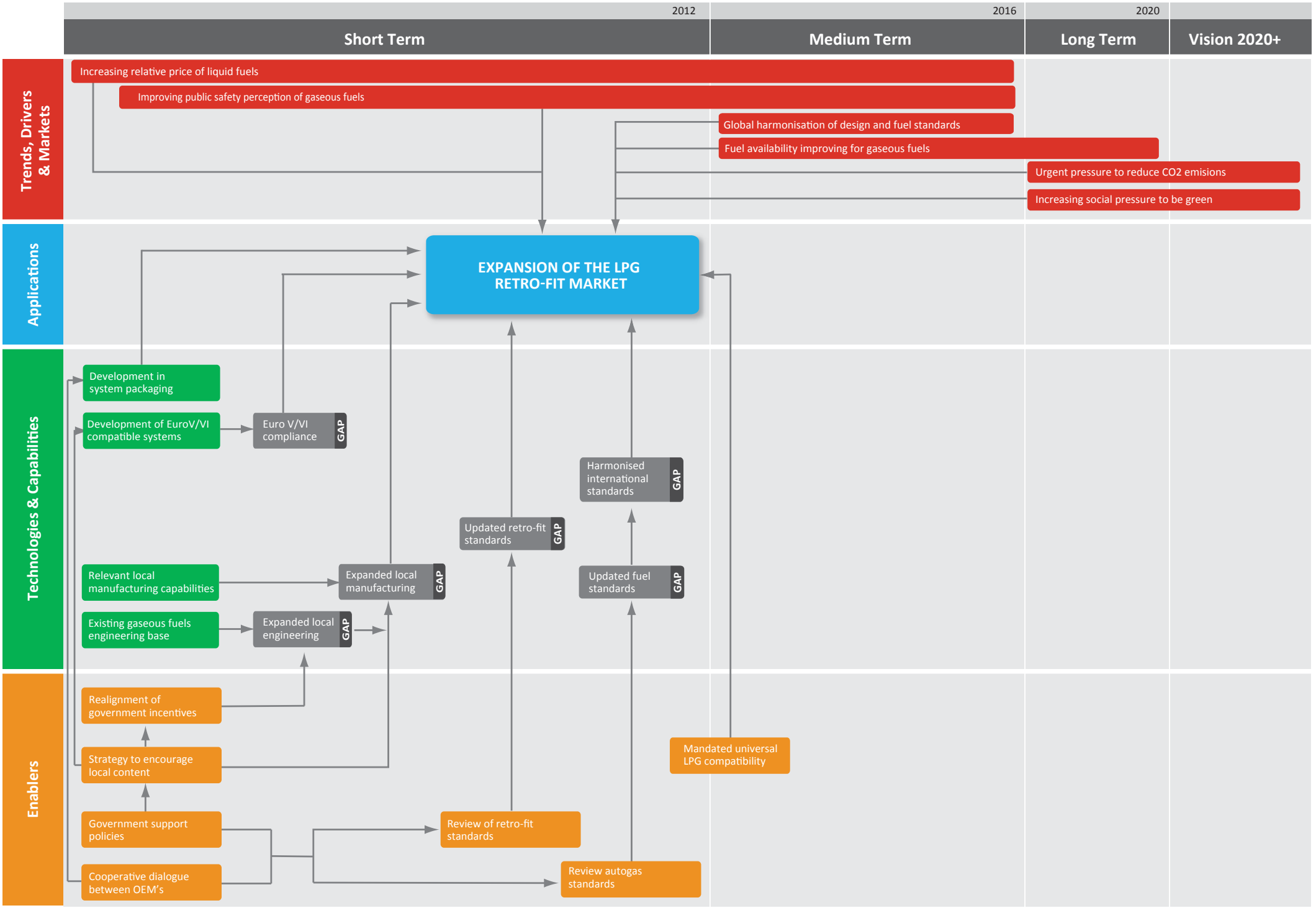

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Consumers demand an improved overall experience including: refuelling speed and connection to vehicle, range, design, performance, etc.
LPG has a poor overall perception (percieved as a 'taxi fuel')
Fill time improved
Applications
FAST FILL SOLUTIONS FOR LPG
Technologies & Capabilities
Existing fill-point, tank and line designs
Thermodynamic modelling capability
CFD, mathematical modelling capability
Existing nozzle technology
Existing network of LPG supply stations
Current review of autogas standard
Fill pressure feedback
GAP
Increased usable volume
GAP
Alternative fuelling Technology
GAP
Updated fuel sensor design
GAP
Updated tank and line design
GAP
New universal nozzle design
GAP
Standardised pressure spec.
GAP
Standardised fuel spec.
GAP
Enablers
Review of supply line Pressure at Stations
Analysis of robustness to infrastructure spec. and fuel consumption
Engage broad stakeholder support
Applied research program
Research program into alternative tech. (e.g. Swap-and-Go)
Government commitment to support program
Develop 'business case for change'
Upgrade program for existing infrastructure


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Deployment of gaseous fuels infrastructure to increase availability of pumps
Consumers demand an improved overall experience including: refuelling speed and connection to vehicle, range, design, performance, etc.
Deployment of optimised CNG refuelling infrastructure
Applications
HIGH CAPACITY, LOW COST ON-VEHICLE STORAGE TANKS FOR CNG
Technologies & Capabilities
Capability for automotive LPG tank manufacture
CNG tank manufacturing
GAP
Aligned engineering expertise
Lightweight, conformable tanks
GAP
Research capacity in lightweighting and gas adsorbents
Gas adsorbent technology
GAP
Tank technology for global market
GAP
Design specification
GAP
Enablers
Research programs into appropriate technology
Green car funding for R&D programs
Feasilbity study (technical and market)
Public education about CNG rechnology
Harmonisation of design installation and servicing standards


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Abundance of LPG, CNG in Australia
Australia has a high percentage of home and off-street parking compared to Europe and Asia
Increasing availability of at-home refuelling
Deployment of optimised CNG refuelling infrastructure
Applications
INCREASING AVAILABILITY OF NATURAL GAS REFUELLING
Technologies & Capabilities
Consumer perceptions (availability)
GAP
Consumer perceptions (refuelling)
GAP
Consumer perceptions (safety)
GAP
Increased availablity of vehicles
GAP
Possible need to increase supply and metering capacity
GAP
Existing compressor technology
Existing capabilities for vehicle production
Vehicle production and conversion
GAP
Existing CNG production, transport and distribution
Existing installer base for LPG conversions
Existing service and maintainence capability
Australian standard
GAP
Research expertise in direct injection
Enablers
Challenge consumer Perceptions
Support program to encourage converstions
Determine implications of direct injection tech.
Support program to encourage infrastructure
Develop a clear, coherent business case
Establish policy on adoption of excise


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
LPG has a poor overall perception (perceived as a 'Taxi Fuel')
Improved public safety perception of gaseous fuels
Increasing availability of at-home refuelling
Deployment of CNG infrastructure
Applications
Expansion of the LPG retrofit market
Increasing availability of natural gas refuelling
Enablers
PUBLIC EDUCATION CAMPAIGN
Current industry funding for marketing
Marketing agencies
Existing knowledge of environmental benefits
Updated messaging
GAP
Updated data for safety and environment
GAP
Dissemination of safety data
Rigorous safety study
Training for industry personnel
Rigorous environmental study
Exisitng training industry (facilities and staff)
Marketing and PR campaign
Identification and distribution of $
Uniform national curricula
GAP
Establish uniform national curricula
Development and implementation of policy and strategy
Knowledge transfer from non-automotive
Industry - government collaboration plan
Identify non-auto groups using LPG, CNG


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Abundance of LPG, CNG in Australia
Energy security concerns and issues
Fuel avaliablity improving gaseous fuels
Increasing social pressure to be green
Urgent pressure to reduce CO2 emissions
Euro VI emission standards adopted
Applications
NATURAL GAS VEHICLE TECHNOLOGY
Technologies & Capabilities
Existing vehicle manufacture base
Understanding of existing heavy vehicle technology
Vehicle technology platform and production system
GAP
Industry CNG knowledge
GAP
Mechanics' CNG knowledge
GAP
Expanded retrofit market
GAP
Availability of infrastructure
GAP
Public safety perception
GAP
Enablers
Support for research, manufacturing and infrastructure
Government structure for structural transition to CNG
Government strategy for transition to gaseous fuels
Market education
Proof of gaseous fuel benefits


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing relative price of liquid fuels
Improving public safety perception of gaseous fuels
Global harmonisation of design and fuel standards
Fuel availability improving for gaseous fuels
Urgent pressure to reduce CO2 emisions
Increasing social pressure to be green
Applications
EXPANSION OF THE LPG RETRO-FIT MARKET
Technologies & Capabilities
Development in system packaging
Development of EuroV/VI compatible systems
Euro V/VI compliance
GAP
Harmonised international standards
GAP
Updated retro-fit standards
GAP
Relevant local manufacturing capabilities
Expanded local manufacturing
GAP
Updated fuel standards
GAP
Existing gaseous fuels engineering base
Expanded local engineering
GAP
Enablers
Realignment of government incentives
Strategy to encourage local content
Mandated universal LPG compatibility
Government support policies
Review of retro-fit standards
Cooperative dialogue between OEM's
Review autogas standards

Gaseous Fuels is an important niche that builds on Australian resources and expertise, with attractive export opportunities. However, the rest of the global industry is moving toward electrification and, if Australia wishes to remain relevant, then we must be competitive in this area.

**BRUCE GRIFFITHS**
Chairman
Futuris Automotive Group

# LIGHTWEIGHTING

- Replacement of Steel Components with Aluminium, Titanium, Magnesium and Composites
- Lightweight, High Volume, Class-A Body and Door Panels
- Lightweight Road Wheels
- Vehicle Structure with 30% Weight Reduction and Improved Crash Performance
- Novel 3D Knitted Composite Applications for Interior Structure and Seats
- Materials and Processes for Advanced Recycling
- Lightweight Modular Vehicle Platform
- Energy Absorbing Foams and Adhesives

# LIGHTWEIGHTING

## A focus on weight reduction in passenger vehicles has been spurred by a number of global trends and drivers, in particular: concerns over the rising cost and increasing scarcity of fossil fuel supplies, and growing awareness of the environmental impact of vehicle emissions.

The primary benefit of weight reduction is a reduction in fuel consumption and consequent emissions, with secondary gains realised through the use of smaller engines and adjusted gearing without sacrificing performance. A recent study estimated potential fuel consumption reduction at:

***0.12 to 0.28 l/100km·100kg (for diesel vehicles)... and 0.15 0.35l/100km·100kg (for gasoline vehicles) [depending on] whether a weight-induced power train adaptation will take place or not.***[10]

Applications for weight reduction have benefit beyond conventional petrol and diesel vehicles. Current drawbacks of electrification, associated with reduced performance and range, can be addressed by reducing vehicle mass.

Lightweighting of passenger vehicles is an opportunity area that builds on Australian competitive strengths in two ways – by taking advantage of abundant mineral resources and by developing applications for those resources through Australia's strengths in research and development.

Specifically, these strengths include:

### Metals Supply

The first step in achieving weight reduction targets has often been replacement of steel components with aluminium and magnesium alloys. Australia is among the top five producers of many key minerals commodities including: the leading producer of bauxite and alumina, and the fifth largest producer of aluminium.[11]

### Research and Development Strengths

Australia has world class capabilities in design, reliability, logistics, innovative systems, and research and development. With a skilled workforce, productive business culture, and sophisticated intellectual property protection manufacturers and suppliers can develop leading products with increasingly sophisticated technology.[12]

Efforts to address vehicle mass can be grouped in two areas:  Materials science through the development of new metal alloys, composites and plastics; and innovative engineering design concepts. As the primary contributor to vehicle weight, developments in metal technology are an obvious first step in mass reduction strategies. Steel is the conventional metal of choice, with ultra-high strength alloys available for lightweight applications, but aluminium, magnesium and titanium are also being used. Aluminium content, as measured by weight and total value, surpassed iron content in passenger vehicles in 2006.[13]

Beyond steel and aluminium, magnesium and titanium are finding broader vehicle application in passenger vehicles. Composites and plastics also play an important role in lightweighting strategies as they are increasingly viable as cost-effective alternatives to metals.

The goal of producing lighter-weight vehicles will not be met solely through developments in metals and composites, but through the combined application of materials science and innovative design concepts. Research programs have been undertaken in Australia and other jurisdictions to apply design and engineering concepts for weight reduction.

As a large consumer of metal resources, the Australian automotive industry has the required capability to make technological advances and to capitalise on Australia's mineral wealth and its skills in liberating and exploiting these resources. The industry contributes significantly to the Australian economy, but gaps remain in onshore processing. Social and political pressure to reduce $CO_2$ emissions and operating costs will continue to drive automotive manufacturers to reduce vehicle weight. The use of lightweight metals, plastics and composites has increased in recently and will continue to do so in coming years.

10 Koffler, C. *On the calculation of fuel savings through lightweight design in automotive lifecycle assessments.*The International Journal of Lifesysle Assessment. Vol. 15, No. 1, January 2010.
11 Minerals Council of Australia. *The Australian Minerals Industry and the Australian Economy*. July 2009. Available at: http://www.minerals.org.au/__data/assets/pdf_file/0017/32804/Aus_min_ industry_fact_sheet_July_2009.pdf
12 Austrade. *Advanced Manufacturing: Engineering Services and R&D*. Retrieved 4 February, 2010: http://www.austrade.gov.au/Invest/Opportunities-by-Sector/Advanced-Manufacturing/Engineering-Services/default.aspx
13 Ducker Research. *Aluminium Content for Light Non Commercial Vehicles to be Assembled in North America, Japan and the European Union in 2006*. 2005.

# LIGHTWEIGHTING APPLICATIONS

Resource scarcity, increasing fuel and energy costs, and environmental concerns are driving the automotive industry to pursue lightweight materials and designs. By removing weight, smaller engines with lower emissions and fuel consumption can power the equivalent vehicle. Restrictions on emissions and fuel consumption are expected to become increasingly strict and so is the consequent consumer demand for smaller and/or lighter vehicles that meet those targets.

Australia has compelling advantages in the development of lightweight metals technologies with rich reserves of aluminium and other metals. Local metals processing technology continues to improve, allowing the true value of domestic resources to be realised within the Australian supply chain.

Customer perceptions of safety must be maintained, as they remain the strongest influence on vehicle purchasing decisions. Embodied energy is another important secondary factor, and taking it into account, will increase the importance of material recyclability.

As a related driver, electric vehicles will see increasing adoption by the market. While they will not see direct improvement in their emissions through lightweighting, they will see reductions in energy use allowing higher performance, at reduced cost to the consumer.

Beyond 2020, changing consumer perceptions regarding mobility and transport will need to be taken into account, but lightweighting will remain an important consideration along with energy efficiency and resource conservation.

## Short Term

**2010-2012**

**Vehicle Structure with 30% Weight Reduction and Improved Crash Performance**
Improves safety while having a large impact on overall vehicle weight, see page 69.

**Lightweight Road Wheels**
Builds on current emerging technology, with inertial benefits beyond those achieved by reducing weight in stationary equipment, see page 68.

**Materials and Processes for Advanced Recycling**
Addresses drawbacks existing lightweight materials to allow wider adoption and reduce end-of-life impact, see page 71.

## Medium Term

**2012-2016**

**Energy Absorbing Foams and Adhesives**
Allows the replacement of metal components with lightweight alternatives, see page 73.

**Novel 3D Knitted Composite Applications for Interior Structure and Seats**
Replace heavier conventional alternatives, offering reduced lead times and equivalent cost, see page 70.

**Lightweight, High Volume, Class-A Body and Door Panels**
Replace heavy, metal panels and offering large potential for vehicle weight savings, see page 67.

**Replacement of Steel Components with Aluminium, Titanium, Magnesium and Composites**
Reflects the scope for lightweighting of most components beyond the structure, interior and panels, see page 66.

## Long Term

**2016-2020**

**Lightweight Modular Vehicle Platform**
Develops new vehicle architecture with design concepts needed to further reduce weight in the long term, see page 72.

## Vision 2020+

**2020+**

New applications targeting lightweighting for energy conservation will continue beyond 2020.

## TECHNOLOGIES AND CAPABILITIES

### Automotive Sector

Existing automotive producers and suppliers, with design development and manufacturing capability, have much of the expertise required to realise lightweighting applications. While predominantly focussed on metals, there are existing capabilities in composites as well. Structural parts are produced in high volumes for both metal and composites, with faster, cheaper composites technology nearing commercialisation. Key gaps remain:

- High volume, class A appearance parts in composites and metals, and
- Advanced adhesive and foam engineering.

### Non-Automotive Sector

Complementary expertise exists outside the automotive industry with composite and light metals technologies utilised for aerospace and defence. Raw materials are extracted locally by the resource base. By transferring this knowledge to the automotive industry, a number of gaps can be targeted:

- Local supply of lightweight metals,
- Local supply of composite raw materials and textiles, and
- Low cost, high volume composites

### Research Sector

There are existing programs examining material characterisation, testing design and analysis. Additionally, current research was identified in a number of specific areas including: joining technology, foam materials, textiles and recycling. These research programs can be targeted to address gaps:

- Design in dissimilar materials,
- Metal-foam hybrid structures ,
- Anti-corrosion technology, and
- New architectures and design concepts

## ENABLERS

### Industry Collaboration

Collaborative research between stakeholders, whether through Cooperative Research Centres or Centres of Excellence, was identified as a key enabler. Promotion of commercial outcomes from collaborative research programs was highlighted as an area for improvement.

### Government Support

Larger development programs were noted as requiring government technology investment through targeted research programs. Policy and regulation relating to emissions reduction was seen as an underlying factor that will increase the viability of lightweighting applications.

### Science and Research

Specific research programs were noted in a number of the priority applications. A crash simulation library would facilitate research into the performance of lightweight material and design concepts, while a focussed program would enable the development of new design concepts.

### Education and Training

Improved training of design engineers was highlighted as an enabler along with promotion of commercial outcomes in all sectors. An industry education campaign would promote the benefits of lightweighting to all stakeholders.

### Feasibility and Planning

Development of a business case to justify investment and secure funding is a critical enabler for most of the applications. This will allow detailed assessment of the global market and competitors, and planning to ensure complementary applications are developed simultaneously.

# LIGHTWEIGHTING ROADMAP

By considering local and global factors, participants highlighted the trends and drivers of particular relevance to lightweighting in Australia, including: availability of resources and increasingly strict emissions standards. Applications, which address these drivers, were identified. They ranged from lightweighting of wheels to the development of a modular vehicle platform. Some technologies and capabilities do not currently exist and enablers were identified to facilitate their development. The figure at left presents an overview.

# LIGHTWEIGHTING

## The System Perspective

In the lightweighting opportunity area, workshop participants identified eight priority application areas and these can be divided across three broad categories:

- Platform and Architecture Development,
- Novel Materials and Processes, and
- Lightweighting of Specific Components.

A view of the interrelationships between applications and enabling actions in the lightweighting opportunity area is presented in Figure 12. Workshop participants identified enablers required to facilitate the realisation of each application, and these have been categorised. By reading across the rows, enablers broadly relevant among applications are apparent. Enablers relating to industry collaboration, and science and research, for example, have impact across almost all of the applications. By contrast, education and training enablers have been deemed relevant only to the development of lightweight wheels and reduced weight structural design.

By reading the columns, applications requiring minimal support, and those in need of wide ranging stakeholder buy-in, are evident. In the case of lightweighting applications, it is evident that 3D knitted composites – a technology that is already nearing commercialisation – has relatively low support need. Commercialisation of lightweight road wheels, however, has been highlighted as requiring enabling action in all categories.

In the section below the interrelationships table, Figure 12 also shows scores based on the predicted performance of each application in five areas: Profit (economic benefit), People (social benefit), Planet (environmental benefit), Investment Cost, and Likelihood of Success. The highest likelihood of success was indicated by participants in the production of lightweight, appearance-grade body and door panels. Investment cost estimates were wide ranging, from $200,000 to $80 million, with production of lightweight wheels requiring relatively little investment, and the development of structural foams and adhesives estimated to be much higher.

Profit potential and environmental benefit scored highly across all applications with all applications having scope to significantly impact vehicle weight. Social benefit scores were more varied, indicating the potential safety and comfort enhancements of some technologies.

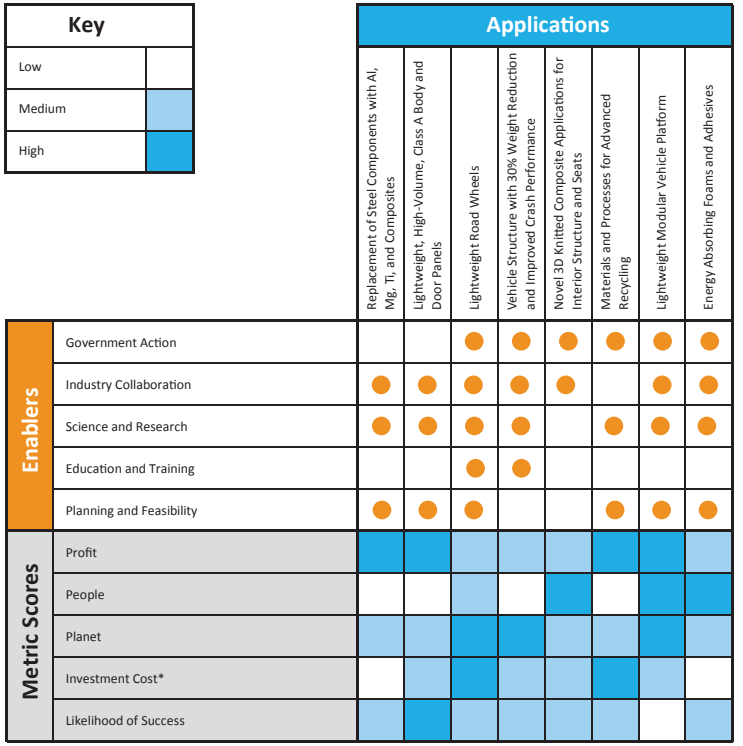



FIGURE 12 – **INTERRELATIONSHIP OF LIGHTWEIGHTING PRIORITY APPLICATIONS AND ENABLERS. APPLICATIONS HAVE BEEN SCORED AGAINST FIVE KEY METRICS. *NOTE: APPLICATIONS WITH LOW INVESTMENT COST RECEIVE HIGH SCORES.**

### Application Linkages

Figure 13 shows linkages between lightweighting applications as identified by workshop participants. Each strong relationship indicates a pair of applications that are dependent on each other for effective realisation. Those pairs that are weakly related can be realised largely independently.

Participants highlighted the replacement of steel components as an application that, in its broadest sense, encompasses a number of other applications, namely: lightweight wheels, body and door panels, structure, and architecture. The structure was also identified as a critical element of a lightweight modular vehicle platform. Of equal importance are applications that show a relatively weak relationship, as they can be realised independently. 3D knitted composites, for example, are not suited to the manufacture of lightweight wheels or class-A body panels.

## Enabling Actions

Workshop participants highlighted key goals, enabling actions and detailed plans required to realise each of the eight identified applications. A summary is presented on the following pages.

### Enabler Linkages

A potential correlation between enablers is indicated when they are identified together in the realisation of multiple priority applications. The relative frequency that each pair has been indicated by workshop participants is recorded on a three-point scale in Figure 14. Industry collaboration and science and research have shown very broad correlation across the other enablers.

Government support has been indicated to act in a coordinated way with enabling action from the science and research sector, with secondary connections to industry collaboration and feasibility exercises. Planning and feasibility shows the strongest links with industry and science sectors, as these are the primary stakeholders in lightweighting technology development. The specific combination of industry collaboration and science and research has ranked very highly. This reflects a general desire in the workshop to promote collaborative research targeting commercial outcomes. Finally, education and training enablers show weak relationship across all enabler categories and this relates to the relatively low occurrence of this category in priority applications overall.

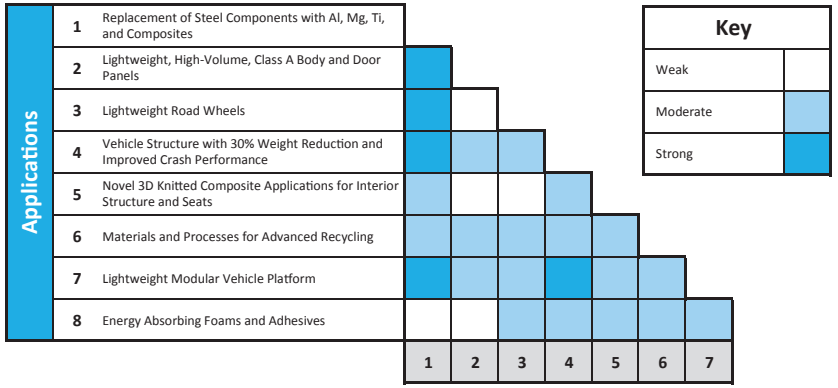



FIGURE 13 – **STRENGTH OF RELATIONSHIP BETWEEN LIGHTWEIGHTING PRIORITY APPLICATIONS**

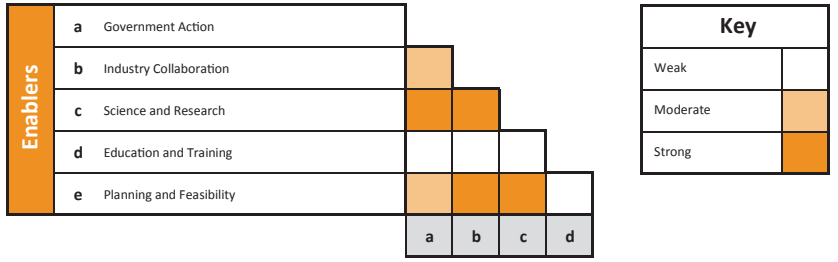



FIGURE 14 – **STRENGTH OF RELATIONSHIP BETWEEN LIGHTWEIGHTING ENABLERS**

# LIGHTWEIGHTING

## Replacement of Steel Components with Al, Mg, Ti and Composites

Specific targets for lightweighting have been identified in other applications, but there is significant opportunity to reduce vehicle weight (approximately 10-15% overall) by targeting steel components in the driveline and running gear. Supporting actions in this area include:

**Funding and Support for Light Metals R&D** to address key technology gaps like magnesium aluminium manufacture, joining of dissimilar metals and cost effective composites.

**An Advanced Materials Lab** that must have funding maintained to complement the R&D activites that target gaps like high speed composites manufacture, magnesium manufacturing and low cost manufacturing processes.

**Assessment of Global Market & Competitors** to allow targeted development of lightweighting capability in the supply base.

**OEM Targets** for weight reduction based on government fuel consumption policy and regulation.

## Lightweight, High Volume, Class-A Body and Door Panels

Body and door panels contribute significantly to overall vehicle weight. Materials and processes exist to produce these appearance-grade components from composites and light metals, but commercialisation requires higher production volumes. This can be achieved by:

**Establishing R&D Centres for Excellence** to fund and execute development of technology in metals processing, joining and standardised composites.

**Educating Industry** stakeholders with the aim of stimulating demand for lightweighting at the OEM level. This demand will encourage industry standardisation in key technology areas – like composites.

**Developing a Business Plan** that defines roles of public and private stakeholders and justifies incentive programs for OEM investment in technology trials.

**Gaining OEM Commitment** to trial and use lightweight technologies that will support supplier investment decisions.

## Lightweight Road Wheels

Additional reduction in fuel consumption is achieved by removing weight from rotating equipment, such as wheels. Existing technology to produce lightweight wheels exists in Australia and is awaiting commercialisation, which can enabled through:

**Development of a Business Case** that will justify industry investment in research and commercialisation activities.

**Commercialisation Funding** leading directly to the commercial production of lightweight wheels.

**Additional Research Funding** to target key technology gaps in anti-corrosion solutions and tyre design suited to lightweight wheels.

**Collaboration with Material Producers** ensuring local supply of appropriate raw materials.

## Vehicle Structure with 30% Weight Reduction and Improved Crash Performance

Safety remains the primary driver influencing consumer buying behaviour, so lightweight solutions must also incorporate improved crash performance. The vehicle structure presents significant opportunity for weight reduction as a major contributor to overall mass. Enablers include:

**Taxation Policy** to stimulate consumer demand for vehicles that produce fewer emissions through reduced fuel consumption.

**Funding for Collaborative Research** and promotion of commercial outcomes to accelerate the development of new lightweight structure technologies in industry and the science sector.

**Targeted Training Programs** for automotive engineers to supply industry and research organisation with graduates having the skills needed for technology development.

**Technology Investment** by government leading to applied prototyping, case studies to demonstrate viability, and real commercial outcomes.

## Novel 3D Knitted Composites for Interior Structure and Seats

Local technology is nearing commercialisation in this area and will provide lightweight interior structures at equivalent cost. With specialised machinery, cycle times and capital investment can match those of metal alternatives, with improvements in lead times and customisation options. Commercialisation can be supported by:

**Integrating Development Programs** across suppliers and OEMs, leveraging existing supply base expertise to address capability gaps in material recyclability and production machinery to increase process yields.

**Government Funding** through existing support schemes like the Green Car Innovation Fund to support the optimisation of knitted structures and prototype demonstration in key application areas.

**Developing Complementary Applications** outside the automotive sector that increase the market size for knitted composite products.

## Materials and Processes for Advanced Recycling

Recyclability of vehicles must be maintained as new materials are developed for lightweighting and it is important that this is considered in the early stages of material and process design. It can be encouraged through:

**Government Policy and Regulation** that limits emissions (ETS) or mandates recyclability quotas to encourage continued adoption of recyclable materials by suppliers and OEMs. Such schemes may also provide funding mechanisms for environmentally sustainable technologies.

**Government Funding** through investment in research and development that targets an enhanced range of recyclable products including: niche products, alternative design strategies and advanced manufacturing.

**Resource Industry Self-Funding** which can be leveraged to expand resource extraction activities into the local production of lightweight, recyclable raw materials and increase the local value-add.

## Lightweight Modular Vehicle Platform

Maximum mass reduction from passenger vehicles can only be achieved by novel concepts in underlying vehicle architecture. Targeted platform development can take advantage of specific material properties and is enabled by:

**Developing a Business Case** that demonstrates the economic feasibility of the design concept and identifies export markets for the technology.

**Additional Funding** from suppliers, research organisations, governments and other existing mechanisms to support proof of concept development and early commercialisation activities.

**Mechanisms for Collaboration** that leverage funding through focussed R&D to promote new design strategies and novel concept development.

## Energy Absorbing Foams and Adhesives

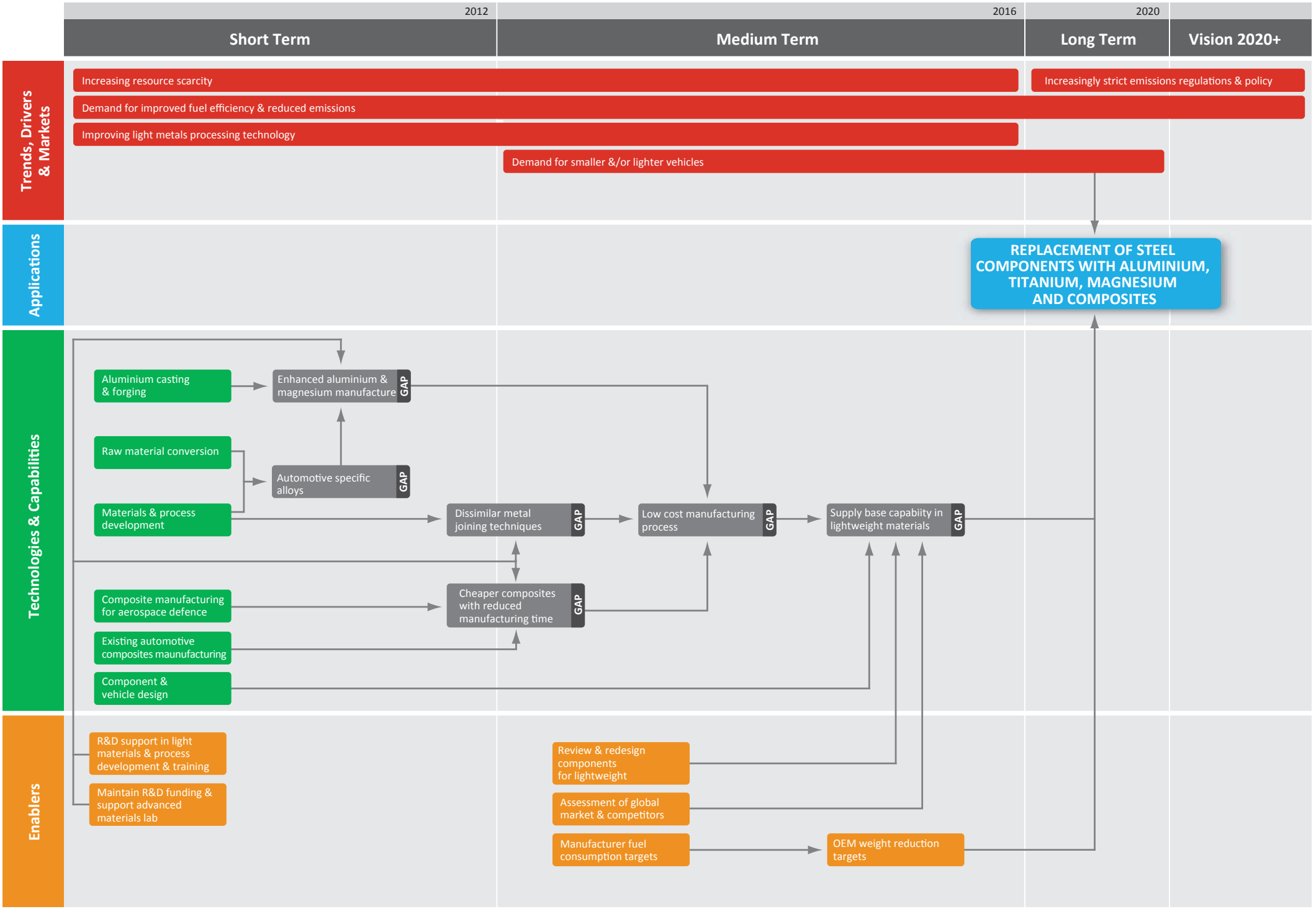
Heavy metal components, like impact beams, can be replaced with hybrid structures to reduce mass while achieving equal, or better, safety performance. Appropriate foam materials and adhesives remain to be fully developed. Enabling actions that support their development include:

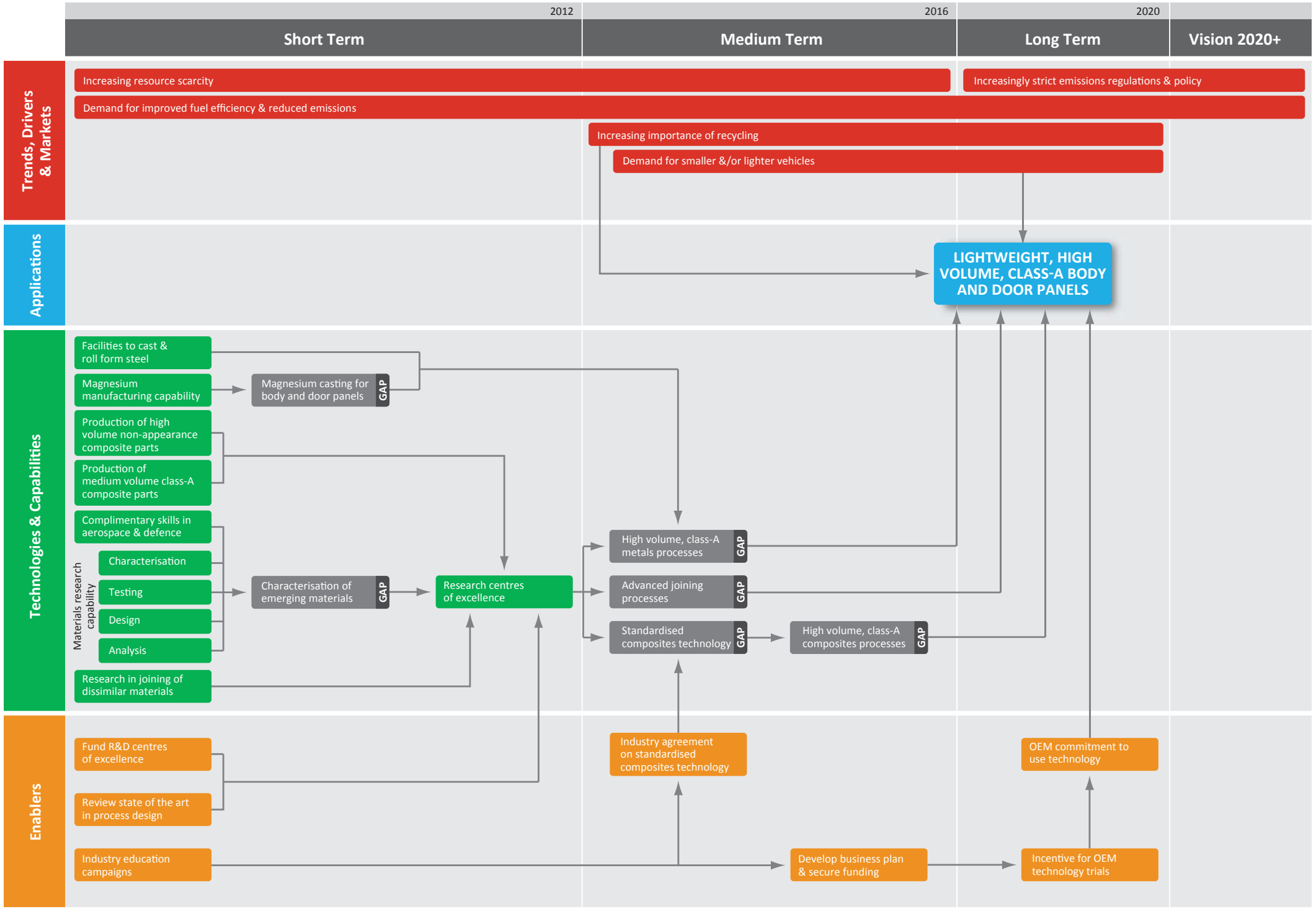
**Government Funding** from state and federal governments to stimulate research programs into foam materials such as thermoset foams and hybrid metal-foam structures.

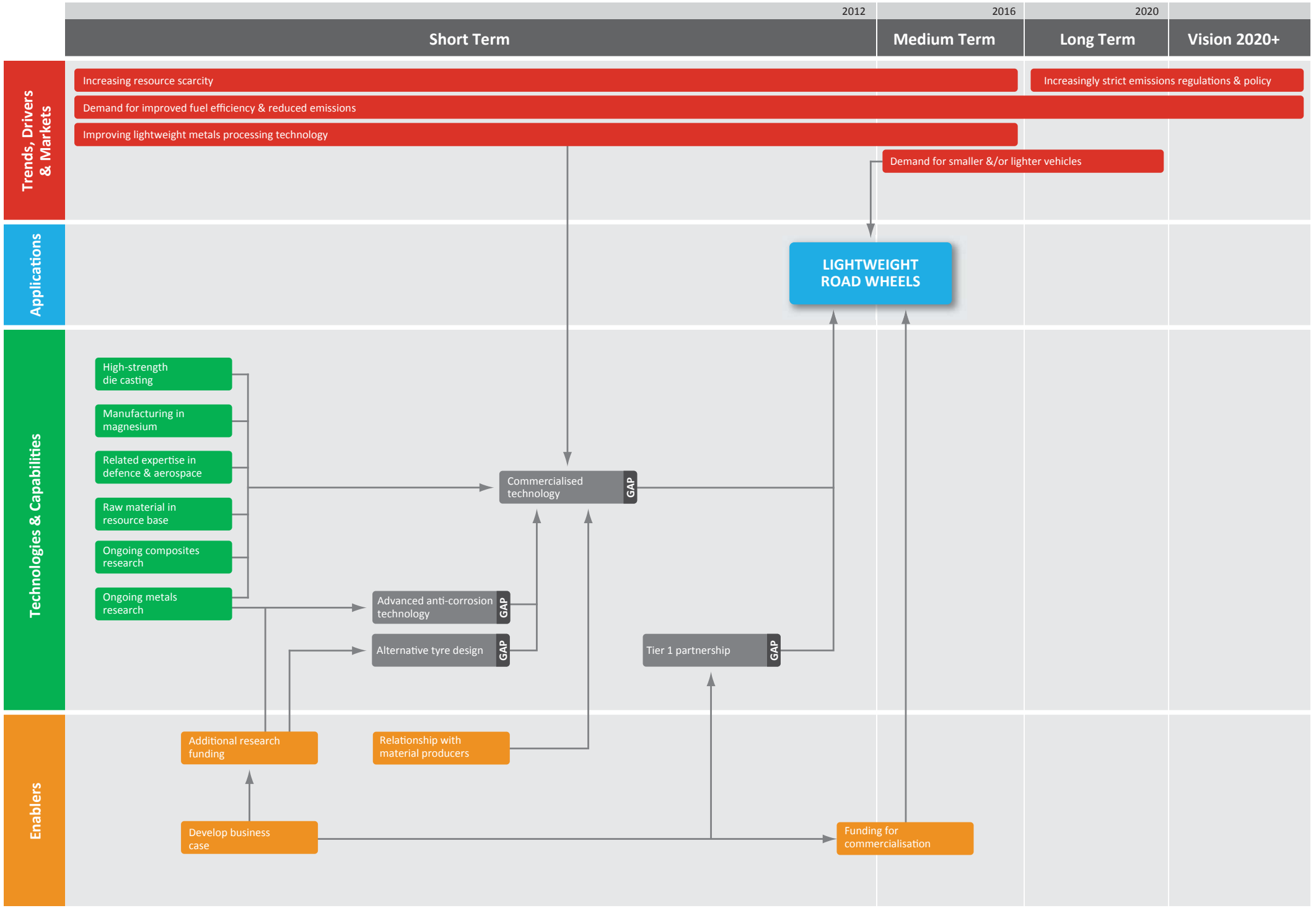
**Aggressive Emissions and Efficiency Policy** from government to stimulate demand from industry for lightweight structural components.

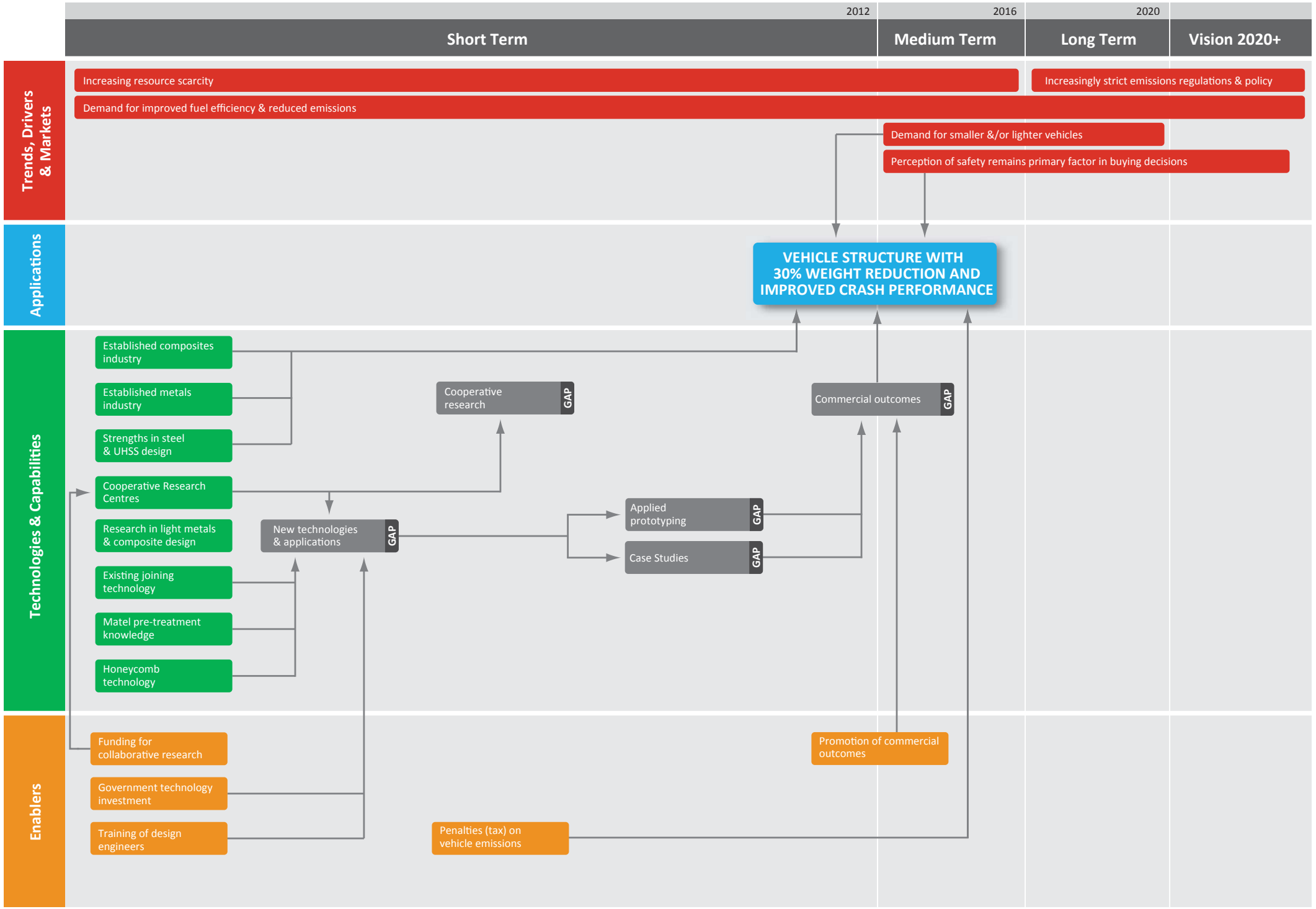
**Development of a Business Strategy** and clear business case to justify investment in production technologies and identify potential customers.

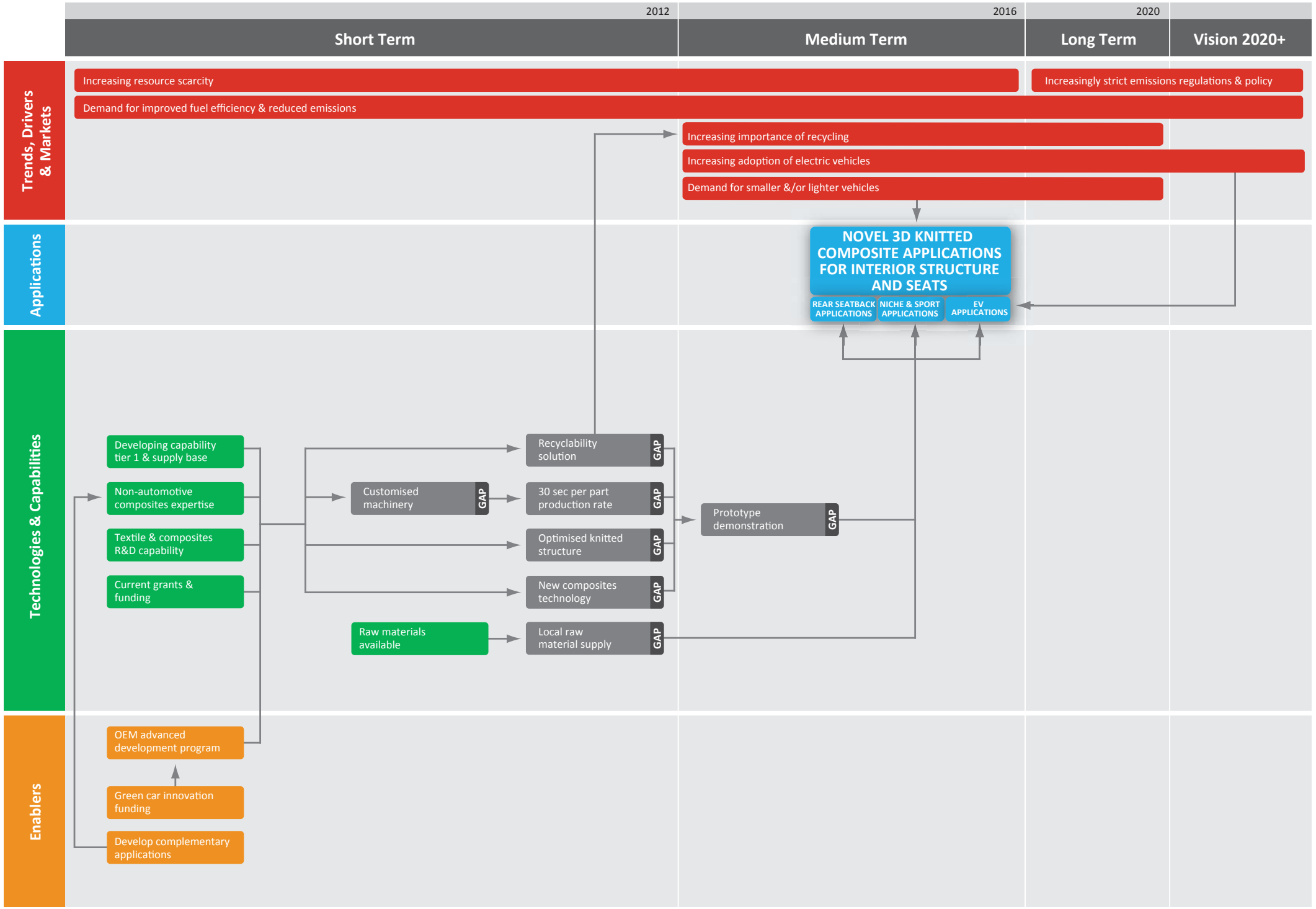
**A Crash Simulation Library** that enables virtual design capability to validate metal-foam hybrid structural design.

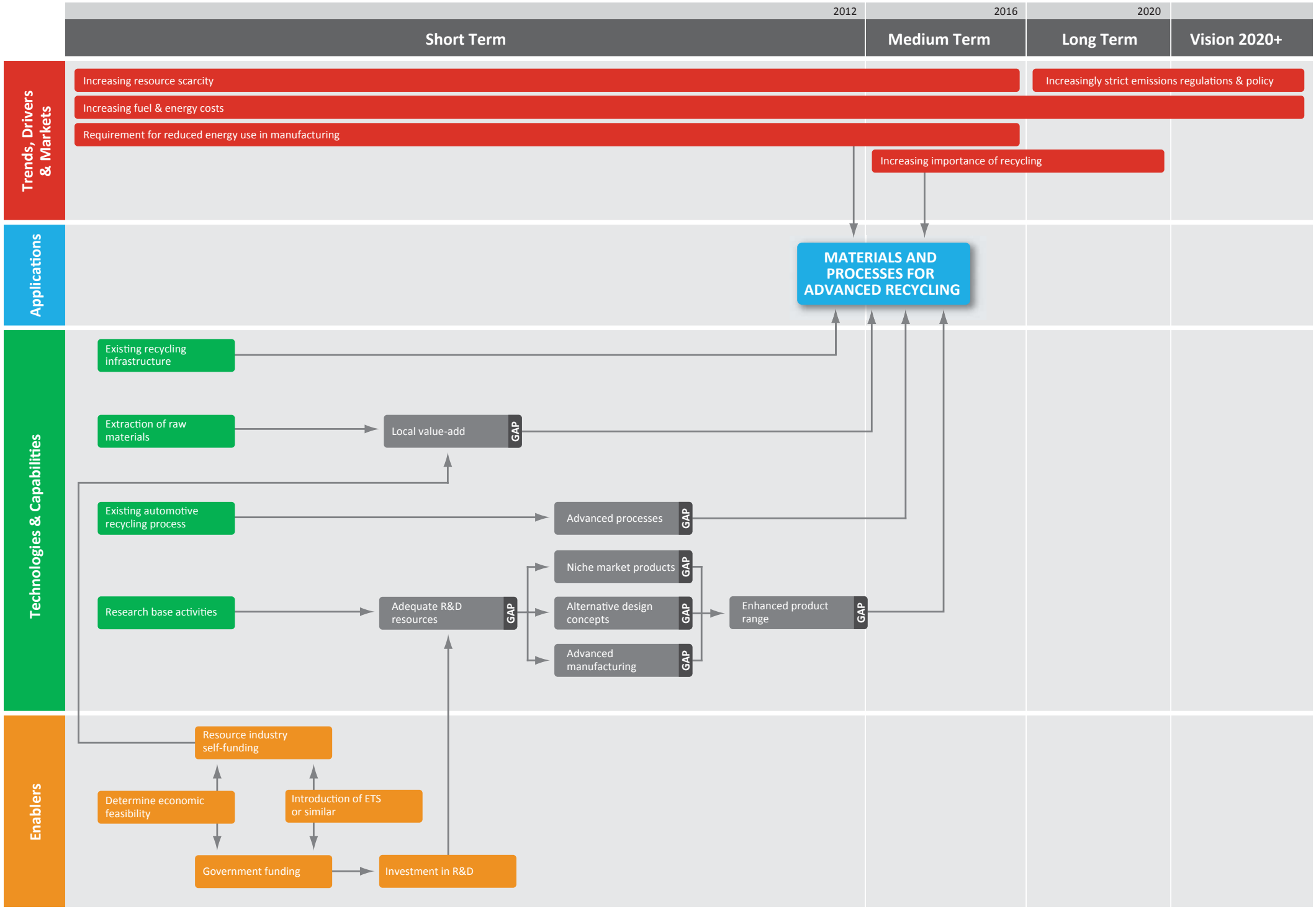

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Improving light metals processing technology
Demand for smaller &/or lighter vehicles
Applications
REPLACEMENT OF STEEL COMPONENTS WITH ALUMINIUM, TITANIUM, MAGNESIUM AND COMPOSITES
Technologies & Capabilities
Aluminium casting & forging
Enhanced aluminium & magnesium manufacture
GAP
Raw material conversion
Automotive specific alloys
GAP
Materials & process development
Dissimilar metal joining techniques
GAP
Low cost manufacturing process
GAP
Supply base capabiity in lightweight materials
GAP
Composite manufacturing for aerospace defence
Cheaper composites with reduced manufacturing time
GAP
Existing automotive composites maunufacturing
Component & vehicle design
Enablers
R&D support in light materials & process development & training
Maintain R&D funding & support advanced materials lab
Review & redesign components for lightweight
Assessment of global market & competitors
Manufacturer fuel consumption targets
OEM weight reduction targets

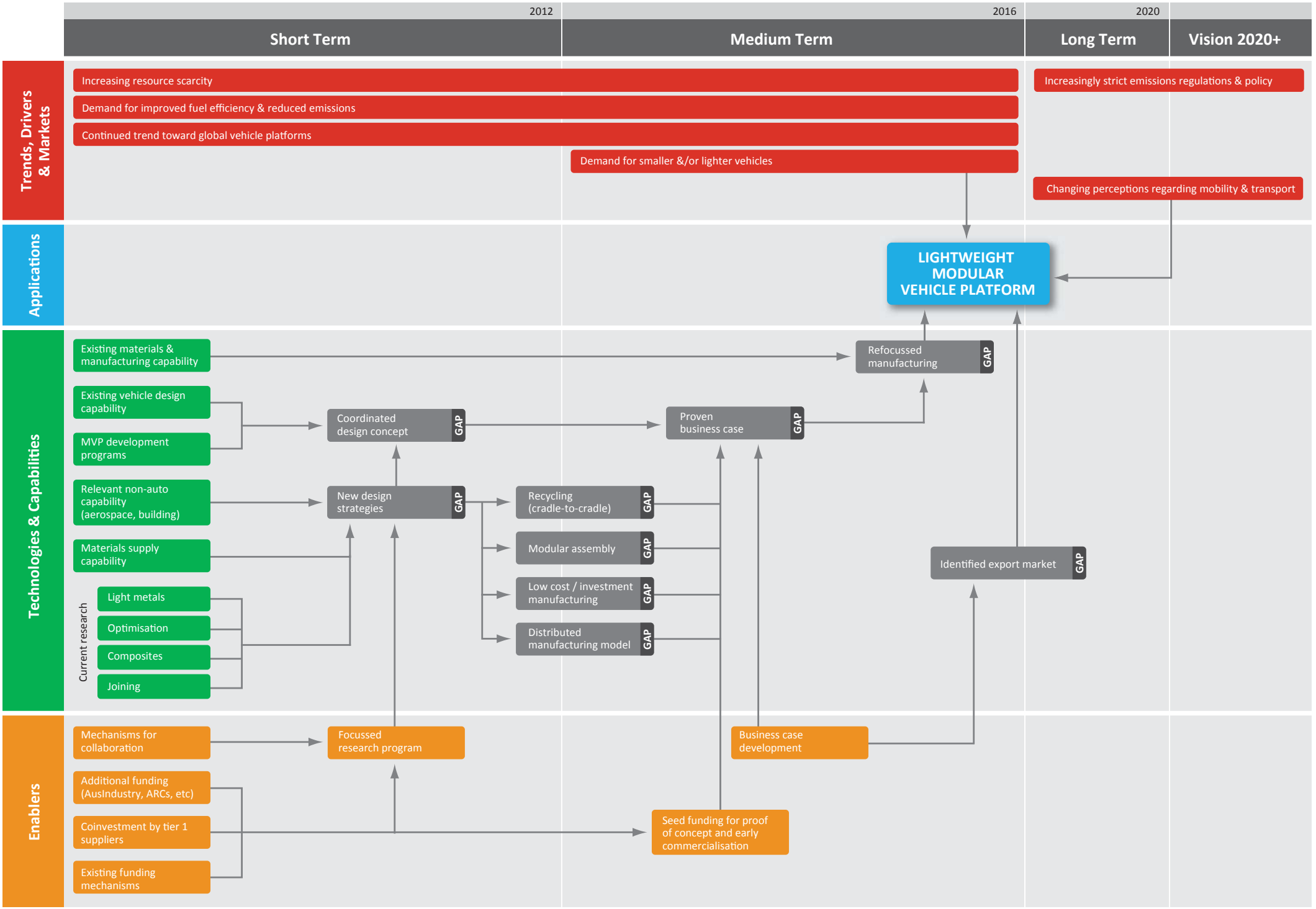

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Increasing importance of recycling
Demand for smaller &/or lighter vehicles
Applications
LIGHTWEIGHT, HIGH VOLUME, CLASS-A BODY AND DOOR PANELS
Technologies & Capabilities
Facilities to cast & roll form steel
Magnesium manufacturing capability
Magnesium casting for body and door panels
GAP
Production of high volume non-appearance composite parts
Production of medium volume class-A composite parts
Complimentary skills in aerospace & defence
Materials research capability
Characterisation
Testing
Design
Analysis
Characterisation of emerging materials
GAP
Research centres of excellence
Research in joining of dissimilar materials
High volume, class-A metals processes
GAP
Advanced joining processes
GAP
Standardised composites technology
GAP
High volume, class-A composites processes
GAP
Enablers
Fund R&D centres of excellence
Review state of the art in process design
Industry education campaigns
Industry agreement on standardised composites technology
Develop business plan & secure funding
OEM commitment to use technology
Incentive for OEM technology trials

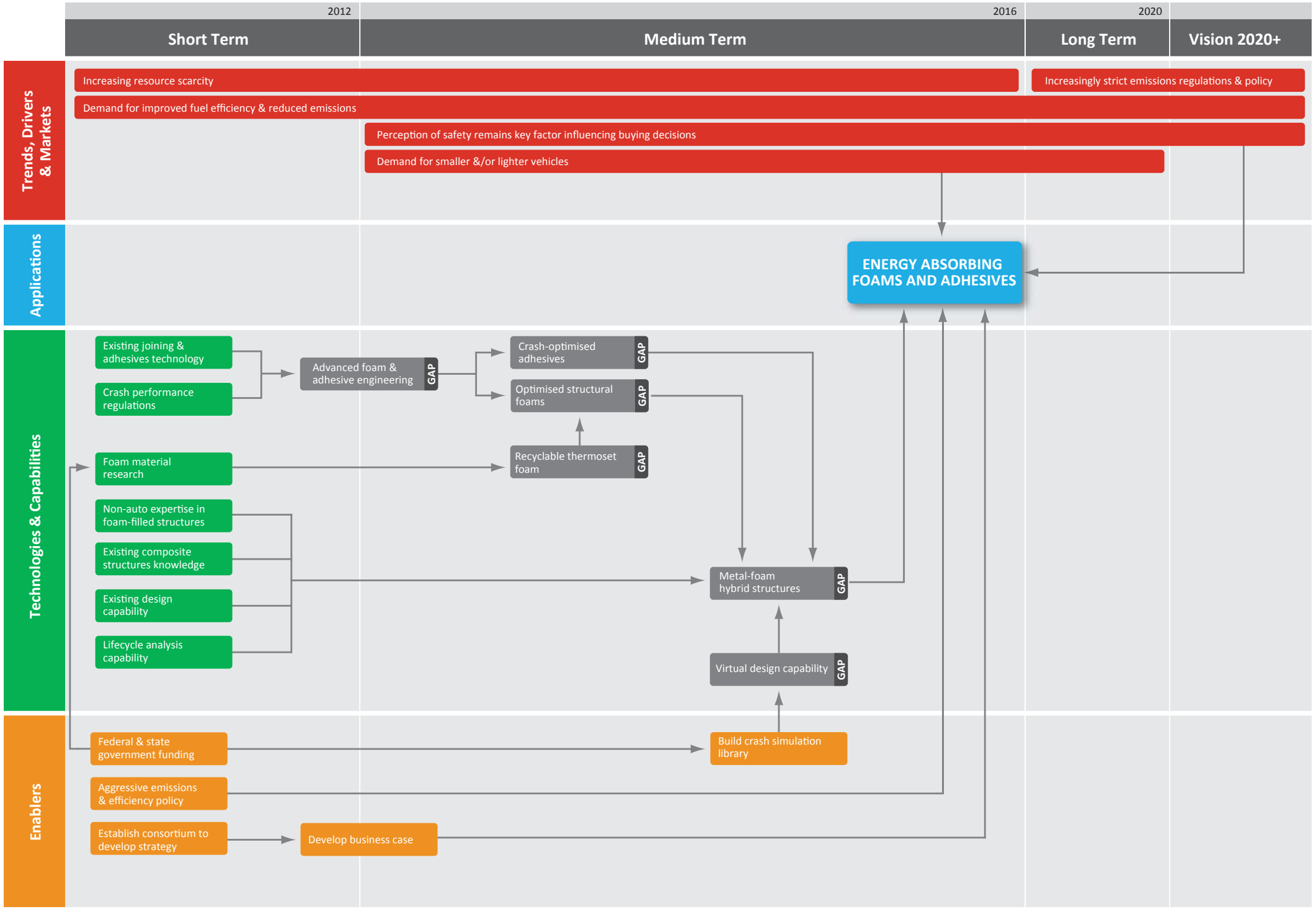

2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Improving lightweight metals processing technology
Demand for smaller &/or lighter vehicles
Applications
LIGHTWEIGHT ROAD WHEELS
Technologies & Capabilities
High-strength die casting
Manufacturing in magnesium
Related expertise in defence & aerospace
Raw material in resource base
Ongoing composites research
Ongoing metals research
Commercialised technology
GAP
Advanced anti-corrosion technology
GAP
Alternative tyre design
GAP
Tier 1 partnership
GAP
Enablers
Additional research funding
Relationship with material producers
Develop business case
Funding for commercialisation


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Demand for smaller &/or lighter vehicles
Perception of safety remains primary factor in buying decisions
Applications
VEHICLE STRUCTURE WITH 30% WEIGHT REDUCTION AND IMPROVED CRASH PERFORMANCE
Technologies & Capabilities
Established composites industry
Established metals industry
Strengths in steel & UHSS design
Cooperative Research Centres
Research in light metals & composite design
Existing joining technology
Matel pre-treatment knowledge
Honeycomb technology
Cooperative research
GAP
New technologies & applications
GAP
Applied prototyping
GAP
Case Studies
GAP
Commercial outcomes
GAP
Enablers
Funding for collaborative research
Government technology investment
Training of design engineers
Penalties (tax) on vehicle emissions
Promotion of commercial outcomes


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Increasing importance of recycling
Increasing adoption of electric vehicles
Demand for smaller &/or lighter vehicles
Applications
NOVEL 3D KNITTED COMPOSITE APPLICATIONS FOR INTERIOR STRUCTURE AND SEATS
REAR SEATBACK APPLICATIONS
NICHE & SPORT APPLICATIONS
EV APPLICATIONS
Technologies & Capabilities
Developing capability tier 1 & supply base
Non-automotive composites expertise
Textile & composites R&D capability
Current grants & funding
Customised machinery
GAP
Recyclability solution
30 sec per part production rate
Optimised knitted structure
New composites technology
Raw materials available
Local raw material supply
Prototype demonstration
Enablers
OEM advanced development program
Green car innovation funding
Develop complementary applications


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Increasing fuel & energy costs
Requirement for reduced energy use in manufacturing
Increasing importance of recycling
Applications
MATERIALS AND PROCESSES FOR ADVANCED RECYCLING
Technologies & Capabilities
Existing recycling infrastructure
Extraction of raw materials
Local value-add
GAP
Existing automotive recycling process
Advanced processes
GAP
Niche market products
GAP
Research base activities
Adequate R&D resources
GAP
Alternative design concepts
GAP
Enhanced product range
GAP
Advanced manufacturing
GAP
Enablers
Resource industry self-funding
Determine economic feasibility
Introduction of ETS or similar
Government funding
Investment in R&D


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Demand for improved fuel efficiency & reduced emissions
Continued trend toward global vehicle platforms
Demand for smaller &/or lighter vehicles
Increasingly strict emissions regulations & policy
Changing perceptions regarding mobility & transport
Applications
LIGHTWEIGHT MODULAR VEHICLE PLATFORM
Technologies & Capabilities
Existing materials & manufacturing capability
Existing vehicle design capability
MVP development programs
Relevant non-auto capability (aerospace, building)
Materials supply capability
Current research
Light metals
Optimisation
Composites
Joining
Coordinated design concept
GAP
New design strategies
GAP
Recycling (cradle-to-cradle)
GAP
Modular assembly
GAP
Low cost / investment manufacturing
GAP
Distributed manufacturing model
GAP
Proven business case
GAP
Refocussed manufacturing
GAP
Identified export market
GAP
Enablers
Mechanisms for collaboration
Additional funding (AusIndustry, ARCs, etc)
Coinvestment by tier 1 suppliers
Existing funding mechanisms
Focussed research program
Seed funding for proof of concept and early commercialisation
Business case development


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Increasing resource scarcity
Increasingly strict emissions regulations & policy
Demand for improved fuel efficiency & reduced emissions
Perception of safety remains key factor influencing buying decisions
Demand for smaller &/or lighter vehicles
Applications
ENERGY ABSORBING FOAMS AND ADHESIVES
Technologies & Capabilities
Existing joining & adhesives technology
Crash performance regulations
Advanced foam & adhesive engineering
GAP
Crash-optimised adhesives
GAP
Optimised structural foams
GAP
Recyclable thermoset foam
GAP
Foam material research
Non-auto expertise in foam-filled structures
Existing composite structures knowledge
Existing design capability
Lifecycle analysis capability
Metal-foam hybrid structures
GAP
Virtual design capability
GAP
Enablers
Federal & state government funding
Build crash simulation library
Aggressive emissions & efficiency policy
Establish consortium to develop strategy
Develop business case

# DATA AND COMMUNICATIONS

Improved HMI and Driver Information

Next Generation Car Navigation Systems

Provision of Real-time Traffic Congestion and Incident Information

Provision of Dynamic Speed Limit Information

# DATA AND COMMUNICATIONS

## Vehicle Data and Communication Systems have become an increasing focus for innovation in the global automotive industry. In fact, the majority of new developments in passenger vehicles are dependent on electronic and electrical systems.

Not only are new technologies reliant on electronics and programming, but historically mechanical systems, like vehicle controls, are being replaced by electrical ones. The increasing use of by-wire technology is one example of this.

Improvements in safety, energy efficiency, and user comfort were highlighted as the primary trends and drivers influencing developments in data and communications. In the case of comfort, consumers are increasingly demanding data connectivity for entertainment in all facets of life. A recent report has determined:

***With smart phones having become more affordable and ubiquitous, consumers are demanding Internet connectivity in cars... An estimated 62.3 million global consumers will have Internet access in their cars by 2016, up from 970,000 at the end of 2009.***[14]

Information availability will improve the ability of drivers and vehicle systems to understand traffic conditions in real time, reducing travel times, congestion, and vehicle emissions. Widespread data connectivity provides both safety benefits and drawbacks. Information is more readily available regarding traffic, the local environment, and incidents that might require driver attention, but this comes at the cost of increased cognitive load.

Relevant Australian capability applicable to the development of future data and communications systems includes:

### An Established ICT Industry

There is an established Australian industry in the design, development and manufacture of electronic products, and in the supply of related equipment. The IT industry represents a significant proportion of the research and development activities carried out in Australia.[15]

### Automotive Research and Development

Leveraging IT strengths to produce new, competitive technologies will be facilitated by the established research and development capability in the Australian automotive industry and the wider market.[16]

The union of these two capabilities provides an opportunity to develop the ultimate potential of data and communication systems via an Intelligent Transport System (ITS) which sees the integration of ICT technology between cars and infrastructure. This can be applied in two areas – systems internal to the vehicle and those that operate in combination with the external environment. External systems rely on communication between vehicles (V2V) and with surrounding infrastructure (V2I), while internal applications might include such systems as GPS, stability control and automated parking.

Simple V2I implementations are already well established in the automotive sector. Automated tolling through vehicle transponders is commonplace throughout the world. With innovative applications and growing consumer interest, more ambitious developments in data and communications systems have widespread market potential.

14 Cellular News. *The Next Internet Boom: Connected Cars*. December 17, 2009.
15 Federal Chamber of Automotive Industries. *Submission to the Review of Australia's Automotive Industry*. May 2008.
16 Department of Innovation, Industry, Science and Research. *ICT Sector Fact Sheet*. Available online: http://www.innovation.gov.au/Section/AboutDIISR/FactSheets/Pages/ICTSectorFactSheet.aspx

# DATA AND COMMUNICATIONS APPLICATIONS

Advancements in electronics and software play a key role in the majority of new technology developed in the automotive industry. While broadly applicable, great potential was identified for data and communications systems that address environmental, safety and convenience issues.

Safety is a key factor influencing consumer buying decisions. Additionally, improvements in road safety (driven in part by the multi-billion dollar cost of road accidents to the Australian economy) are prime target areas for regulators and society generally.Examples of this include government mandating of automated emergency calling systems in vehicles, with the ultimate goal identified for public safety being zero road fatalities beyond 2020.

As the population ages and technology rapidly advances, there will be variable HMI requirements for drivers of diverse age and levels of technology literacy.

Population increases in Australia put strain on infrastructure and result in more congestion and longer travel times. This has a large social and economic cost that could be reduced through improved efficiency of traffic flow. There are secondary benefits for emissions and fuel consumption that can be achieved by simply addressing traffic congestion.

## Short Term

**2010-2012**

In the near term, evolutionary developments are expected to continue in the segment with increasing integration of functionality and devices.

Data connectivity and navigation systems are becoming more prevalent as is provision for interfacing with portable electronic devices, like mobile phones and media players.

Deployment of communications infrastructure to support related devices is also ongoing. Integration of these devices and services will create a need for improved driver interfaces.

## Medium Term

**2012-2016**

**Provision of Real-time Traffic Congestion and Incident Information**
Integrates communications infrastructure with the wide range of available data, see page 83.

**Next Generation Car Navigation Systems**
Achieve safety targets by enabling accident prediction and protection systems with high accuracy positioning and maps, see page 82.

**Improved HMI and Driver Information**
Manage the increasing data load available to drivers through adaptive information delivery and human factors considerations, see page 81.

## Long Term

**2016-2020**

**Provision of Dynamic Speed Limit Information**
Ensures drivers are aware of local speed limits set in response to traffic conditions, weather, road construction, or existing incidents.

Data can be gathered from road signs, or delivered from a centrally updated database, see page 84.

## Vision 2020+

**2020+**

Evolution of these technologies will be maintained in the years beyond 2020, with improved driver information and communications systems continuing to provide increasing levels of safety, convenience and efficiency to motorists.

## TECHNOLOGIES AND CAPABILITIES

### Automotive Sector

Much of the underlying capability and many of the required technologies are already existent in the Australian automotive industry or are available on world markets. Systems are already available to measure performance, environmental, traffic, positioning and driver state data. Gaps in local capability can be addressed by building on expertise held in parent companies of international vehicle manufacturers and component suppliers. These gaps include:

- Visual display units,
- Common V2V and V2I platforms,
- Sensors, and
- HMI expertise.

### Non-Automotive Sector

The local electronics industry has capability in component design and on-chip integration that can be applied to data and communications applications. Relevant expertise exists in trucking and taxi industries where communications and fleet management are commonplace. Key gaps that can take advantage of non-automotive expertise include:

- Communications and data management protocols,
- Real world testing, and
- Technology demonstration.

The proliferation of internet connected mobile devices like smartphones can also be leveraged for data gathering and presentation.

### Research Sector

There is existing related capability available in the science sector relating to human factors and ergonomic design. There is also capability in sensor design and technology integration. This research expertise can be used to address gaps in:

- Smart sensor development,
- Appropriate user interfaces,
- Driver behaviour algorithms, and
- Data fusion and management protocols.

## ENABLERS

### Infrastructure Support

Infrastructure is required for applications relating to the provision of information. One example is a need for next generation satellites positioning under development in Europe, the United States and Russia.

### Industry Collaboration

Broad stakeholder support is important in a sector that will be reliant on standardised communication protocols and common infrastructure.

### Government Action

Existing funding programs have not been identified as suitable to data and communications applications, but government policy to legislate adoption was highlighted. Access to government traffic databases will facilitate provision of data.

### Science and Research

Funding for development programs in the research base can be targeted to address gaps in knowledge of driver habits, human-machine interface design, ergonomics and data processing for next generation navigation systems.

### Education and Training

The public adoption of technology to reduce congestion and emissions while improving safety can be increased by educating consumers about energy and safety responsibility. Developing specialised skills in engineering for IT and HMI will support technology development.

### Planning and Feasibility

Development of a business case and proof of feasibility is highlighted as an important first step in the majority of the data and communications applications identified.

# DATA AND COMMUNICATIONS ROADMAP

By considering local and global factors, including the ageing population and increasing traffic congestion in urban areas, workshop participants highlighted relevant applications. These applications were focussed around the provision of data and driver interfaces. Technologies and capabilities required for their realisation must also be available, and enablers were identified to facilitate their development. The figure at left presents an overview.

# DATA AND COMMUNICATIONS

## The System Perspective

In the Data and Communications opportunity area, four specific applications were identified by workshop participants. There are two categories of data and communications opportunities:

- Provision of Data through V2V and V2I communications, and
- Internal systems including Driver Information and Interfaces.

By categorising the enablers identified by participants and plotting their occurrence across each of the four priority applications, the interrelationships between enablers and applications can be viewed across the data and communications opportunity area. This plot is shown in Figure 15. The enabler requirements of each application can be easily identified by reading the columns. Advanced navigation and positioning systems, for example, had enablers identified in only two categories – industry collaboration, and feasibility. The provision of dynamic speed limit data and development of improved HMIs, however, demand broader engagement across stakeholder groups.

Reading across the rows allows enablers of broad or narrow applicability to be identified. Many of the data and communications applications do not rely on revolutionary technology development, instead taking advantage of existing sensors, protocols and systems. As a consequence, science and research support has only been indicated as relevant in the development of improved HMI and driver information systems. Industry collaboration, and planning and feasibility are important to ensure commercial outcomes through broad stakeholder support and are highlighted in the majority of the applications.

In the section below the interrelationships table, Figure 15 presents the predicted relative performance of each application against five key metrics: Profit (economic benefit), People (social benefit), Planet (environmental benefit), Investment Cost, and Likelihood of Success. Environmental benefits and social impacts have been indicated as particular strengths due to the ability of the applications to reduce congestion and travel times while improving safety. Investment cost has ranked poorly in general, due to the need for supporting infrastructure with development costs estimated between $5 and $50 million.

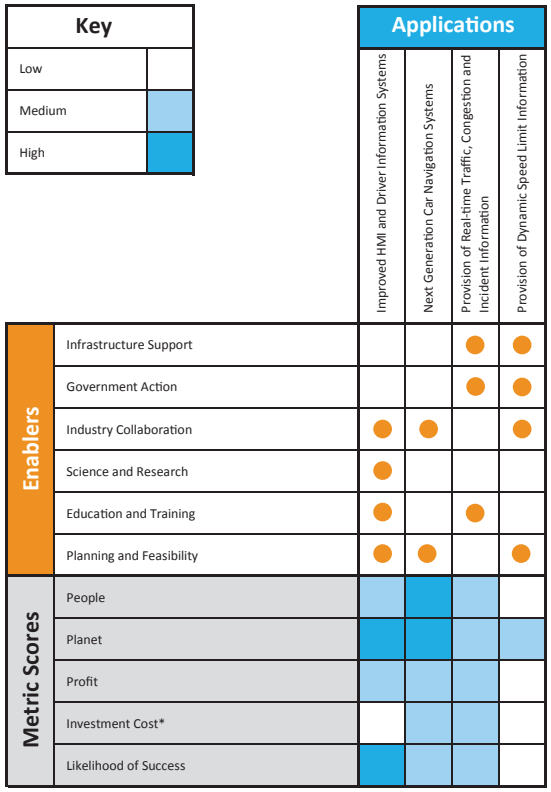



FIGURE 15 – INTERRELATIONSHIP OF DATA AND COMMUNICATIONS PRIORITY APPLICATIONS AND ENABLERS. APPLICATIONS HAVE BEEN SCORED AGAINST FIVE KEY METRICS. *NOTE: APPLICATIONS WITH LOW INVESTMENT RECEIVE HIGH SCORES.

### Application Linkages

Strong linkages were identified by workshop participants between the majority of applications in the Data and Communications opportunity area. This has been depicted in Figure 16.

It is clear that there is interrelationship between underlying systems among all four applications. Each will rely on integration with vehicle systems and infrastructure communications. In the case of driver interface, each of the other applications might be considered a component part, passing information to the HMI for communication with the driver.

## Enabling Actions

Priority applications will require gaps in technology and capability to be addressed before their benefits can be realised. Workshop participants identified these benefits, enabling actions and detailed plans to achieve success as summarised in the following pages.

### Enabler Linkages

The frequency with which pairs of enablers appear in data and communications applications was recorded as a measure of the interrelationship between enablers. Figure 17 presents the relative strength of correlation for each enabler pair as indicated by workshop participants on a three-point scale. There is broad correlation indicated in most areas, with higher scores occurring in two areas.

Infrastructure support was shown to be strongly linked with government action. This is unsurprising due to the substantial costs associated with the deployment of communications infrastructure. It also reflects the fact that existing roads and road infrastructure systems are predominantly government controlled. Planning and feasibility has shown correlation across all sectors, but a particularly strong relationship is indicated with industry collaboration. This further reinforces the need for broad stakeholder support and standardisation in the development of communications, interface and data provision solutions.

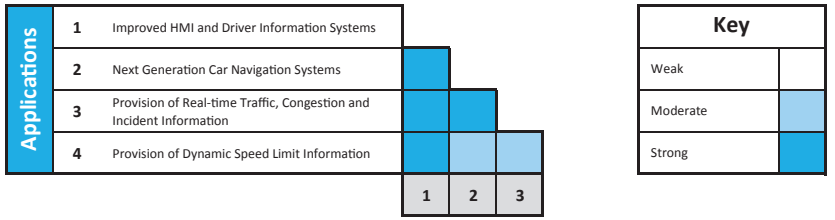



FIGURE 16 – **STRENGTH OF RELATIONSHIP BETWEEN DATA AND COMMUNICATIONS PRIORITY APPLICATIONS**

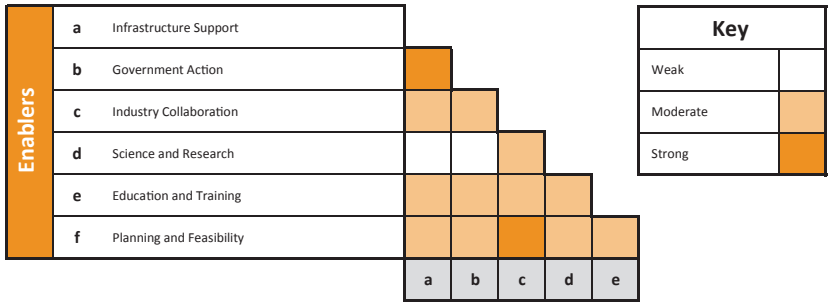



FIGURE 17 – **STRENGTH OF RELATIONSHIP BETWEEN DATA AND COMMUNICATIONS ENABLERS**

# DATA AND COMMUNICATIONS

## Improved HMI and Driver Information

Increasing availability of data results in increased cognitive load on drivers. This can be alleviated through enhanced HMI and information delivery to realise accompanying improvements in road safety and reduced traffic congestion. Key enablers include:

**Development of a Business Case** by key stakeholders to justify collaboration activities that serve as a mechanism for funding and undertaking development and commercialisation.

**A Scientific Study** funded through a public-private partnership that examines driver habits and existing implementations to allow selection and development of appropriate technologies.

**Social Responsibility Education** delivered to the public, which encourages uptake of systems that increase safety and reduce emissions.

**Satellite Technology** for positioning is currently being deployed by governments in the United States, Russia and the European Union.

**Education of HMI Specialists** provide industry with skills required for effective development of sensors, algorithms and APIs.

## Next Generation Car Navigation Systems

Refined positioning resolution required by lane-level navigation systems, 0.5 metre 3D positioning resolution, allows autonomous systems to reduce traffic congestions and improve safety. These are enabled by:

**Market Review** that supports the development of a clear business case to justify funding and gather stakeholder support.

**Stakeholder Support** enabling universal standards and interoperability between V2I communication systems and databases, simplifies the efficient and widespread adoption of high resolution positioning.

**Development Programs** in imaging and electronics design that address key technology gaps in high resolution imaging, automatic feature extraction, real time mapping systems, data fusion and data management.

## Provision of Real-time Traffic Congestion and Incident Information

Availability of real-time information is a key requirement for the implementation of advanced driver information and autonomous vehicle systems. Through these systems, available data provides social and economic benefit by reducing traffic congestion and improving road safety. Identified enablers in this area were:

**Enabling Policy and Legislation** informed by a current trial of dedicated short range communications (DSRC) systems encourages open access to available data, spectrum allocation and ensures rollout of appropriate infrastructure.

**V2V and V2I Infrastructure Rollout** which is needed to support and augment existing data gathering systems to direct available information to drivers and vehicles.

**Development of IT and Engineering Skills** at universities and in industry to support continued evolution of data gathering, processing, and delivery.

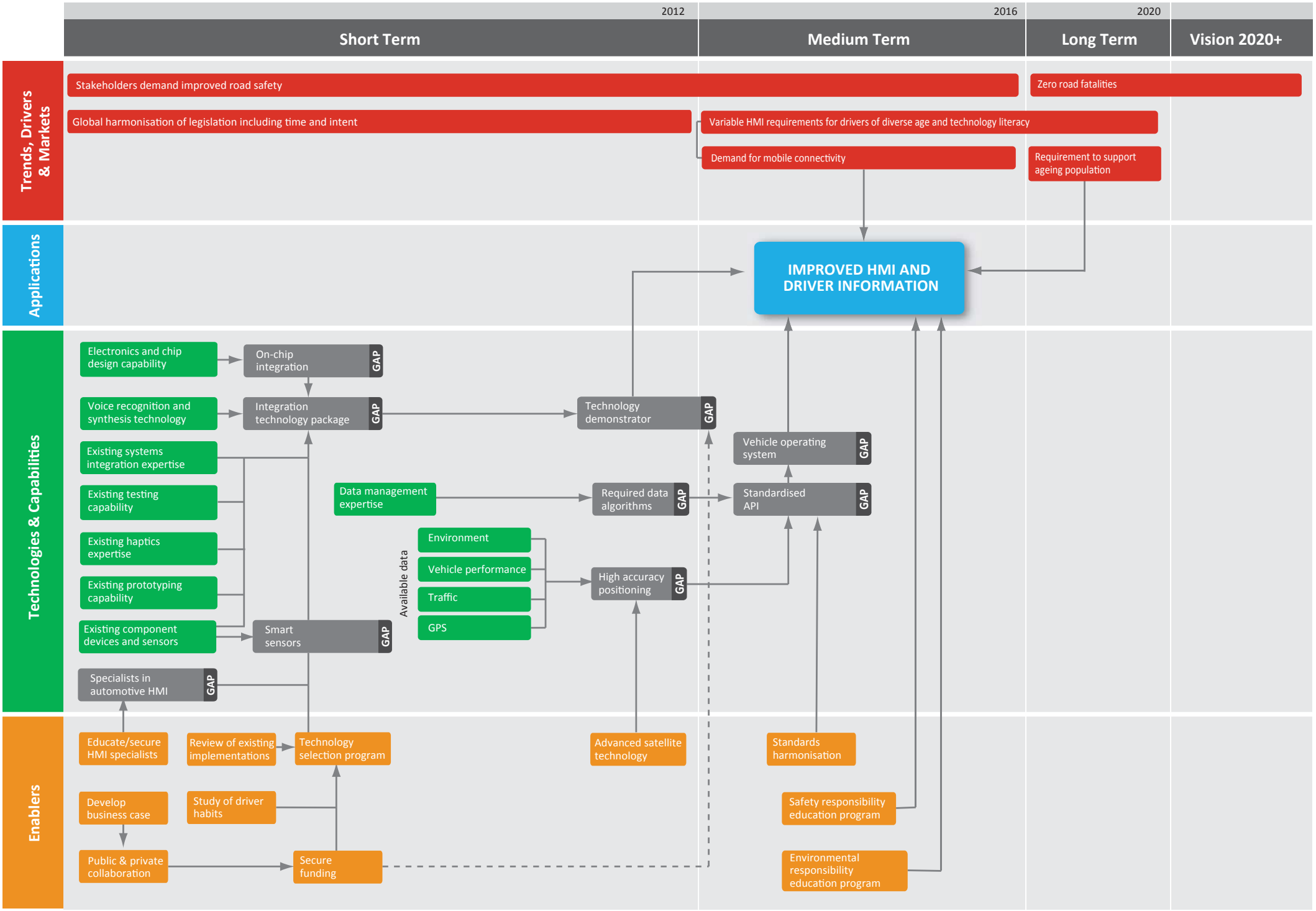
## Provision of Dynamic Speed Limit Information

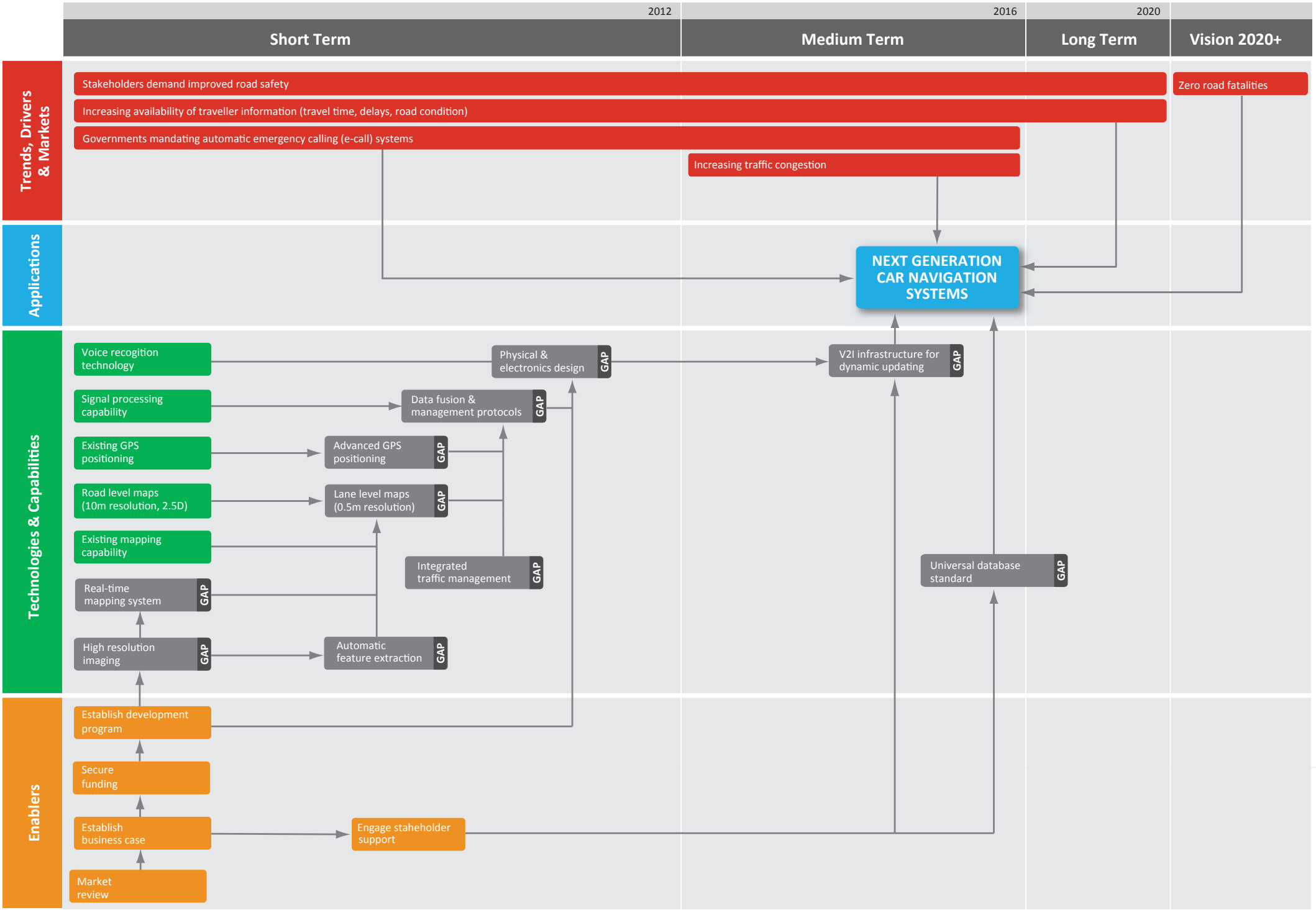
Limits can be adjusted to suit conditions as they evolve in real-time and can be communicated directly to vehicles through active or passive infrastructure communications. Safety is improved by providing drivers with speed limits that reflect weather, roadwork, incidents and other hazards. It can be achieved through:

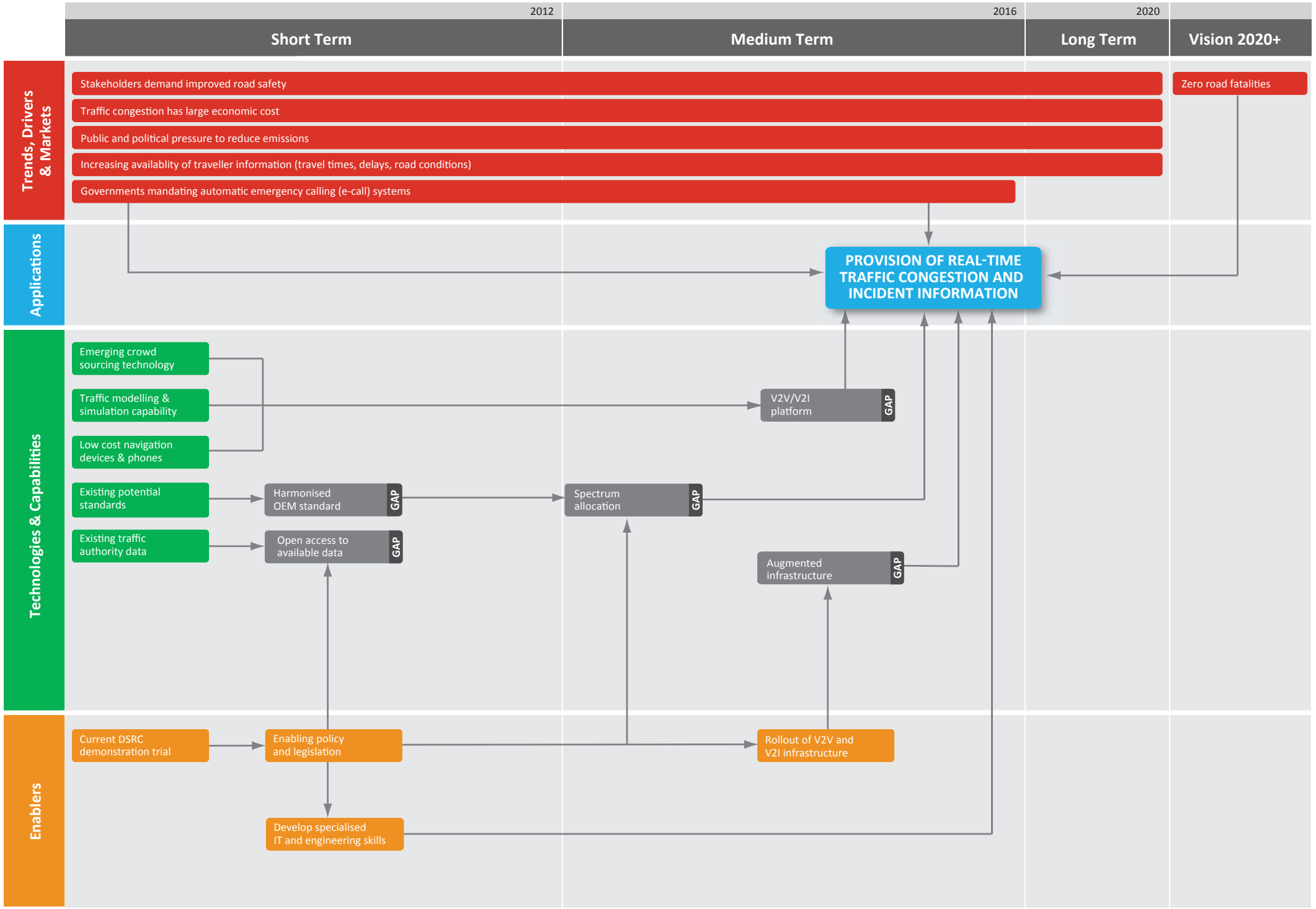
**Securing Funds** for early stage business planning and later stages of commercialisation in field trials.

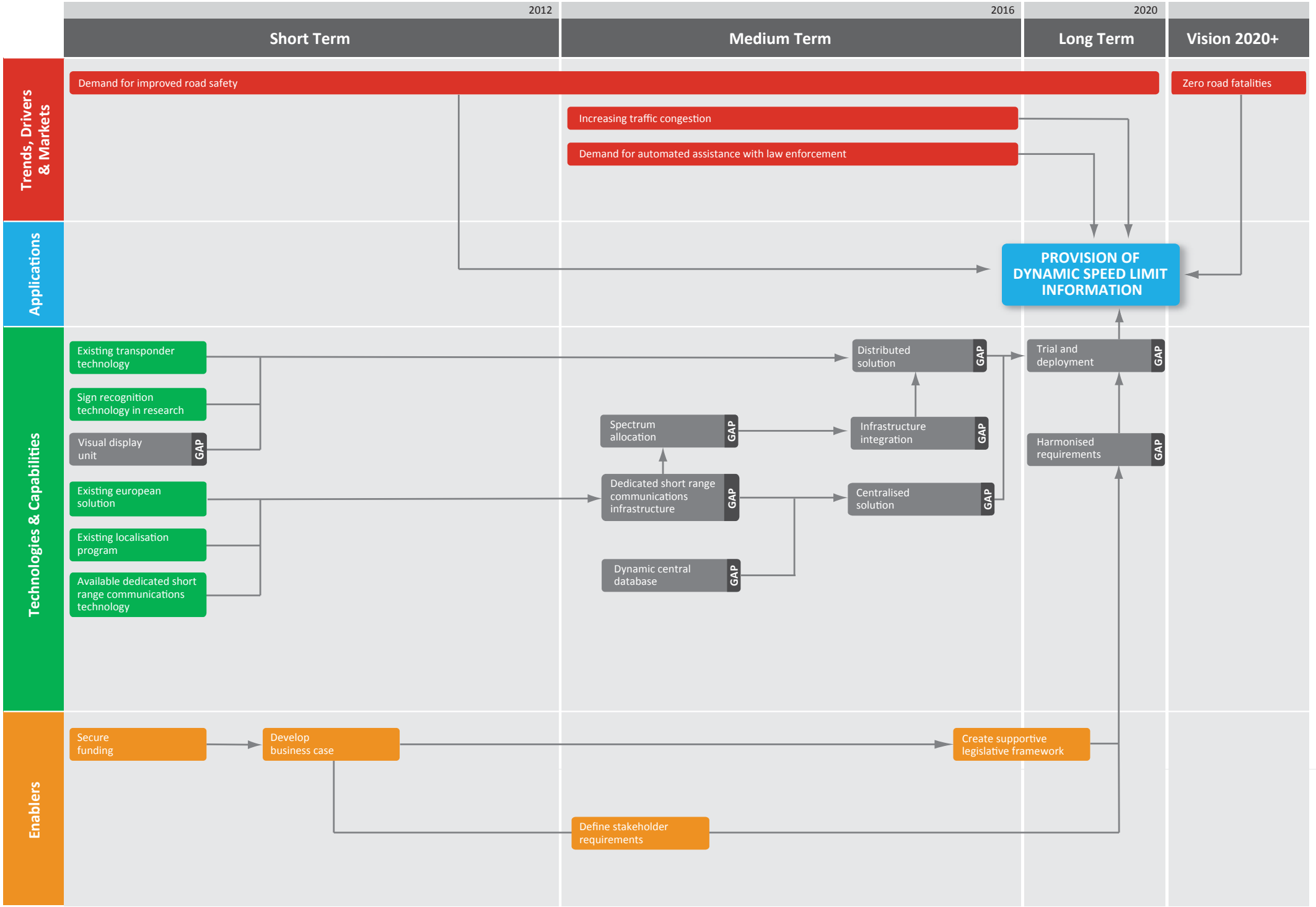
**Development of a Business Plan** that spans public and private sector interests to define legislative requirements and responsibilities of all stakeholder groups.

**A Supportive Legislative Framework** that encourages harmonised systems and requirements.


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Stakeholders demand improved road safety
Zero road fatalities
Global harmonisation of legislation including time and intent
Variable HMI requirements for drivers of diverse age and technology literacy
Demand for mobile connectivity
Requirement to support ageing population
Applications
IMPROVED HMI AND DRIVER INFORMATION
Technologies & Capabilities
Electronics and chip design capability
On-chip integration
GAP
Voice recognition and synthesis technology
Integration technology package
GAP
Technology demonstrator
GAP
Existing systems integration expertise
Existing testing capability
Existing haptics expertise
Existing prototyping capability
Existing component devices and sensors
Smart sensors
GAP
Specialists in automotive HMI
GAP
Data management expertise
Required data algorithms
GAP
Vehicle operating system
GAP
Standardised API
GAP
Available data
Environment
Vehicle performance
Traffic
GPS
High accuracy positioning
GAP
Enablers
Educate/secure HMI specialists
Review of existing implementations
Technology selection program
Develop business case
Study of driver habits
Public & private collaboration
Secure funding
Advanced satellite technology
Standards harmonisation
Safety responsibility education program
Environmental responsibility education program


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Stakeholders demand improved road safety
Increasing availability of traveller information (travel time, delays, road condition)
Governments mandating automatic emergency calling (e-call) systems
Increasing traffic congestion
Zero road fatalities
Applications
NEXT GENERATION CAR NAVIGATION SYSTEMS
Technologies & Capabilities
Voice recogition technology
Signal processing capability
Existing GPS positioning
Road level maps (10m resolution, 2.5D)
Existing mapping capability
Real-time mapping system
High resolution imaging
Physical & electronics design
Data fusion & management protocols
Advanced GPS positioning
Lane level maps (0.5m resolution)
Integrated traffic management
Automatic feature extraction
V2I infrastructure for dynamic updating
Universal database standard
GAP
Enablers
Establish development program
Secure funding
Establish business case
Market review
Engage staheholder support


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Stakeholders demand improved road safety
Traffic congestion has large economic cost
Public and political pressure to reduce emissions
Increasing availablity of traveller information (travel times, delays, road conditions)
Governments mandating automatic emergency calling (e-call) systems
Zero road fatalities
Applications
PROVISION OF REAL-TIME TRAFFIC CONGESTION AND INCIDENT INFORMATION
Technologies & Capabilities
Emerging crowd sourcing technology
Traffic modelling & simulation capability
Low cost navigation devices & phones
Existing potential standards
Existing traffic authority data
Harmonised OEM standard
GAP
Open access to available data
GAP
V2V/V2I platform
GAP
Spectrum allocation
GAP
Augmented infrastructure
GAP
Enablers
Current DSRC demonstration trial
Enabling policy and legislation
Develop specialised IT and engineering skills
Rollout of V2V and V2I infrastructure


2012
2016
2020
Short Term
Medium Term
Long Term
Vision 2020+
Trends, Drivers & Markets
Applications
Technologies & Capabilities
Enablers
Demand for improved road safety
Zero road fatalities
Increasing traffic congestion
Demand for automated assistance with law enforcement
PROVISION OF DYNAMIC SPEED LIMIT INFORMATION
Existing transponder technology
Sign recognition technology in research
Visual display unit
GAP
Existing european solution
Existing localisation program
Available dedicated short range communications technology
Distributed solution
GAP
Spectrum allocation
GAP
Infrastructure integration
GAP
Dedicated short range communications infrastructure
GAP
Centralised solution
GAP
Dynamic central database
GAP
Trial and deployment
GAP
Harmonised requirements
GAP
Secure funding
Develop business case
Create supportive legislative framework
Define stakeholder requirements

“The Automotive Australia 2020 Roadmap represents the efforts of many participants to articulate the issues, technologies and resource inputs required to remain competitive, providing potential investment directions for both Government and the broader auto industry. It highlights the future challenges that the Australian Automotive Industry must address to survive.”

RUSSELL PETTIS
Managing Director
DENSO Automotive Systems Australia

# Recommendations

**The Automotive Australia 2020 Roadmap has identified four priority opportunity areas for the long-term success of the Australian automotive industry: Vehicle Electrification (including hybrid and electric vehicles); Gaseous Fuels; Lightweighting; and Data and Communication Systems.**

These four areas represent opportunities for Australian suppliers to generate new business in both domestic and overseas markets and for Australian multinationals to acquire business from their overseas counterparts. Within each of these areas specific applications have been defined, which build on current Australian technologies and capabilities.

The following recommendations would realise Australian potential in the four priority areas. They represent the enabling actions that must be carried out by industry stakeholders to achieve success in the top-ranked applications. Recommendations can be categorised into the five major themes: Industry Collaboration; Science and Research; Government Action; Education and Training; and a Short Term Action Plan. There are also three recommendations on the next steps forward to sustain and implement the outcomes of the Automotive Australia 2020 Roadmap.

**Industry Collaboration**

OEMs and suppliers, supported by the Green Car Innovation Fund and CRCs (such as AutoCRC, AMCRC, CRCACS, CAST CRC), can strengthen their collaboration and significantly extend their levels of engagement with R&D providers to develop priority capabilities. The industry should:

1 Apply to the Green Car Innovation Fund to support research and development in the areas of: supercapacitors for high energy batteries; development of modular electric vehicle battery packs; modular electric vehicle powertrains; high capacity, low cost on-vehicle storage tanks for CNG; and dedicated direct injection systems for LPG.

2 Apply for Green Car Innovation Fund support for development and implementation of lightweight technologies in the areas of: gaseous fuel tanks; electric vehicles; and body, structural and driveline components.

3 Develop joint ventures and consortia between suppliers and research organisations in the area of vehicle electrification to exploit applications including: supercapacitors for high energy batteries, high energy density metal-air batteries, modular standardised battery pack optimized for large passenger vehicles and the development of a modular electric vehicle powertrain.

4 Establish shared centres of excellence involving vehicle producers, suppliers and research organisations in the areas of: battery development and manufacture; gaseous fuel technology; lightweighting; electric machines; and automotive human-machine interfaces.

5 Integrate suppliers into OEM-advanced development programs in the area of lightweighting applications.

6 Collaborate to develop appropriate electric machine technologies that meet local requirements.

7 Encourage collaboration between suppliers and OEMs to identify a standard technology for composite body panels, allowing focussed development and reduced manufacturing costs in the area.

8 Produce detailed feasibility studies and business plans as part of the implementation of the identified AA2020 applications.

9 Undertake the development of a detailed specific technology action plan to define Australia's direction in the area of vehicle electrification, which is diverse and rapidly growing.

**Science and Research**

The science and research base can develop a number of strategically essential local capabilities to support the identified priority opportunities. The science and research sector should:

10 Increase research and development of technology to improve the power density of batteries, including molecular modelling for the development of advanced battery chemistry and metal-air technology.

11 Increase research into power electronics and powertrain systems for the development of a modular electric vehicle powertrain.

12 Establish a program, through industry and science collaboration, to develop and prototype dedicated direct injection vehicles for gaseous fuels.

13 Undertake a research study into alternative gaseous fuels filling technology.

14 Develop a university based applied technology research program into fluid and thermodynamic modelling to increase usable tank volume and filling speed for gaseous fuels.

15 Expand existing electrochemical laboratory facilities in both research and industry organisations to realise opportunities in battery development.

16 Increase research into lightweighting technologies such as: joining of dissimilar materials; cheaper composites with reduced manufacturing times; and enhanced aluminium and magnesium manufacture.

17 Increase the understanding of driver habits and behaviour through additional research and investigation.

**Government Action**

Government can direct existing funding initiatives, like the Green Car Innovation Fund, toward the priority opportunity areas. Additionally, targeted policy, incentives and standards can promote the adoption of new technologies. Government should:

18 Direct the Green Car Innovation Fund toward research and development in three opportunity areas: Vehicle Electrification, Gaseous Fuels and Lightweighting.

19 Develop uniform gaseous fuel standards for supply pressure, infrastructure specification and fuel composition which are compatible with international standards.

20 Provide incentives to drive lightweight vehicle development and design with the aim of reducing fuel consumption.

21 Establish an incentive program to encourage lightweight technology trials.

22 Develop a gaseous fuels support program, to encourage emerging gaseous fuel technology and the upgrade of infrastructure.

23 Implement financial incentives, based on vehicle emissions, that encourage the uptake of emission reducing technologies (such as lightweighting, alternative fuels and electrification).

**Education and Training**

The education and training sectors support the development of Australian skills and capabilities which will be needed in the implementation of this roadmap. To address identified gaps, the education institutes and government should:

24 Undertake undergraduate and postgraduate training in the areas of vehicle electrification, human-machine interfaces and lightweighting now to ensure that skilled graduates are available in these developing areas.

25 Develop and undertake an industry education program supported by government and industry to inform stakeholders of the capabilities of composite materials. This program should be based on detailed research and analysis of composite material properties.

26 Undertake a public education program in the areas of environmental and safety responsibility.

**Short-term Action Plan**

In addition to these long-term measures it is also essential to ensure the immediate viability of the Australian supplier base, to sustain critical mass to be able to leverage the long-term opportunities identified.

To this end, the AA2020 Roadmap has identified the following priority actions:

27 Government and OEMs should encourage and support suppliers to realise opportunities for local manufacture of components. Specific targets have been identified in the *Automotive Australia 2020 Opportunity Portfolio*: aluminium cylinder head, combi-meter and clock, pressings, auto-shifter, radiators, and aluminium and steel as raw materials.

28 Suppliers should target areas of strong capability and international demand as opportunities to develop and expand export markets. Government and OEM support in the development of export markets as diversified suppliers increase the competitiveness of the industry overall. Specific export opportunities have been identified in the *Automotive Australia 2020 Opportunity Portfolio*: paint, brakes, suspension, ABS/ESC, styling, design, tooling, aluminium, cylinder heads, steering, exterior mirrors, pressings and seating.

29 Government and OEMs need to work with suppliers in areas of existing business that are important to strategic local capabilities. Specific areas have been identified in the *Automotive Australia 2020 Opportunity Portfolio*: seating, instrument panel, radiators, painting, brake rotors and ABS/ESC.

**Implementing and Sustaining the AA2020 Roadmap**

The AA2020 Roadmap forms a vital first step towards delivering a globally relevant, profitable and sustainable automotive sector in Australia. International research shows that real benefits will only be fully realised through the development of an industry culture and governance structure to sustain, develop and deliver the roadmap through to 2020 and beyond. Achieving this requires:

30 Communication of the AA2020 Roadmap widely to all relevant stakeholders (within and outside the automotive industry) using multiple media and means.

31 The AIIC to swiftly advise on implementation of actions, both to minimise delay and, more importantly, to underpin the central role of the roadmap in driving the agenda for the industry. This will build on the momentum achieved through the collaborative efforts of over 160 stakeholder organisations in creating this roadmap.

32 The AIIC to establish a governance structure to develop and enhance the AA2020 Roadmap, and ultimately to refresh it as appropriate. This body should also encourage, through the provision of training and support, all participants in the resulting projects to develop and publish aligned action plans, enabling communication and effective collaboration across the sector.

# Stakeholder Participation

**Successful roadmapping requires significant stakeholder participation. For the AA2020 project, a broad range of data has underpinned its development.**

Participants included: vehicle producers, automotive suppliers, research organisations, relevant non-automotive companies, government officials and other stakeholder groups.

Engagement was achieved through workshops, surveys and interviews, with many organisations making a significant contribution. Approximately 220 individuals from 160 organisations contributed more than 2500 hours. A breakdown by sector is provided in Figure 18.

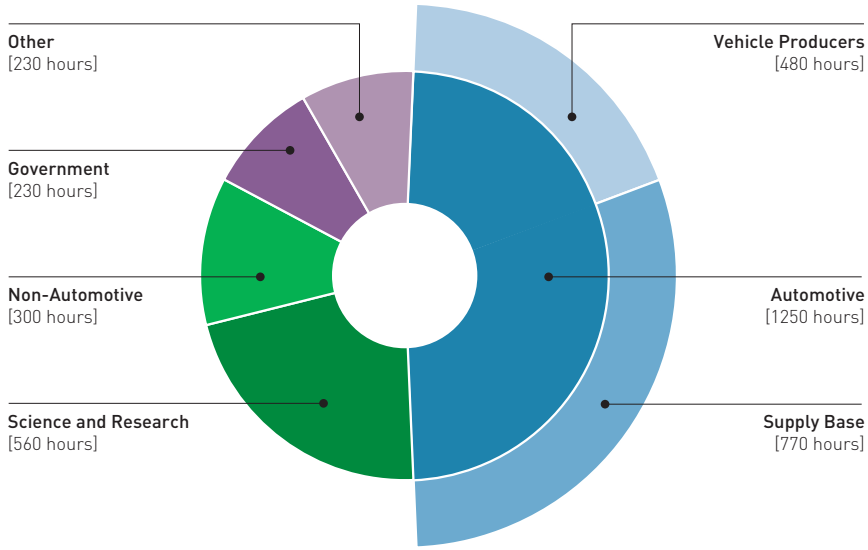



FIGURE 18 – **BREAKDOWN OF INDUSTRY HOURS**

## Industry Feedback

Formal and informal feedback was received, with both indicating that participants were engaged and enthusiastic in developing this roadmap to take their industry to 2020 and beyond. Formal feedback was gathered at all workshops, with 97% of participants agreeing that the development of this roadmap has been good, very good, or excellent. Figure 19 shows aggregated industry feedback regarding the project. Organisations that have made a direct contribution to the AA2020 Roadmap are listed on the following pages.

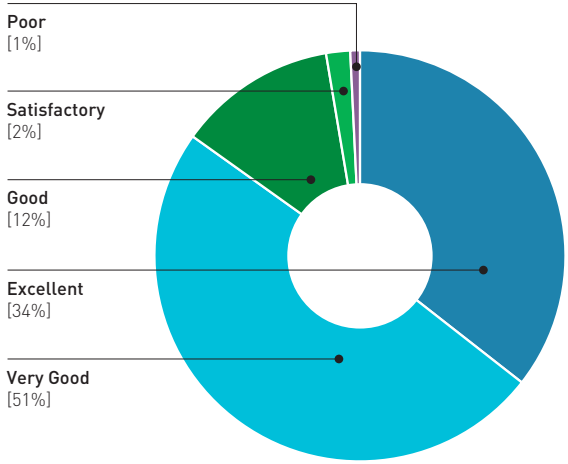



FIGURE 19 – **AGGREGATE PARTICIPANT FEEDBACK**

# Participating Organisations

ABB Australia

ACS Australia

Adtech Engineering

Advanced Centre for Automotive Research & Testing (ACART)

Advanced Fuels Technology

Advanced Manufacturing Australia (AMAus)

Advanced Manufacturing CRC (AMCRC)

Air International Thermal Systems

Aisin Australia

Alternative Fuels Innovation (AFI)

Andrew Engineering

APV Automotive Components

ARB

ARC Centre of Excellence for Autonomous Systems

ARC Centre of Excellence for Design in Light Metals

ARC Centre of Excellence for Electromaterials Science

Australian Arrow

Australian Automotive Aftermarket Association (AAAA)

Australian Automotive Air

Australian Automotive Intelligence

Australian Electric Vehicle Association

Australian Government – Austrade

Australian Government – Department of Energy, Resources and Tourism

Australian Government – Department of Infrastructure, Transport, Regional Development and Local Government

Australian Government – Department of Innovation, Industry, Science and Research

Australian Government – Department of the Environment, Water, Heritage and the Arts

Australian Government – Office of the Minister for Innovation, Industry, Science and Research

Australian Manufacturing Technology Group Limited (AMTIL)

Australian Manufacturing Workers Union (AMWU)

Autofab

AutoHub

Autoliv

Automotive Alternative Fuels Research Board

Automotive Supplier Excellence Australia (ASEA)

Backwell IXL

BASF Coatings Australia

Better Place

Bishop Technology Group

Blackwell IXL

Blade Electric Vehicles

BOC Australia

Boeing Research and Technology

Bostik Australia

Broens Industries

CAP-XX

CAST CRC

Century Yuasa

Ceramic Fuel Cells

CFS International

Clipsal

CMG Engineering Group

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Composite Materials Engineering (CME)

Concentric

Continental Australia

Co-operative Research Centre for Advanced Automotive Technology (AutoCRC)

Co-operative Research Centre for Advanced Composite Structures Ltd (CRCACS)

CPC Auto Components

Culter Brands

Curtin University

DAIR

Dana Australia

Davis Craig

Deakin University

Deloitte Touche Tohmatsu

Delphi Australia

Denso

Diver Consolidated Industries

Dolphin Products

Elgas

Exide Technologies

Federation of Automotive Products Manufacturers (FAPM)

FMP Group

Ford Motor Company of Australia

Frontline Australasia

Future Climate Australia - LEV Automotive Partnership

Futuris Automotive Group

GKN Aerospace

GM Holden

Government of South Australia – Department for Transport, Energy & Infrastructure

Government of South Australia – Department of the Premier and Cabinet

Government of South Australia – Department of Trade and Economic Development

Grant Thornton Australia

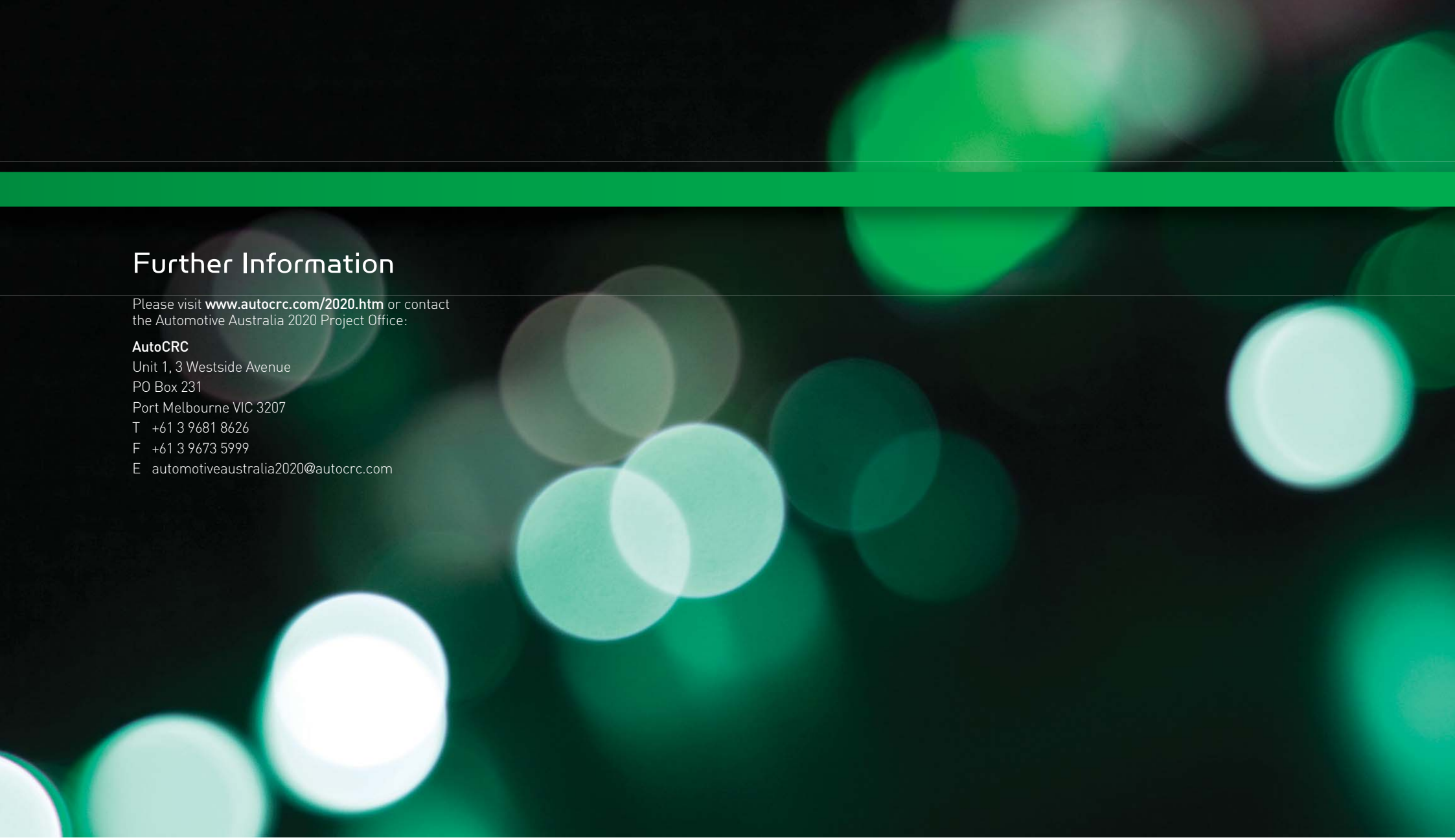
Harrington Industries

Harrop Engineering Australia

Hella Australia

Henkel Australia

Hoffman Engineering
Hook Plastics
Howe Automotive
HSV
Huntsman
I.N.C Corporation
Impco Industries
Intellimatics
Intercast & Forge
Iveco Trucks Australia
Kapsch
KPMG
Latrobe University
LPG Australia
Marand Precision Engineering
Mett
MHG Plastic Industry
Mitsubishi Australia
Monash University
MtM Automotive Components
National ICT Australia (NICTA)
National Union of Workers
Nissan Casting
Nitto Denko
NTC Powertrain
Orbital Australia
Origin Energy
Oz Press
PPG Industries Australia
Precise Machining and Manufacturing
Precision Plating
Prodrive Automotive Technology
Production Parts
Queensland University of Technology (QUT)
Quickstep Technologies
Rare Consulting
RMIT University
Robert Bosch Australia
Romteck
Royal Automobile Association of South Australia (RAA)
Sims Metal Management
SMR Automotive Australia
State Government of Victoria – Department of Industry, Innovation and Regional Development
State Government of Victoria – Department of Sustainability and Environment
State Government of Victoria – Department of Transport
State Government of Victoria – VicRoads
Sumitomo Corporation
Swinburne University
Tenneco Australia and New Zealand
Thales Australia
The Austrlian National University (ANU)
The Automotive Industry Innovation Council (AIIC)
TI Automotive
T-MAG
Toll Group
Toyota Boshoku
Toyota Motor Corporation Australia
Unidrive
University of Melbourne
University of Queensland (UQ)
University of South Australia (UniSA)
University of Sydney
University of Technology, Sydney (UTS)
Venture DMG
Victorian Centre for Advanced Materials Manufacturing (VCAMM)
Victorian Partnership for Advanced Computing (VPAC)
W. Granowski
Westport Innovations
ZF Boge Elastmetall Australia
ZF Lemforder Australia



# Further Information

Please visit **www.autocrc.com/2020.htm** or contact the Automotive Australia 2020 Project Office: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