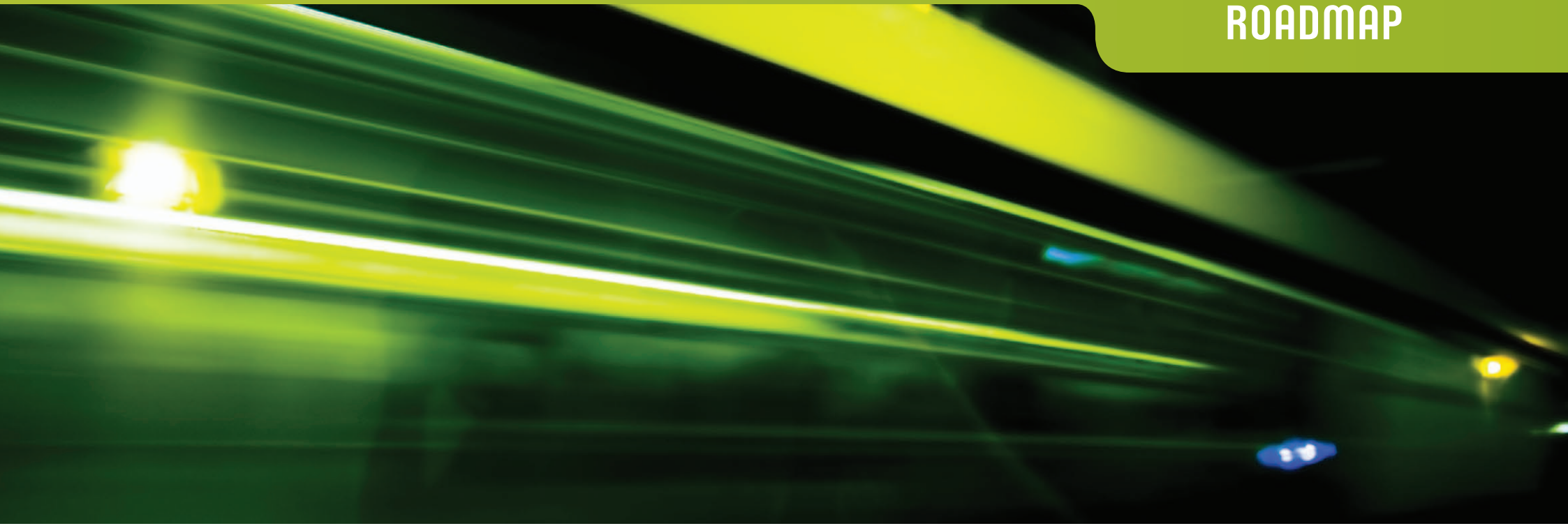
# on track to 2040

PREPARING THE AUSTRALIAN RAIL SUPPLY INDUSTRY FOR CHALLENGES AND GROWTH

## ROADMAP



ON TRACK TO 2040

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# Foreword

The Australian rail industry has been a vital part of our manufacturing sector for over a century.

The landscape in which our rail industry operates has changed significantly over recent times. We cannot secure the future of the Australian rail industry by persisting with the status quo. The emergence of low cost competitors has meant that the industry needs now, more than ever, to collaborate and build a new vision for the future. The industry also needs to invest in new technologies, new capabilities, improved productivity and skills.

In 2009 a strategic plan for the Australian rail industry was developed with the goal of developing the industry into a strong, globally competitive industry. To that end, the industry has been actively engaged in seven key initiatives to address challenges the industry faces, drive competitiveness and maximise opportunities.

These initiatives include:

- Supplier Continuous Improvement Program (SCIP)
- Demand forecasting for rolling stock
- Harmonisation of targeted rolling stock specifications
- Rail statistics
- Capability promotion and business matching
- Increasing international business opportunities
- Technology roadmap

This roadmap has brought industry stakeholders, government and academia together to deliver a vision for the Australian rail manufacturing sector's future.

This project has involved engagement by more than 210 representatives from 110 organisations. It will position the Australian rail supply sector well to continue to grow to 2040 and beyond.

*On Track to 2040* presents a unified view of the industry's technology and manufacturing capabilities but also the development opportunities these present.

This project is symbolic of the industry's determination to achieve a consensus on a vision – it outlines directions for future opportunities and pathways. Importantly it sets out necessary short-term decisions that will lay the foundations for long-term sustainability.

It gives rail manufacturers a common reference point by which to understand their opportunities and challenges and ensures unified communication across the industry and with governments.

I congratulate the industry on its support and engagement during the roadmap's preparation and encourage you to embrace it so we can harness these opportunities to innovate and to grow the Australian rail manufacturing industry.

**Bruce Griffiths**
Rail Supplier Advocate

# on track to 2040

## Glossary

| | |
|---|---|
| AC | Alternating Current |
| ADB | Asian Development Bank |
| ARA | Australasian Railway Association |
| CAD | Computer-Aided Design |
| CAM | Computer-Aided Manufacturing |
| CBTC | Communications-Based Train Control |
| COAG | The Council of Australian Governments |
| CRC | Cooperative Research Centre |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DBI | The Victorian Department of Business and Innovation |
| DC | Direct Current |
| DSDIP | The Queensland Department of State Development, Infrastructure and Planning. |
| DFSS | Design for Six Sigma |
| DIISRTE | The Commonwealth Department of Industry, Innovation, Science, Research and Tertiary Education |
| DSTO | The Defence Science and Technology Organisation |
| ECP | Electronically Controlled Pneumatic |
| EMMMv | The Exploration, Mining, Metals and Minerals Vertical |
| FEA | Finite Element Analysis |
| FMEA | Failure Mode and Effect Analysis |
| GUI | Graphical User Interface |
| HMI | Human Machine Interface |
| HPC | High Powered Computing |
| ICN | Industry Capability Network |
| LNG | Liquefied Natural Gas |
| NTCS | National Train Communications System |
| RBI | Risk Based Inspection |
| RISSB | The Rail Industry Safety and Standards Board |
| RISEG | Railway Industry Small Enterprise Group |
| SCIP | Supplier Continuous Improvement Program |
| SCOR | Supply Chain Operations Reference |
| SCOTI | Standing Committee on Transport and Infrastructure |

## Contents

# Executive Summary

**The Australian rail supply industry is a large one, ranging from small enterprises through to large multinationals. It is a vital manufacturing sector, providing more than 15,000 skilled, high paying jobs in urban and regional Australia. The Rail Industry Development Strategy identifies seven initiatives to raise the competitiveness of Australian rail suppliers, promote industry capabilities and maximise opportunities. In developing this strategy, it was recognised that the industry needed to drive the development of a united context in which to discuss the opportunities and challenges presented by the next 30 years. The On Track to 2040 roadmapping process was developed to address that need.**

## Vision

This roadmap represents a collective view of the industry as articulated by more than 210 participants from more than 110 organisations. The project has been championed by the Rail Supplier Advocate and is funded by state and federal governments in partnership with industry. Developed over ten months, On Track to 2040 defined an industry vision, identified 18 priority opportunities among 80 promising applications of local capability and technology, and presents 22 strategic recommendations that will support the industry in achieving its goals.

Supported by targeted interviews and research, more than 40 industry leaders developed an industry vision in response to national and global trends and drivers in areas including increasing competition, growing levels of urban congestion, higher fuel costs and skills shortages. The Australian industry must respond to these global market trends while addressing domestic challenges including lumpy procurement cycles, inadequate infrastructure and a lack of industry recognition, if it is to realise the opportunities of the future.

By developing an understanding of current and developing Australian capabilities, and aligning these with local and international markets, participants identified the opportunities and strategic objectives that prepare the rail supply sector for challenges and growth over coming decades.

The industry vision begins:

The Australian Rail Supply Sector will be innovative and cohesive, having developed a strong sense of industry. This united industry will be capable of embracing change, enabling it to respond to international trends and achieve profitable growth on a local and global scale.

How can Australia ensure its rail suppliers are prepared to capture growth opportunities?

## Challenges: The Current Context

To realise future opportunities, and the industry vision, requires more than technology development. The Australian rail industry has a long history characterised by diverse standards and requirements split across state, market segment and customer boundaries. This has resulted in a fragmented industry and small disparate markets. Despite this fragmentation, freight, passenger and heavy haul operations are today supported by a manufacturing and maintenance sector of more than 330 organisations. Further, the country boasts some world-leading rail technologies and systems. Examples include: heavy rail operations in the resource sector, and the world's largest urban tram network in Melbourne.

Australian rail manufacturers are experiencing unprecedented volatility due to trends in the global economy, especially in manufacturing industries. This dynamic external environment presents significant challenges. Globalisation and the dominant position of China in the Asia-Pacific region are now recognised facts of business, and increasing demand for Australian natural resources continue to place price pressures on locally manufactured goods. Challenges further extend into market areas, where operators face the need to evolve service offerings, increase capacity and improve performance to meet the growing needs of end users. Volatility, coupled with a historically slow rate of innovation in the sector, represent a need for action to ensure the rail supply industry is best equipped to meet future challenges.

## Opportunities for Growth

By adopting and implementing the industry vision and embracing change, rail suppliers will be able to position themselves to capture growth opportunities. There is increasing demand for urban and regional services due to demographic shifts. Larger projects in the passenger sector, such as high-speed rail operations to link Eastern capitals, are also on the horizon. In the freight sector, the energy and carbon efficiency advantages of rail over competing transport modes are being recognised, and there is continued strong demand from the resource sector as mining companies look for step-changes in productivity and have funds to support innovation.

Internationally, many of the same trends and drivers are stimulating interest in the rail sector. This presents opportunities for the Australian industry to contribute to the development of international rail projects, particularly in the Asian region. Strong demand for Australian capabilities is recognised around services such as design, planning and project management; civil works such as construction, tunnelling and infrastructure; and products such as signalling and air conditioning. The opportunities are large, growing and achievable throughout an innovative collavorative approach.

How can the rail manufacturing sector adapt to meet these future challenges?

## Outcomes

The On Track to 2040 process identified 80 opportunities for technological development (see Appendix A for a complete list). Industry stakeholders further prioritised the key opportunities that were most attractive and best satisfied the vision. This highlighted three broad areas of opportunity:

### Materials and Manufacturing

Opportunities were identified for innovation in manufacturing processes that reduce production costs, and new high performance materials to reduce weight and increase payloads in the heavy haul sector.

### Monitoring and Management

Opportunities identified included improved operational, maintenance and safety systems, representing the potential to more effectively and efficiently use current infrastructure, while enhancing safety.

### Power and Propulsion

Opportunities identified respond to drivers such as the increasing cost of fuel and increasing attention on emissions reduction.

Within each of these opportunity areas, six high priorities were identified and detailed roadmaps developed. These roadmaps show a potential path from the current industry capabilities to filling the future market needs.

Achieving these opportunities requires more than just technology development. A key outcome is the further identification of strategic implementation priorities for all industry stakeholders. By linking strategic and technological objectives the roadmap represents a coherent strategy to realise the opportunities presented. A strong, innovative industry will require action by all industry stakeholders across six implementation areas.

### Governance

Structures and approaches that build momentum to promote, implement and maintain the roadmap.

### Policy

Integrated support action from state and commonwealth governments.

### Research

Strategies that directly enable the development of new technology.

### Funding

Identification and allocation of appropriate resources.

### Collaboration

Efforts between stakeholders to achieve common, pre-competitive goals.

### Standardisation and Regulation

Mechanisms to facilitate unified specifications and safety standards across states and markets.

Development of this roadmap as a collaborative strategy document is an implementation step in itself, representing the initial realisation of vision objectives for a more cohesive and collaborative industry.

## Future steps and collaboration

This report consists of two sections. The first presents an overall strategic view of the rail supply industry including the vision, identification of broad opportunity areas and resulting implementation plans and recommendations. The second describes the technology opportunities for the Australian rail supply industry. Through detailed opportunity roadmaps stakeholders defined a path that builds on the current industry capabilities to satisfy market needs.

Each implementation plan and opportunity roadmap that forms the project outcomes was developed by participants to highlight the steps required to support the industry vision, realise the priority opportunities and prepare the Australian rail supply sector for challenges and growth. These led to the development of 22 strategic recommendations – priority actions identified by stakeholders. By embracing the strategic and technology priorities identified in the roadmap, the industry can set itself on course toward achieving its vision, becoming more collaborative, cohesive and competitive to 2040 and beyond.

# Summary of Findings

**The following list summarises recommended implementation actions and priority technology opportunities. By taking these actions, the Australian rail supply industry will take the first steps toward realising the identified opportunities and set course toward achieving its vision.**

## Strategic

Across the six implementation priority areas, 22 recommendations for stakeholder action were identified:

### Governance

- Establish steering committee
- Appoint industry champion
- Promote roadmap and outcomes

### Regulation and Standardisation

- Define and catalogue national standards
- Establish a single safety and standards body
- Target funding toward standardisation

### Funding

- Map available funding sources
- Consolidate funding
- Prioritise funding toward roadmap

### Collaboration

- Develop business case for change
- Establish test and development facility
- Facilitate data access
- Open software architecture

### Research

- Establish manufacturers research body
- Align research funding to roadmap
- Investigate technologies in allied industries
- Benchmark rail against similar industries

### Policy

- Define national rail policy agenda
- Establish rail development agency
- Provide incentive for strategic rail R&D
- Prioritise rail relevant engineering education
- Define and establish efficiency targets

## Technological

Six opportunities were identified in each of the technological priority areas for a total of 18 potential applications of Australian expertise:

### Materials and Manufacturing

- Advanced design
- Low cost manufacturing systems
- High performance materials for heavy haul
- Advanced manufacturing
- Advanced materials for lightweighting
- Simulation for materials and manufacturing

### Monitoring and Management

- Automated health monitoring for smarter infrastructure
- Automated control and operations
- Advanced asset management systems
- Safety threat detection, intervention
- Advanced data analysis and information systems
- Advanced operations management

### Power and Propulsion

- Energy regeneration
- Advanced braking systems
- Energy use management tools
- Electric motors and systems
- Emissions reduction technologies
- Gaseous fuels

# Introduction

## Preparing for challenges and growth

**The On Track to 2040 project has developed a roadmap to drive the Australian rail supply sector toward its vision of a strong, cohesive, innovative and globally competitive industry.**

This roadmap has been the product of extensive industry participation with more than 210 representatives from over 110 stakeholder organisations involved in process. It forms one of seven initiatives in the Rail Industry Development Strategy as championed by the Rail Supplier Advocate.[1]

The project is funded in partnership by:

- The Commonwealth Department of Industry, Innovation, Science and Research, and Tertiary Education (DIISRTE);
- The Victorian Department of Business and Industry (DBI);
- Queensland Department of State Development, Infrastructure and Planning (DSDIP);
- New South Wales Department of Trade and Investment, Regional Infrastructure and Services; and
- The Australasian Railway Association (ARA) on behalf of industry, with the strong support of:
  - Bombardier Transportation Australia,
  - Downer EDI Rail, and
  - United Group Limited.

Developed over ten months, On Track to 2040 defined an industry vision, identified 18 priority opportunities among 80 promising applications of local capability and technology, and presents 22 strategic recommendations that will support the industry in achieving its goals.

## Scope and scale of the industry

The Australian rail industry provides passenger, freight and heavy haul services across the country. Today these three sectors are supported by a manufacturing and maintenance sector made up of more than 330 organisations. A 2011 survey[2] measured the extent and economic impact of the rail supply sector, finding a strong industry with revenues of $4.26 billion, employing 15,000 workers and adding $1.6 billion to the Australian economy each year. The rail supply industry provides high paying, skilled jobs with approximately 13% of firms headquartered in regional centres.

Over the last 30 years, freight and passenger sectors have fared differently. The passenger sector has shown only modest growth when compared to the increasing use of road and air transport. More recently however, competing modes have shown a levelling (in annual passenger-kilometre terms) in the Australian marketplace, while the rate of adoption of rail has increased more sharply.

1 Department of Industry Innovation Science, Research and Tertiary Education, *Industry Development Strategy*, January 2012.
2 Department of Innovation, Industry, Science and Research, *A Profile of the Railway Manufacturing Industry in Australia*, 2011.

In the case of freight transport, Australia's use of bulk freight in resource and agriculture areas has kept total amount of freight transport (measured in tonne-kilometres) in relative balance with road freight over time. The long-term trend continues to be for rapid increase in this sector.

A recent ARA report[4] shows that population growth alone represents an annual need for 250 passenger cars for the next 30 years. Urbanisation and congestion factors influencing choice of transport mode could double this need – metropolitan rail investment has been highlighted as government priority[5].

Bigger projects are also looming, with Department of Transport scoping studies for Australian high-speed rail projects totalling more than $60 billion[6]. In the freight sector, the energy and carbon efficiency advantages of rail over competing modes yield opportunities to capitalise on environmental concerns and a carbon restricted economy.[7]

Additionally, there is continued strong demand from the resource sector as mining companies demand improved productivity and have funds to support innovation.

## An international perspective

In 2010 the Worldwatch institute assessed that the total number of train sets is to rise by 70%, to 3,725 by 2015[8]. This significant growth in the rail sector will include projects in Asia, Europe, North Africa, the Middle East, South America, Russia and the USA. Within the Asian region, the Asian Development Bank (ADB) has identified opportunities for projects in the areas of sustainable transport development, intelligent transport systems and new fuel and vehicle technologies[9]. Studies have identified that, within the Asia region, transport systems improvements have not been keeping pace with demand despite considerable investment. The ADB is currently supporting rail projects in Bangladesh, Vietnam, Kazakhstan and India.

**FIGURE 1** AUSTRALIAN DOMESTIC PASSENGER TRAVEL BY MODE OF TRANSPORT. SOURCE: BITRE INFRASTRUCTURE STATISTICS YEARBOOK, 2011[3]

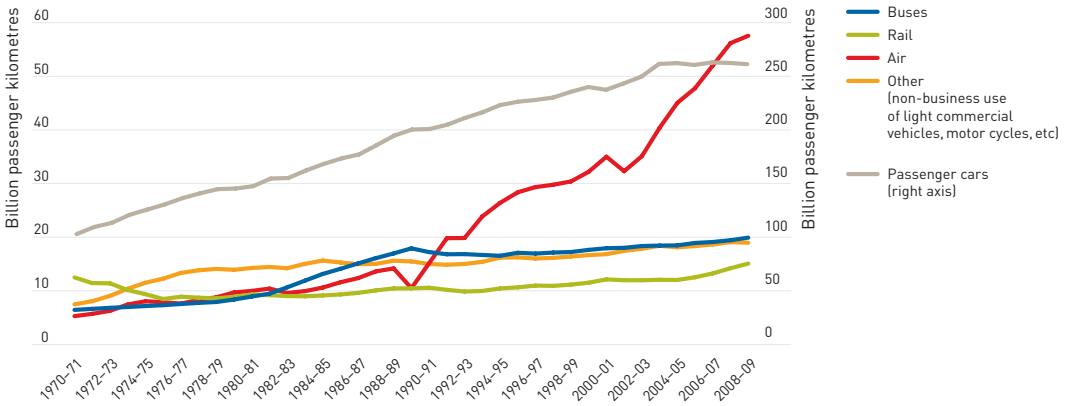
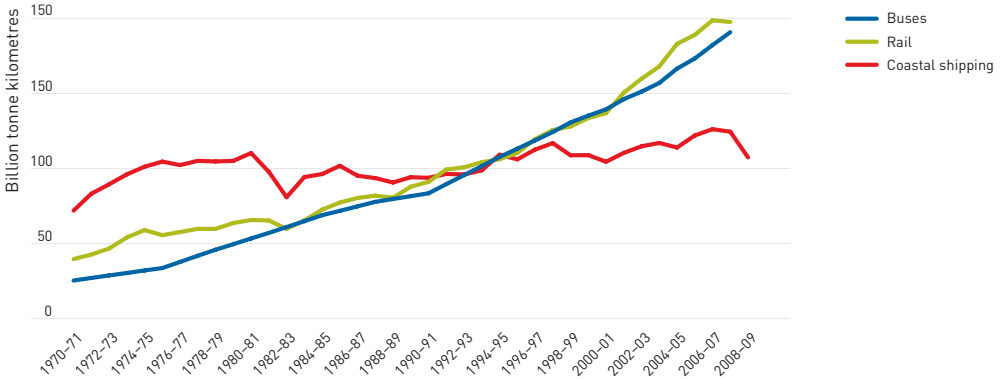



**FIGURE 2** AUSTRALIAN DOMESTIC FREIGHT TRANSPORT BY MODE. SOURCE: BITRE INFRASTRUCTURE STATISTICS YEARBOOK, 2011[3]




3 Bureau of Infrastructure, Transport and Regional Economics, *Yearbook 2011 – Australian Infrastructure Statistics*, 2011.
4 The Australasian Railway Association, *Submission to the Prime Minister Taskforce on Manufacturing: Consultation Issues Paper*, February, 2012.
5 The Treasury, *Australia to 2050: future challenges*, 2010.
6 AECOM Australia Pty Ltd, *High Speed Rail Study – Phase 1*, 2011.
7 The Australasian Railway Association, *The True Value of Rail*, 2011.
8 Michael Renner and Gary Gardner, *Global Competitiveness in the Rail and Transit Industry*, September, 2010.
9 Asian Development Bank, *Sustainable Transport Initiative, Operational Plan*, July, 2010.

## On Track to 2040

The 10-month process uses international best-practice strategic roadmapping techniques to understand where the industry is now, develop a vision for where stakeholders see the industry in 2040, and articulate a coordinated plan to see the vision achieved.

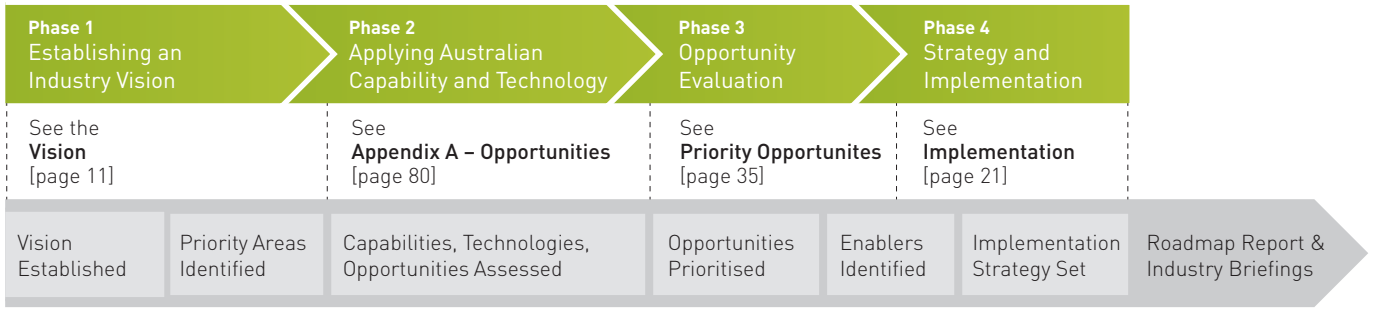



**FIGURE 3** THE ON TRACK TO 2040 ROADMAPPING PROCESS INVOLVED FOUR PHASES OVER APPROXIMATELY 10 MONTHS. PROJECT OBJECTIVES AND DELIVERABLES ARE SHOWN IN THE GREY BAR.

# vision

Establishing a clear vision for the industry is the first step in developing a roadmap. By understanding where industry stakeholders aspire to drive the industry by 2040, a strategic path between the industry's current state and this vision – a roadmap – can be defined. In August 2011, a Vision Workshop was convened with representatives spanning public and private operators; Tier 1, 2, and 3 suppliers; state and federal governments; industry bodies; and researchers. Participants in the workshop identified and prioritised key themes in areas that include innovation, sense of industry, global recognition and building on competitive advantage. In connecting these themes, participants described a vision.

The Vision (right) highlights opportunities for the Australian rail supply industry to deliver more effective, more efficient, higher quality service to its direct customers, and the broader rail market. These three areas of effectiveness, efficiency and quality provided a focus for following stages of the roadmap project.

**In 2040, the Australian Rail Supply Sector will be innovative and cohesive, having developed a strong sense of industry. This united industry will be capable of embracing change, enabling it to respond to international trends and achieve profitable growth on a local and global scale.**

The sector will have developed effective and integrated national and international supply chains linked to a globally competitive manufacturing base. Australian suppliers will achieve recognition as innovative developers and integrators of technology and intellectual property, collaborating with partners inside and outside the supply sector to develop scalable solutions. By leveraging the networks of international partners, Australian suppliers will gain access to new markets that build on local competitive advantages.

Investing in opportunities with global scale that are driven by customer needs and provide world-class standards of safety, reliability, performance and efficiency, Australian suppliers can deliver leading technologies to the world. The supply sector, collaborating with the wider industry to address global drivers and market trends, will help rail become the transport mode of choice, providing strong integration to the broader transport sector. This thriving, profitable, vibrant supply industry will attract a growing, adaptable, skilled workforce and will be the first choice for customers and operators.

# Local and Global Trends

**Establishing the realistic and informed vision described in the previous section requires insight into the context in which the Australian rail supply industry operates. It was therefore necessary to understand global trends and drivers that impact society in general, the industry, and its customers specifically.**

Input data was gathered through a combination of methods, with workshop participants analysing and prioritising this input based on their industry knowledge and experience. Input data sources included:

- A review of existing available information and international roadmaps
- Interviews with senior representatives of all key stakeholder groups
- Direct interaction with the industry at events and training sessions
- Pre-workshop surveys to gain participant perspectives

Through this process of gathering additional detail and perspectives of the industry stakeholders to augment academic research inputs, trends and drivers having the greatest relevance and impact on the Australian rail industry were identified. Trends and drivers were collected in three key areas shown in Figure 4.

### EXTERNAL TRENDS AND DRIVERS

THESE ARE THE MAJOR GLOBAL FACTORS OF INFLUENCE FOR SOCIETY AND, AS A CONSEQUENCE, THE RAIL SECTOR.

KEY THEME AREAS INCLUDE:

- SOCIAL
- TECHNOLOGICAL
- POLITICAL AND LEGAL
- ECONOMIC
- ENVIRONMENTAL
- REGULATORY

### PROCUREMENT PLANS AND LIFE CYCLES

AUSTRALIA'S RAIL INDUSTRY IS UNIQUE. WHILE RELATIVELY SMALL, HISTORICAL DIVISIONS ACROSS STATE BORDERS HAVE CAUSED FRAGMENTATION AND LITTLE COLLABORATION ACROSS SECTORS. PROCUREMENT IS VOLATILE, HAVING THREE TYPES OF CUSTOMERS WITH VERY DIFFERENT PROCUREMENT APPROACHES. DIRECT CUSTOMERS INCLUDE:

- PUBLIC OPERATORS
- PRIVATE OPERATORS
- INFRASTRUCTURE PROVIDERS

### STAKEHOLDER TRENDS AND DRIVERS

THESE ARE THE INTERNAL NEEDS OF MEMBERS OF THE RAIL SUPPLY CHAIN, WHICH INCLUDES OTHER TANGENTIALLY RELATED SERVICE AND SUPPORT PROVIDERS.

STAKEHOLDERS INCLUDE:

- TIER 1 SUPPLIERS
- TIER 2, AND 3 SUPPLIERS
- RESEARCHERS
- SERVICE PROVIDERS
- GOVERNMENTS
- INDUSTRY BODIES

**FIGURE 4** CLASSIFICATION OF TRENDS AND DRIVERS

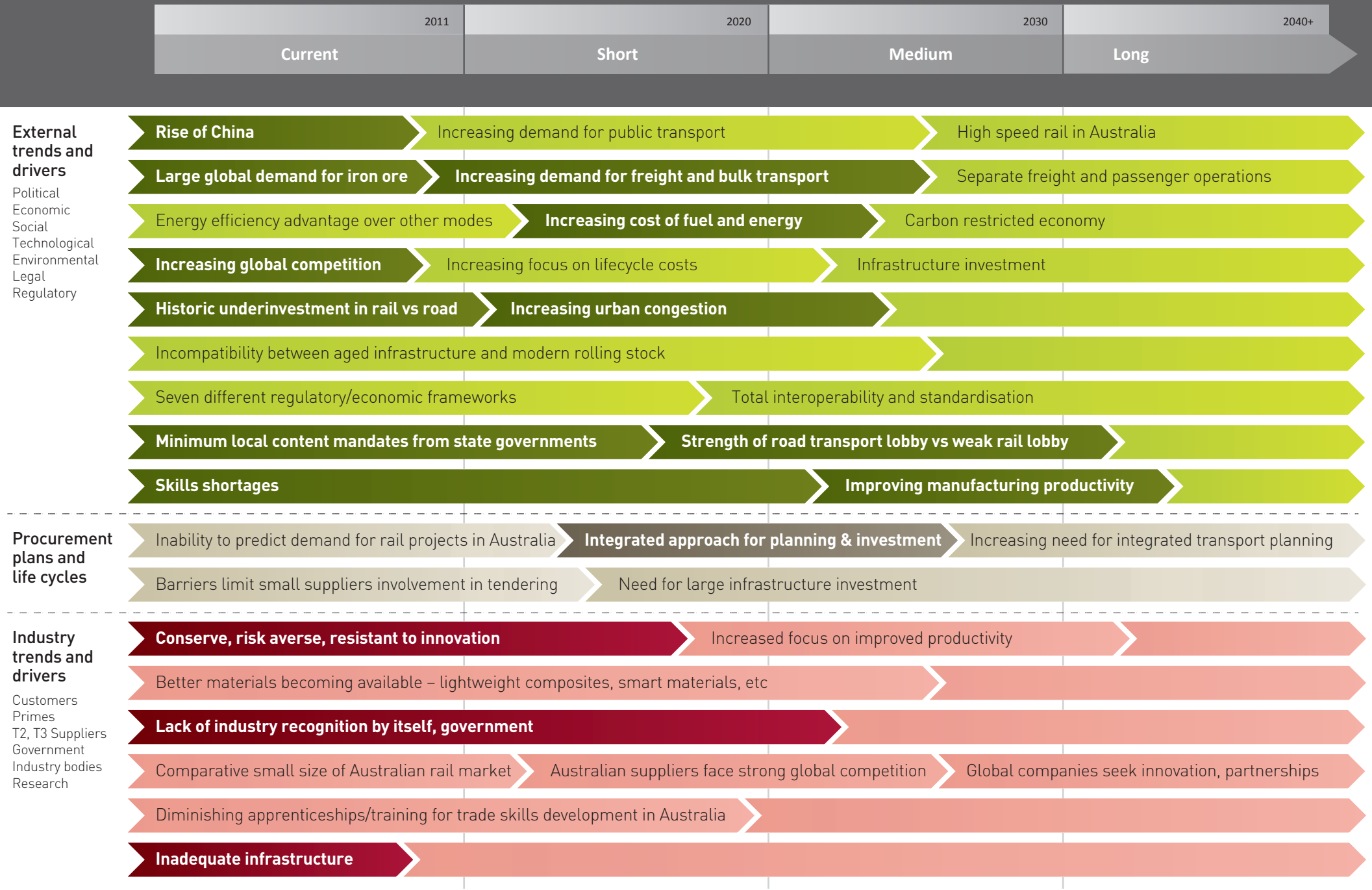



**FIGURE 5** THE TOP TRENDS AND DRIVERS SELECTED BY RAIL INDUSTRY STAKEHOLDER ARE SHOWN IN THREE LAYERS: EXTERNAL, INTERNAL AND PROCUREMENT PLANS. THE RESULTS OF A PRIORITISATION EXERCISE CAN ALSO BE SEEN WITH THOSE SELECTED BY MORE THAN 25% OF PARTICIPANTS SHOWN IN BOLD TYPE.

To understand the most relevant factors, participants were asked to select drivers having impact on their own organisation, their segment of the supply sector, or on the industry more broadly. Three levels of priority were determined based on the total votes allocated by participants to each trend or driver: Important (those receiving votes from multiple participants); Key (those receiving votes from more than 10% of participants across multiple stakeholder groups); and Priority (those selected by more than 25% of participants). While only Key and Priority trends are described in this report, a complete list was published in the vision report.[10]

Having this knowledge of the trends and drivers most relevant to the industry allowed participants to shape their vision for the future of the Australian rail supply sector. By ensuring the opportunities that eventuate from the process meet these trends and drivers, and satisfy the industry vision, the strongest link can be assured with the wider needs of local and international markets. This connection between market, industry vision and technology strategy ensures the rail industry is best prepared to deal with future challenges and achieve growth through upcoming opportunities.

A broad initial search for potential opportunities to address these trends and drivers was conducted as part of the Vision Workshop. Participants examined the potential for opportunities from a market pull perspective by looking toward areas of need. By categorising the opportunities identified, eight market need areas across three market priorities were identified. Participants were also asked to identify factors that would allow us to determine whether a potential opportunity in any of these areas would help the industry satisfy its vision. These factors formed an evaluation framework discussed in detail on page 35.

These areas of need (shown in Figure 6) shaped the search for potential opportunities. Later stages of the On Track to 2040 process involved examinations of the technologies and capabilities required to realise opportunities, and any barriers or gaps to be overcome.

**EFFECTIVE OPERATIONS**

THERE IS A RECOGNISED NEED TO DELIVER IMPROVED THROUGH-LIFE PERFORMANCE TO DIRECT CUSTOMERS AND END USERS INCLUDING:

- INCREASED CAPACITY
- IMPROVED RELIABILITY

**QUALITY SERVICE**

OPERATORS, PASSENGERS, FREIGHT CONSIGNEES AND OTHER MEMBERS OF THE SUPPLY CHAIN CONTINUE TO DEMAND MORE RESPONSIVENESS AND SAFETY OUTCOMES INCLUDING:

- CUSTOMER INFORMATION
- PRODUCT DELIVERY
- INCREASED SAFETY

**EFFICIENT SYSTEMS**

IMPROVED COST EFFICIENCIES HAVE A DIRECT IMPACT ON PROFITABILITY, WHILE ENVIRONMENTAL PRESSURES DRIVE A NEED TO REDUCE IMPACT INCLUDING:

- REDUCED COST
- LOWER EMISSIONS
- LIMITED EXTERNAL IMPACT

**FIGURE 6** THREE AREAS OF MARKET NEED IDENTIFIED BY INDUSTRY LEADERS.

10 ANU Edge, *On Track to 2040 – Vision*, August 2011.

## International opportunities

The Australian rail supply sector has the opportunity to leverage local skills and knowledge to provide products and services into international markets. There is a demand in the Asian region for the development of large-scale infrastructure. This work has included significant rail projects in developing nations. Some immediate opportunities have been identified by Austrade[11] and others:

- Malaysia ($12 b.)
- Vietnam ($7.7 b.)
- Indonesia ($2.8 b.)[12,13]
- Cambodia ($140 m.)[14]
- Philippines ($4.7 b.)[15]
- Thailand ($7.9 b.)

Strategic efforts to identify and expand international opportunities have also been made. Recent Supplier Advocate initiatives have included:

- Industry Mission to China and Hong Kong 2012
- Austrade Rail Mission to Hong Kong 2011
- Australian Mission to InnoTrans, Berlin

These projects show the level of growth in rail infrastructure in the Asian region. Such projects in developing nations will need expertise and experience in provision of rail services and products. Australian rail suppliers will have opportunities to access these markets, leveraging their local capabilities and experiences.

## Import replacement

The Australian rail industry operates in a project driven market place with uneven demand cycles and requirements that are developing over time. At the same time the industry is facing increasing competition from international suppliers.

Over the past decade, successful import replacement and local content projects have provided significant contributions to the Australian rail supply sector. Some examples of these include the Adelaide Electric Multiple Unit and, the Vlocity Diesel Multiple Unit trains and Electric Multiple Unit trains for Perth with around 70% local content. Locally realised benefits extend to investment in production process development and tooling, and large opportunities for Tier 2 and 3 suppliers. Through careful planning and targeted product development, the Australian Rail supply sector has the capabilities to provide competitive import replacements.

Opportunities identified through the On Track to 2040 process have the potential to replace future imports. Import replacement can be encouraged and supported by:

- Supply chain collaboration,
- Asset utilisation, or
- New technology development.

### Supply Chain Collaboration

There is an opportunity for Australian suppliers to provide internationally competitive products into the domestic market through increased collaboration. These opportunities have been identified in the following areas:

- Coordinated approaches to resources development projects
- Development of integrated subsystems packages for supply to prime contractors
- Early supplier involvement freight route upgrades (eg: Melbourne to Hastings route)

### Asset Utilisation Opportunities

There is also a growing demand for increased effectiveness in the utilisation of current assets. This presents an opportunity for Australian supplier to provide solutions through products and services in this area that include:

- Asset management including: Inspection technologies, data evaluation and Risk Based Inspection (RBI) technologies as used in other industries.
- Smart planning of national freight corridor updates including: planning and construction of passing loops and improved intermodal terminals.
- Use of smart technologies for grade separation.

### New Technology Development

As the rail industry is developing, consumers and operators are demanding new technology development and this must be integrated into contracts. To ensure that the Australian supply sector can compete within the international market place, opportunities for Australian suppliers have been identified in the following areas:

- Signalling and control solutions
- Smart design to increase the life of rolling stock and networks
- Renewable energy use for smart detection equipment and outstations
- Regenerative braking for currently non-regenerative tram and trains systems
- Emissions reducing technology
- Passenger information systems

11 Austrade, *ASEAN Rail and Mass Transit Opportunities*, 2010.
12 *The Jakarta Post*, 27/07/2010
13 *The Jakarta Post*, 01/12/2011
14 *Asian Development Bank – Rehabilitation of the Railway in Cambodia Project*
15 *Bloomberg News*, 24/04/2012

# Preparing for Challenges and Growth

Where are we now?

Where do we want to be?

How can we get there?

## What is a roadmap?

The roadmap provides structured approach to presenting the complex interconnections in the industry over time. It aims to answer the key questions and develop the key understandings described above. To achieve this the roadmap works to construct layer-by-layer, a picture of the industry, its positioning in the wider community and its evolution toward strategic goals over time. Each layer examines a manageable portion of the overall roadmap.

### Trends and Drivers

These have been described in the preceding section of the report, but represent the evolution of factors in the internal and external environment that impact the industry. Such factors include social, political and economic considerations in the wider community, and how these translate to needs in the market and within the industry itself.

### Opportunities

By understanding the factors of influence, the industry can then examine potential solutions to pressing problems that represent opportunities to grow existing business, expand into new areas, or change direction to mitigate threats. To become more than just an application of technology, an opportunity must build on existing technical capacity and give strategic consideration to overcoming any gaps and barriers.


**FIGURE 7** SCHEMATIC REPRESENTATION OF A STRATEGIC ROADMAP. THE PROCESS OF DEVELOPING A ROADMAP SEEKS TO ANSWER THREE KEY QUESTIONS: WHERE ARE WE NOW? WHERE DO WE WANT TO BE? HOW CAN WE GET THERE?

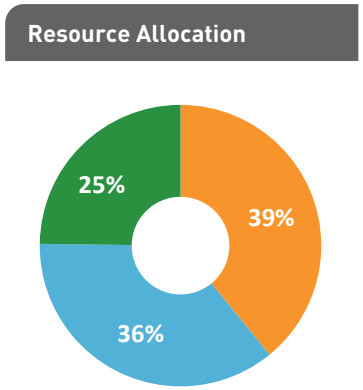




**FIGURE 8** STRENGTH OF CORRELATION BETWEEN MARKET AND TECHNOLOGICAL PRIORITY AREAS AND RESOURCE ALLOCATION AS A PERCENTAGE OF INDUSTRY INVESTMENT FOCUS ON EACH TECHNOLOGICAL AREA.

### Technologies and Capabilities

Current technical capacity is assessed by the size and competitiveness of the capability and technology currently in use in the industry. Some can be directly translated into realising an opportunity, while others will need gaps and barriers addressed before success can be achieved.

### Enabling Actions

Finally, enabling actions can be defined to build on support mechanisms and actions already existing in the industry. These will be the steps taken to cause opportunities to be exploited by overcoming barriers and addressing gaps.

## The On Track to 2040 Roadmap

This entire report should be viewed as the On Track to 2040 Roadmap, with the graphic presented on the following page serving as a top-level summary and a guide to the more detailed information presented in other sections of the report.

## Technical priority areas

Importantly, On Track to 2040 provides strategic direction for the rail supply industry. With this aim in mind the opportunities, capabilities and technologies in the roadmap have been broken down across three technical priority areas that encompass all of the priority opportunities that were identified in the process. Each of these technical areas, and the opportunities they contain, have the potential to impact the market need areas defined by the vision group (presented in the previous section). For this reason, each Priority Area has been evaluated against the need areas and the correlation is shown in the Figure 8.

Additionally, industry leaders were asked to rate the relative importance of each area by determining the percentage of future industry focus and investment that should be applied to each Priority Area. This allocation (as shown in the Figure 8), should be considered while examining the detailed information presented later in this report.

**FIGURE 9** SHOWN ON THE NEXT PAGE, THE ON TRACK TO 2040 ROADMAP PROVIDES AN OVERVIEW OF INTERNAL AND EXTERNAL TRENDS AND DIVERS; OPPORTUNITIES THESE REPRESENT FOR THE AUSTRALIAN RAIL INDUSTRY; CAPABILITIES AND TECHNOLOGIES THAT COULD BE LEVERAGED TO SUPPORT THESE OPPORTUNITIES; AND ENABLING ACTIONS TO ADDRESS ANY GAPS AND BARRIERS.

# Roadmap

| | Current | Short 2020 |
|---|---|---|
| **Trends and Drivers** | | **Short term trends and drivers:** Australian suppliers are facing increasing and strong global competition from countries such as China. Inadequate infrastructure and historic underinvestment present opportunities to improve performance and capacity, while new materials with improved performance characteristics are increasing available design options. |
| **Opportunities** | **Current capabilities and technologies**<br>In the short term, only capability currently existing in the sector can be used to realise the identified opportunities due to lead times in the development of new technical or operational capacity. Capacity will be built on these existing capabilities in the manufacturing and supply base.<br>Over time, complementary capabilities available in other industries will be adapted for rail applications, while other novel capabilities are developed based on the outcomes of research programs currently under way.<br>More information about the technology and capability development is presented in the detailed sections for each opportunity. | **Materials and Manufacturing**<br>**Advanced design** 2020<br>Exploit new approaches and computational methods to improve commercial outcomes of R&D<br>**Monitoring and Management**<br>**Automated health monitoring for infrastructure** 2016<br>Remote, built-in health data monitoring systems to allow predictive maintenance of fixed assets<br>**Automated control and operations** 2020<br>Operator-less trains and operational systems<br>**Power and Propulsion**<br>**Energy regeneration** 2018<br>Recovery of waste heat and kinetic energy for reuse on-board or in trackside applications<br>**Energy use management tools** 2020<br>Approaches and software to intelligently minimise energy consumption in driven and driverless trains |
| **Enabling Actions** | **Existing support**<br>Existing industry bodies and funding sources should be coordinated and leveraged to support the recommended implementation actions identified within the roadmap. | **Immediate actions**<br>The momentum of the roadmap needs to maintained. This requires effective communication amongst stakeholders, establishment of governance structures, focus of research funding and industry collaboration to support the initial implementation of the roadmap. |

**Medium** 2030 | **Long** 2040

**Medium term trends and drivers:** Continued increases in the cost of energy, coupled with recognition of rail's efficiency advantages over other modes. In the freight sector, demand for Australian resources remain a driving factor. Growth in passenger will be driven by increasing urbanisation and congestion concerns. More broadly, continued global competition and skills shortages will require renewed focus on productivity improvement. To enable continued growth, global companies will increasingly seek innovation from partners.

**Long term trends and drivers:** Integrated approaches to transport planning will see large infrastructure investment, particularly in areas like high speed rail and segregation of passenger and freight. Interoperability and standardisation will be commonplace, while the carbon restricted economy will drive continued focus on efficiency and low-emission fuels or energy sources.

### Low cost manufacturing systems — 2022
Improved processes to ensure competitiveness with low manufacturing volumes

### High performance materials for heavy haul — 2025
Solutions to overcome physical limitations and allow capacity improvements up to 45T axle loads

### Advanced manufacturing — 2030
Develop processes that increase competitiveness and drive technology development in the supply sector

### Advanced materials for lightweighting — 2032
New substances that reduce weight without sacrificing cost or performance

### Simulation for materials and manufacturing — 2040
Accurate techniques for digital verification of new designs, materials and methods before manufacture

### Advanced asset management systems — 2020
Predictive maintenance (based on data) to drive increased asset utilisation and longer lifecycles

### Safety threat detection, intervention — 2025
Standardisation of data measurement, delivery and processing to improve safety outcomes

### Advanced data analysis and information systems — 2030
Algorithms and processing methodologies to intelligently manage and interpret available data

### Advanced operations management systems — 2030
Tools and approaches to use available data to improve and automate operational performance

### Advanced braking systems — 2025
Rollout and retrofit of electronically controlled pneumatic (ECP) and regenerative braking systems

### Gaseous fuels — 2025
Development and implementation of LPG or LNG locomotives and supporting infrastructure

### Electric motors and systems — 2030
Retrofit installation of AC traction and high-efficiency power electronic systems for locomotives

### Emission Reduction Technologies — 2035
Alternative and renewable fuels, and system to reduce non-carbon emissions

### Ongoing priority actions
In the medium term actions are required to support a national approach to rail. This includes the establishment of standards and regulations, appropriate policy conditions and support to foster research and collaboration to see the development of a vibrant, innovative and cohesive rail supply industry supplying products to domestic and international markets.

## Priority opportunities

Eighteen priority opportunities, as presented in the three opportunity areas of the roadmap on the previous page were highlighted by participants as critical for more detailed analysis. These are a subset of the 80 opportunities identified but not prioritised, that are shown in Appendix A on page 80. The results of this analysis are presented in later sections. It is also important to consider how these priority opportunities link to the market needs defined by participants while establishing the vision. Figure10 provides a quick reference allowing correlation between priority opportunities and the market needs they impact.

**FIGURE 10** STRENGTH OF CORRELATION BETWEEN MARKET PRIORITY AREAS AND OPPORTUNITIES.

● Strong Correlation ◉ Moderate Correlation

### Materials and Manufacturing

This area covers all types of material, and design for lightweighting, improved performance and cost reduction. Also included are manufacturing process improvements, particularly cost effective, short run solutions.

| Effective Operations | | Quality Service | | | Efficient Systems | | | Materials and Manufacturing Opportunities | Page |
|---|---|---|---|---|---|---|---|---|---|
| Enhanced Capacity | Improved Reliability | Customer Information | Product Delivery | Increased Safety | Reduced Cost | Lower Emissions | Limited External Impact | | |
| ◉ | ◉ | | ● | | ● | ◉ | | Advanced design | 40 |
| ◉ | | | ● | | ● | | | Low cost manufacturing systems | 42 |
| ◉ | ◉ | | | | | | | High performance materials for heavy haul | 44 |
| | ◉ | | ● | | ● | | | Advanced manufacturing | 46 |
| ◉ | | | | | | ◉ | | Advanced, lightweight materials | 48 |
| ◉ | ◉ | | ● | | ◉ | ◉ | | Simulation for materials and manufacturing | 50 |

### Monitoring and Management

This area covers all aspects of management and safety systems: sensors (on-board and off); remote telemetry and communications; data management; analysis; systems design and integration; and safety solutions.

| Effective Operations | | Quality Service | | | Efficient Systems | | | Monitoring and Management Opportunities | Page |
|---|---|---|---|---|---|---|---|---|---|
| Enhanced Capacity | Improved Reliability | Customer Information | Product Delivery | Increased Safety | Reduced Cost | Lower Emissions | Limited External Impact | | |
| | ● | ● | | | ● | ◉ | | Automated health monitoring for infrastructure | 54 |
| ● | | ◉ | | ◉ | ● | ◉ | | Low cost manufacturing systems | 56 |
| | ● | ● | | | ● | ◉ | | Advanced asset management systems | 58 |
| ◉ | ● | | | ● | ◉ | | | Safety threat detection, intervention | 60 |
| ◉ | ◉ | ◉ | ◉ | ◉ | ◉ | ◉ | | Advanced data analysis and information systems | 62 |
| ● | | ● | | | ◉ | ● | | Advanced operations management systems | 64 |

### Power and Propulsion

This area covers all elements of fuel and energy delivery, storage, management and regeneration; as well as braking systems, emissions reduction technology and general equipment efficiency.

| Effective Operations | | Quality Service | | | Efficient Systems | | | Power and Propulsion Opportunities | Page |
|---|---|---|---|---|---|---|---|---|---|
| Enhanced Capacity | Improved Reliability | Customer Information | Product Delivery | Increased Safety | Reduced Cost | Lower Emissions | Limited External Impact | | |
| ◉ | | | | | ◉ | ● | | Energy regeneration | 68 |
| ◉ | | | | | ◉ | ● | ● | Advanced braking systems | 70 |
| ◉ | | ◉ | | | ● | ● | | Energy use management tools | 72 |
| ◉ | | | | | | ◉ | | Electric motors and systems | 74 |
| ◉ | | | | | | ● | | Emissions reduction technologies | 76 |
| ◉ | | | | | ● | ● | | Gaseous fuels | 78 |

# Implementation

**Roadmapping is an exercise that has been undertaken in a range of different industries around the world. Assessment of roadmapping has shown that the delivery of the roadmap is only one step in successfully realising benefits for the industry. These assessments have also shown that the benefits to the industry are not only the strategic direction provided by the roadmap but far broader.**

This section addresses the steps that industry leaders have defined to sustain and realise the benefits of the roadmap. These enabling actions, and the associated recommendations, are in response to world's best practice in roadmapping and subsequent implementation.

## World's Best Practice

To fully realise the benefits of a roadmap requires movement from a one-time activity to the establishment of a roadmapping culture. Successful roadmapping is seen as a three-stage process in Figure 11.

During the development of a first industry roadmap, success can be measured through the level of stakeholder involvement in the process. The second phase, implementation of the first roadmap, should see changes within the industry, including:

- Strategic alliances;
- New projects and resources;
- New participants;
- Linkages and references to the roadmap;
- Changes in R&D directions and policies;
- Increased number and type of technological solutions; and
- Products developed and commercialisation activity.

The final phase sees the development of an industry-sustained roadmapping culture. By making strategic planning part of the industry culture stakeholders will see the addition of new participants to the process, monitoring of outcomes and the iteration of the first roadmap in response to industry change and development.

Research has shown that successful implementation of a roadmap requires action in a range of different areas including industry governance, policy, research and collaboration. Each of these areas are addressed in detail in the following sections and include priority actions identified through On Track to 2040 that will initiate and sustain a successful long-term roadmapping culture.

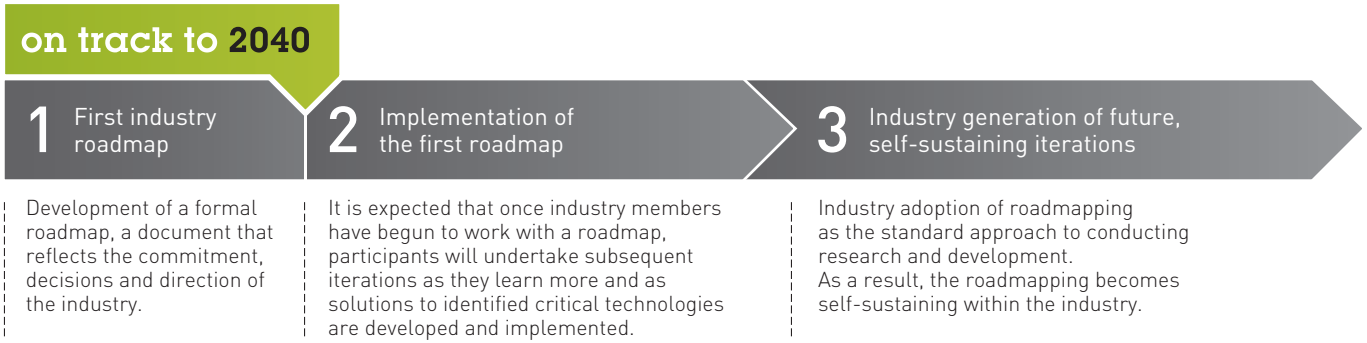



**FIGURE 11** BEST PRACTICE IN ROADMAP IMPLEMENTATION[16].

16 Industry Canada, *Evaluating Technology Roadmaps – A Framework for Monitoring and Measuring Results*, 2007.

## Governance

International experience has shown that the most successful roadmapping exercises maintain the momentum generated by the roadmapping exercise itself and translate this momentum into an industry-driven self-sustaining culture of industry strategic planning. Maintaining cross-stakeholder participation through a coordinated governance system is a key element of this objective. Eventually, success depends on transfer of ownership and responsibility to industry representatives, while retaining involvement from other stakeholders. As industry trends, capabilities and needs evolve, the roadmap should be updated periodically, with future iterations dependent on the pace of change observed in the industry.

Critically, effective champions with seniority and influence within government and industry must support the roadmap through coordinated communication. Wide distribution and promotion of initial outcomes (at trade shows, meetings, events, seminars, conferences, etc.) should be supported through ongoing dissemination of success stories, promotion of the roadmap among companies as a tool to guide strategic technology planning, and continuous feedback opportunities.

### Objectives

Participants identified an industry-led governance structure as an initial need. Such a structure should be established to lead efforts in the area of rail manufacturing strategy, including: harmonisation of standards, innovation, pre-competitive collaboration and roadmap implementation. A body should be established with strong support from all stakeholders – industry, policy-makers, state governments, unions, national and industry bodies, and research organisations. Clear definition of terms of reference, objectives and membership of the group were indicated as priority actions, with initial suggestions including:

- **Stakeholder representatives:** CEOs of Primes (ARA manufacturers group); RISSB; RISEG; and the Rail Supplier Advocate.
- **Strong interfaces in their areas of expertise are needed with:** ICN, RISSB, the CRC for Rail Innovation, State Governments, and the Commonwealth.
- **Key objectives:** Establish the body and terms of reference (1 year); A roadmap for cost-effective procurement (1 year); Drive harmonised standards (1-3 years); Establish Australian Design Rules for rail (5-10 years).

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding governance are suggested.

The industry should:

**Recommendation G1:**

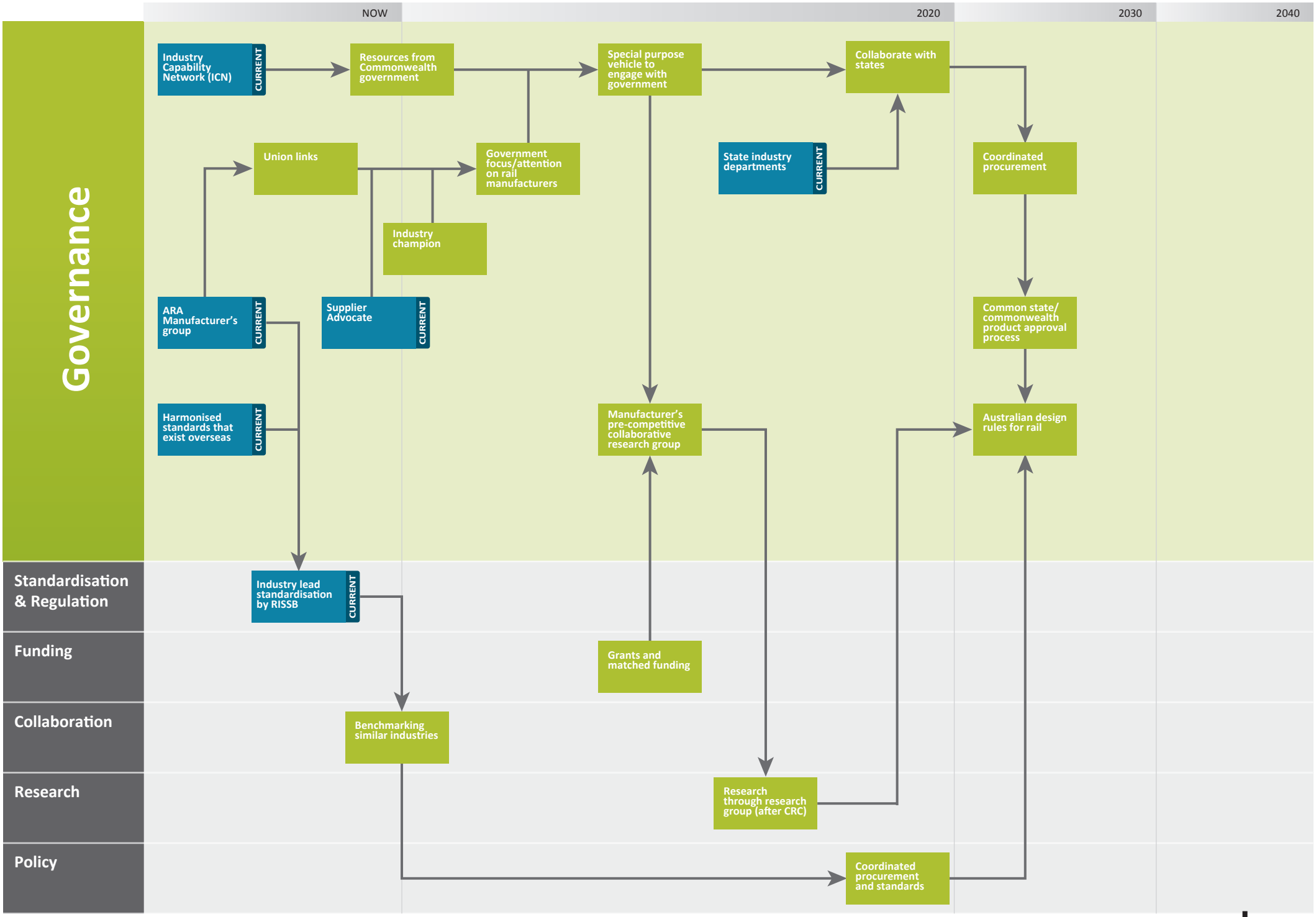
Fund an industry steering committee to facilitate collaboration, drive roadmap implementation and the communication of progress to government.

**Recommendation G2:**

Identify and appoint a rail supply industry champion to provide industry leadership with a mandate to drive policy and facilitate collaboration.

**Recommendation G3:**

Promote the outcomes of the roadmap and publicise them throughout supplier, operator and state and federal networks.


NOW
2020
2030
2040
Governance
Industry Capability Network (ICN)
CURRENT
Resources from Commonwealth government
Special purpose vehicle to engage with government
Collaborate with states
Union links
Government focus/attention on rail manufacturers
State industry departments
CURRENT
Coordinated procurement
Industry champion
ARA Manufacturer's group
CURRENT
Supplier Advocate
CURRENT
Common state/ commonwealth product approval process
Harmonised standards that exist overseas
CURRENT
Manufacturer's pre-competitive collaborative research group
Australian design rules for rail
Standardisation & Regulation
Industry lead standardisation by RISSB
CURRENT
Funding
Grants and matched funding
Collaboration
Benchmarking similar industries
Research
Research through research group (after CRC)
Policy
Coordinated procurement and standards

## Standardisation and Regulation

This area is an industry specific implementation area that was apparent through all stages of the On Track to 2040 process as a source of concern and need amongst participants. While not a feature of all strategic roadmapping activities, the volume of enabling actions and needs identified in the area of standardisation has caused it to be separated here.

### Objectives

A national regulator comes into place in January 2013 and should seek input from all industry bodies (including international bodies in target markets or with complementary expertise). This will allow the identification and prioritisation of standardisation gaps within the first year. Over the 5 following years, and with the support of industry, federal and state governments, and the public, standards can be integrated in a number of key areas, such as: risk management; asset management; operations and maintenance; and product specification.

In the next 8-10 year timeframe, an enforceable set of nation-wide, performance-based standards can be established based on internationally relevant benchmarks with the strong support of national bodies including the ARA, RISSB and research organisations. Beyond technology standardisation, work toward harmonisation of procurement specifications and processes has already commenced.

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding standardisation are suggested.

The industry should:

**Recommendation S1:**

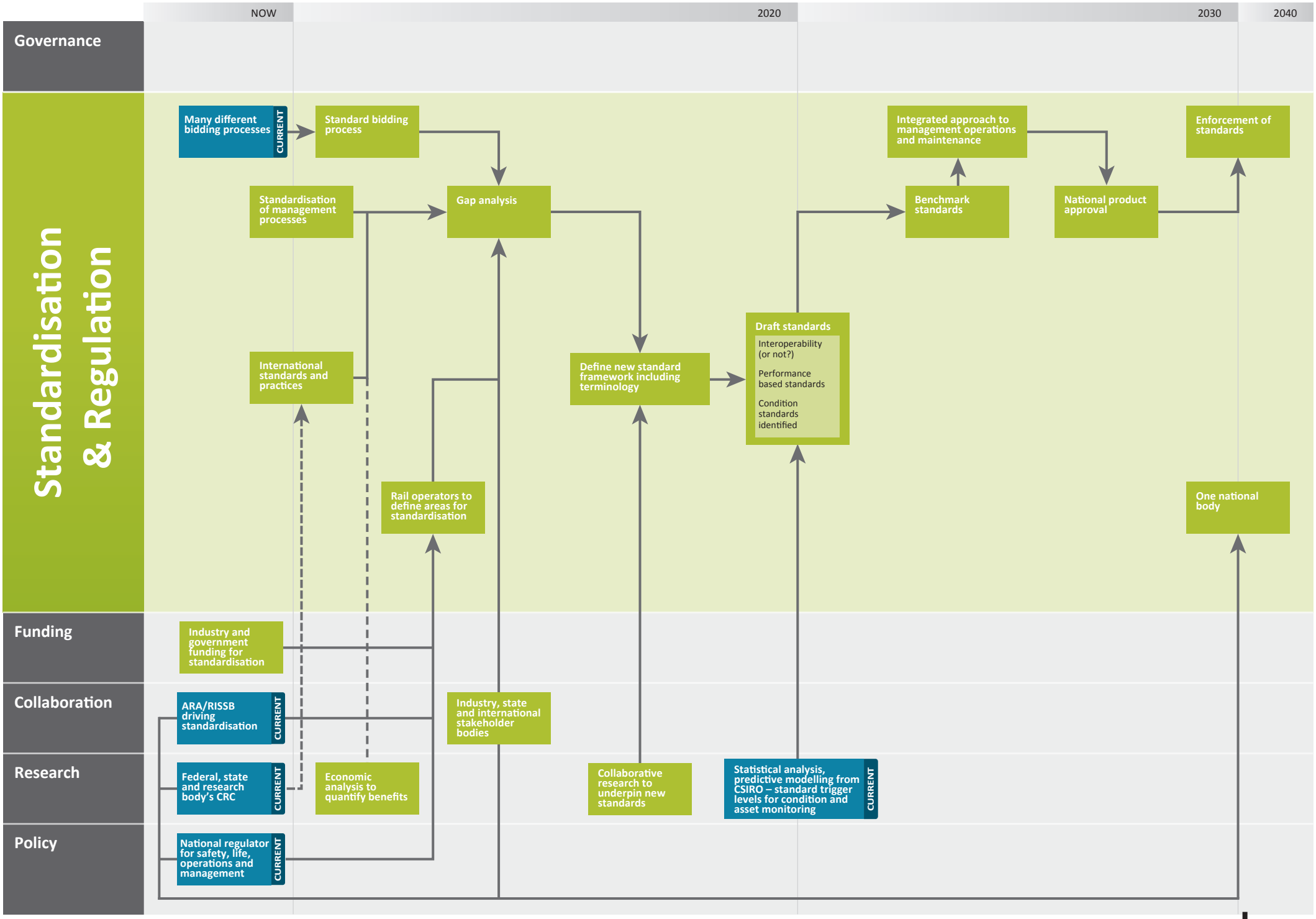
Through research and collaboration identify the benefits of standardisation and where appropriate define and catalogue national industry standards in the areas of: data and communication, product approval and validation, bidding processes, safety, wayside energy storage, inter-modal cargo handling, electronic systems, and risk management.

**Recommendation S2:**

Coordinate a national body in which there is representation from industry, research, and federal and state government to oversee the definition and enforcement of future national rail standards.

**Recommendation S3:**

Provide funding to support standardisation within the industry.


NOW
2020
2030
2040
Governance
Standardisation & Regulation
Many different bidding processes
CURRENT
Standard bidding process
Standardisation of management processes
Gap analysis
International standards and practices
Define new standard framework including terminology
Draft standards
Interoperability (or not?)
Performance based standards
Condition standards identified
Benchmark standards
Integrated approach to management operations and maintenance
National product approval
Enforcement of standards
Rail operators to define areas for standardisation
One national body
Funding
Industry and government funding for standardisation
Collaboration
ARA/RISSB driving standardisation
CURRENT
Industry, state and international stakeholder bodies
Research
Federal, state and research body's CRC
CURRENT
Economic analysis to quantify benefits
Collaborative research to underpin new standards
Statistical analysis, predictive modelling from CSIRO – standard trigger levels for condition and asset monitoring
CURRENT
Policy
National regulator for safety, life, operations and management
CURRENT

## Funding

Funding is a very public signal of intent, but should not be viewed as the sole domain of the public sector. Mechanisms can be implemented to align funding across sectors: industry, research and government. As stakeholders begin to see funding and investment decisions linked to roadmap opportunities and recommendations, interest and participation levels will increase.

Funding actions should be aligned with the roadmap priorities to ensure other implementation areas are taken forward. Potential mechanisms to achieve this outcome have been implemented overseas and include using the roadmap alignment as a decision criterion in tender processes, and encouraging companies and consortia to develop their own aligned roadmaps.

### Objectives

Participants indicated an immediate need to understand available sources of funding and to quantify the need for funding to support On Track to 2040 opportunities. By communicating the Technology Roadmap broadly in the industry, stakeholders can begin to understand their needs, however there is inadequate centralised knowledge about existing funding options. It was proposed that a national body be resourced appropriately to undertake a study of available funding sources and link these to specific strategic needs. This would allow targeted, effective collaboration and lobbying based on a clear understanding of available funds, the needs of industry participants and a coordinated plan.

Beyond existing traditional sources of funding, participants indicated a need for new collaboration models to provide mechanisms for realising the opportunities at the Tier 2 and Tier 3 levels.

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding funding are suggested.

The industry, along with funding providers, should:

**Recommendation F1:**

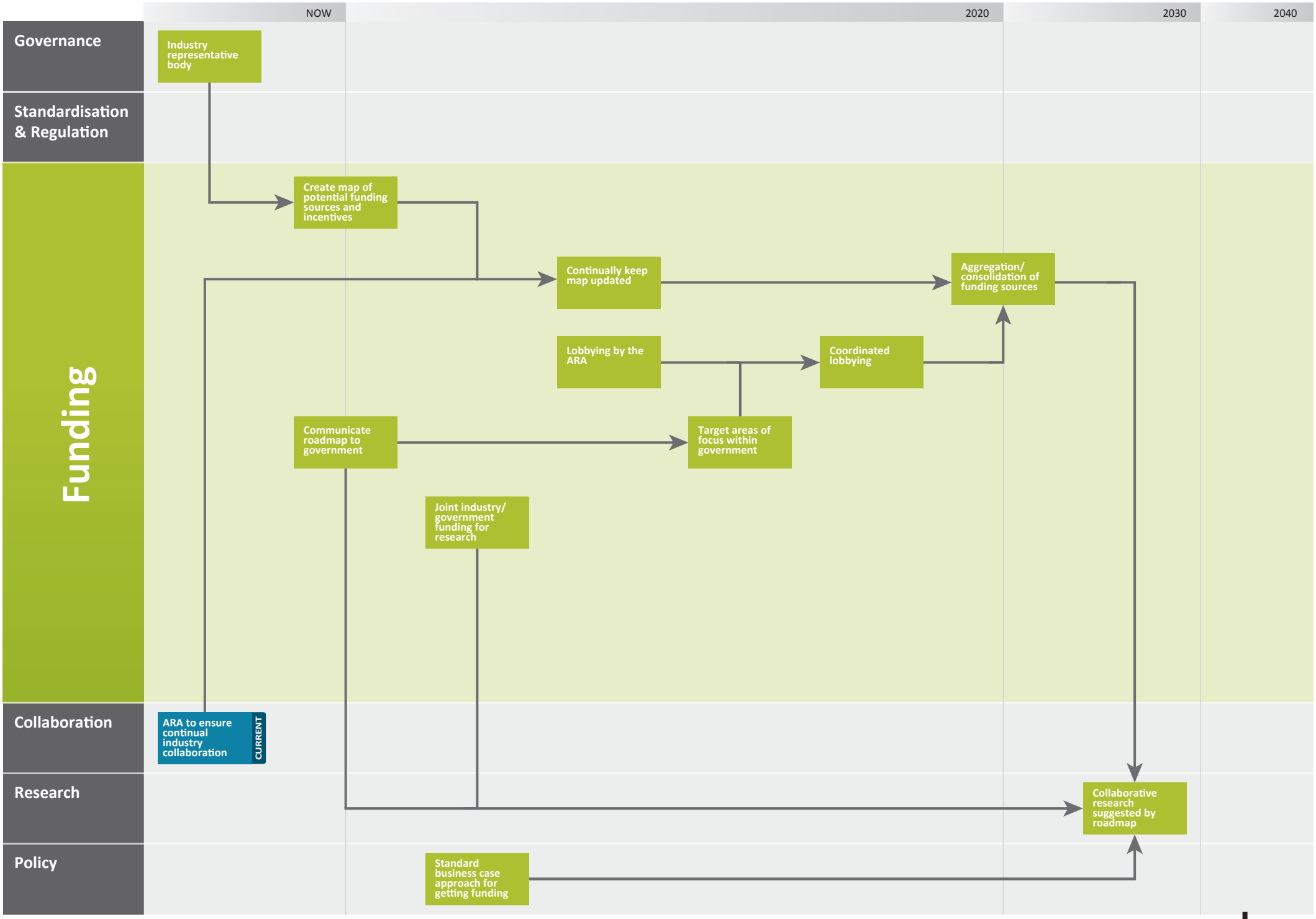
Create, maintain and publicise a map of accessible funding sources relevant to the rail industry in order to improve the visibility and funding outcomes.

**Recommendation F2:**

With active engagement of all stakeholders, aggregate and consolidate funding sources to improve accessibility and minimise duplication.

**Recommendation F3:**

Prioritise technologies identified in the On Track to 2040 roadmap when considering where to invest or offer funding. Such concerns include funding toward: the continuation of Australian manufacturing, the increase of productivity, the calculation of costing new products or processes, the building of demonstration models for new technologies, research and development, the writing of software for energy and asset management as well as automation, improvements to infrastructure, and the productisation of new rail technologies.


NOW
2020
2030
2040
Governance
Standardisation & Regulation
Funding
Collaboration
Research
Policy
Industry representative body
Create map of potential funding sources and incentives
Continually keep map updated
Aggregation/ consolidation of funding sources
Lobbying by the ARA
Coordinated lobbying
Communicate roadmap to government
Target areas of focus within government
Joint industry/ government funding for research
ARA to ensure continual industry collaboration
CURRENT
Collaborative research suggested by roadmap
Standard business case approach for getting funding

## Collaboration

International best-practice in implementation suggests that a key collaborative objective is the work of industry associations to promote the use of the roadmap as a tool for companies to guide strategic technology investment and business planning. It is important that initial implementation activities focus on knowledge transfer across industrial boundaries and science base disciplines by prioritising collaborative projects (domestic and international).

Measures of participation in the roadmap across the industry are recognised as the most important metrics for success and future sustainability. These metrics include resulting decisions, actions, communication, consensus, and collaboration. Through strong encouragement and participation from industrial leaders to set the right direction, the industry can seek the most immediate successes to build and sustain momentum.

### Objectives

Workshop attendees determined that the first target for collaboration should be the establishment of an appropriate, industry-led governance body to drive rail manufacturing strategy. This could only be achieved with all stakeholders working toward agreement on either a new or existing body, that can be endorsed and supported industry-wide. Further, within the first 6 months, appropriate roles for all stakeholders (government, operators researchers, industry bodies, manufacturers, suppliers, service providers and the public) should be agreed to define the makeup of the representative body described in the Governance section.

Participants also proposed that collaboration facilitators be appointed to forge links between customers, manufacturers and researchers. With the support of the steering committee, these facilitators would define metrics and KPIs, evaluate potential opportunities and make appropriate collaborative or funding links between stakeholders.

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding collaboration are suggested.

The industry as a whole should collaborate in such a way as to:

**Recommendation C1:**

Undertake market research and develop a business case for all the priority opportunities in order to fully understand the feasibility and profitability ("bang for buck") of medium and long-term opportunities.

**Recommendation C2:**

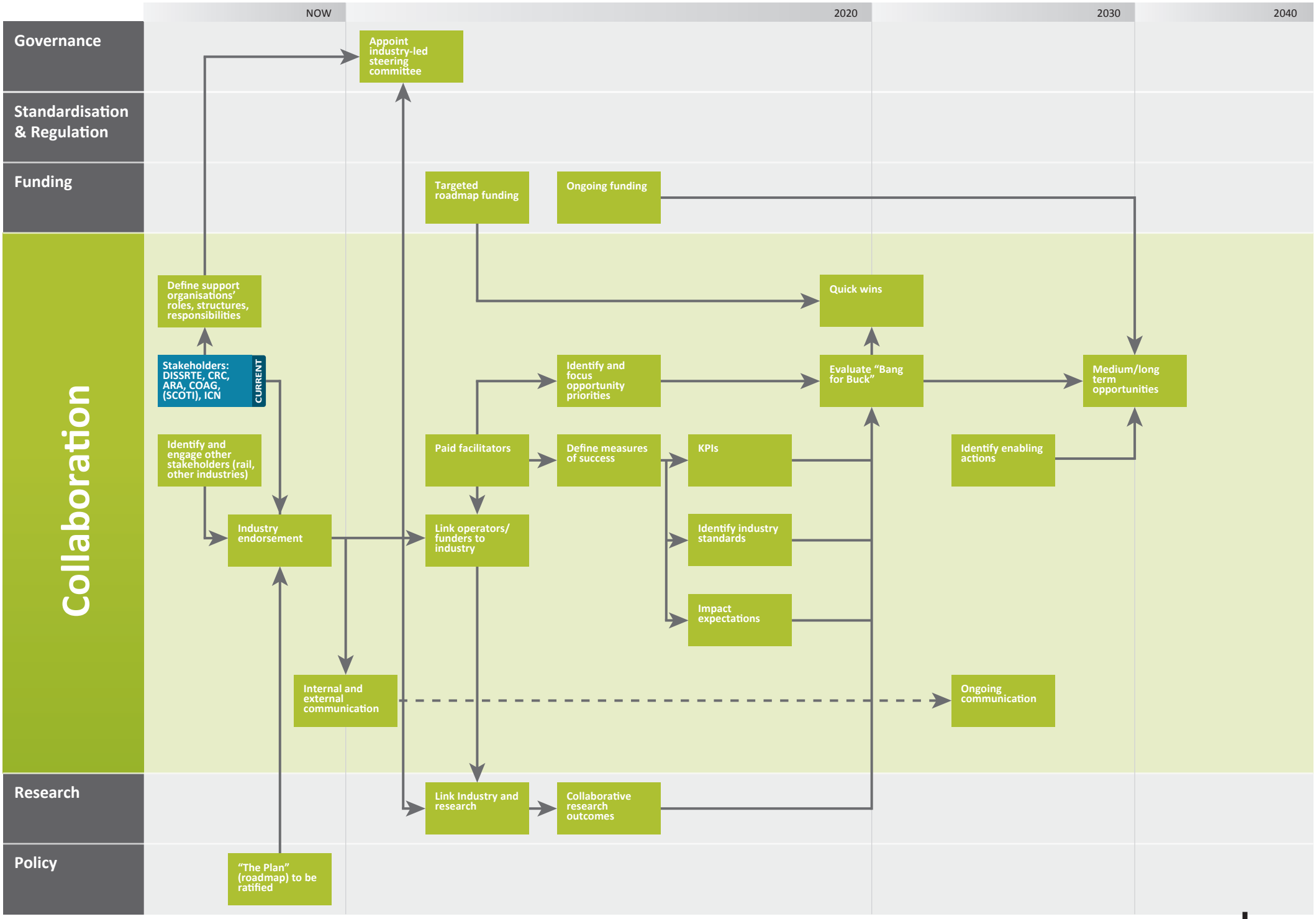
Establish an appropriate national facility for the development, testing and demonstration of new rail technology.

**Recommendation C3:**

Provide access, via a nationally agreed framework, to currently captured data such as temporary speed restrictions and route information for the development of effective monitoring and management systems.

**Recommendation C4:**

Establish a software platform based on open architecture for the integration of rail to allow computerised monitoring and control.


NOW
2020
2030
2040
Governance
Standardisation & Regulation
Funding
Collaboration
Research
Policy
Appoint industry-led steering committee
Targeted roadmap funding
Ongoing funding
Define support organisations' roles, structures, responsibilities
Quick wins
Stakeholders: DISSRTE, CRC, ARA, COAG, (SCOTI), ICN
CURRENT
Identify and focus opportunity priorities
Evaluate "Bang for Buck"
Medium/long term opportunities
Identify and engage other stakeholders (rail, other industries)
Paid facilitators
Define measures of success
KPIs
Identify enabling actions
Industry endorsement
Link operators/ funders to industry
Identify industry standards
Impact expectations
Internal and external communication
Ongoing communication
Link Industry and research
Collaborative research outcomes
"The Plan" (roadmap) to be ratified

## Research

On Track to 2040 provides a framework that can be used to guide research direction and funding. It highlights relationships amongst different research activities, allowing opportunity for coordination of research program objectives. Further, the roadmap provides a common reference point for communication of the sector's research objectives to potential partners and customers, and its research needs to potential supporters.

### Objectives

A new research program is required that interfaces with all stakeholders and is specifically focused on an innovation agenda for manufacturing. The current CRC for Rail Innovation will finish in 2014, meaning timing is critical if the momentum of the roadmap and the knowledge embedded in existing researcher skill base is to be maintained. Participants described a need for a new collaborative research entity (possibly a new CRC or an entity based on another collaboration model) to be established in 2013.

To achieve research goals, strong links to the governance body will ensure support and alignment of objectives. Specifically, potential support areas identified included: expanded partnerships (internal and with other industries); national research programs, international collaboration and benchmarking; incentives (such as tax cuts); support from operators; support form large manufacturers; and standardisation.

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding research are suggested.

The industry should:

**Recommendation R1:**

Establish a research body, through the CRC scheme or an alternative, with joint government and industry funding to facilitate and promote rail supplier technology development.

**Recommendation R2:**

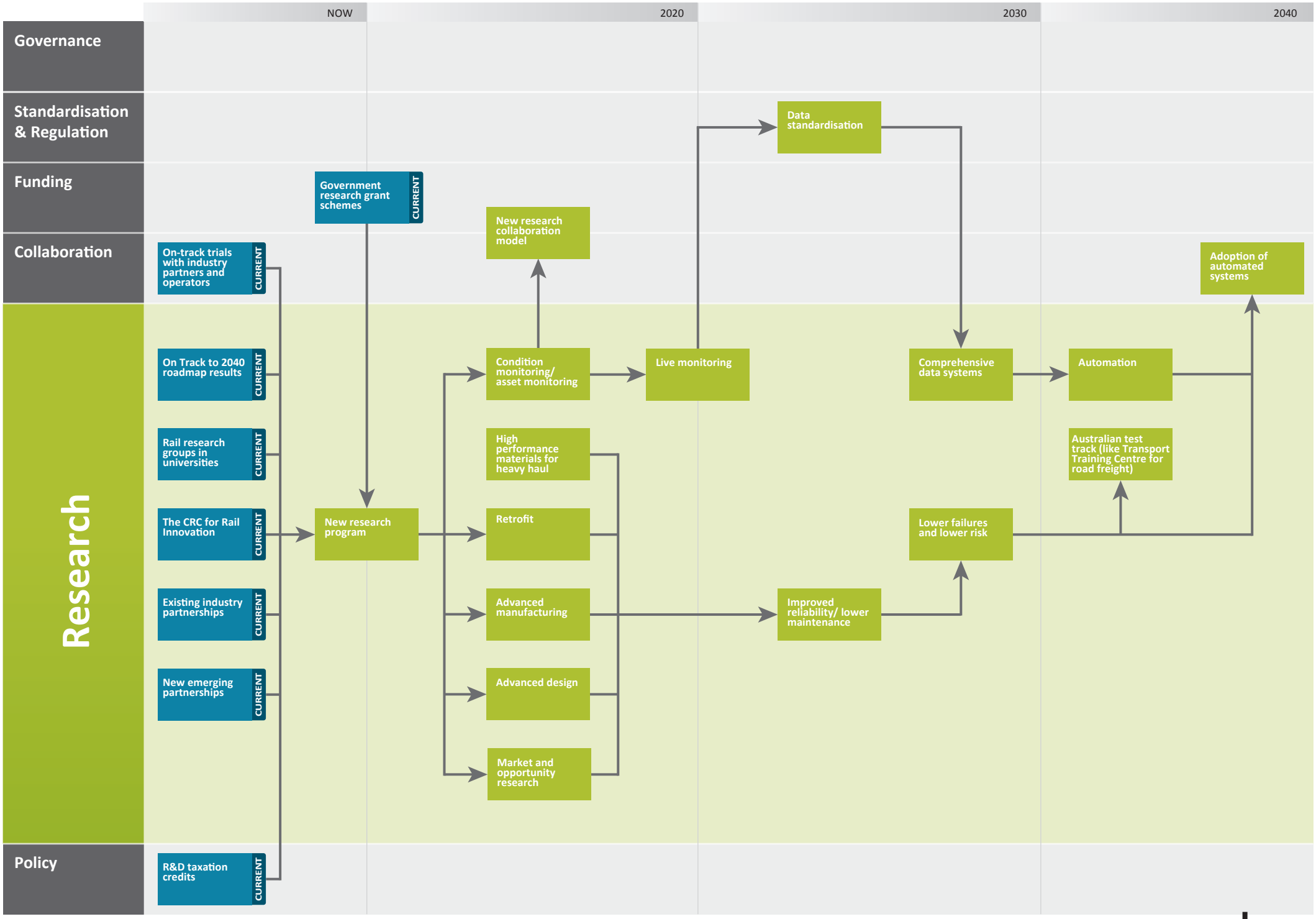
Research grant schemes in rail technology should be aligned with the technologies identified in the On Track to 2040 roadmap including: advanced design, high-performance materials for heavy haul, advanced manufacturing, gaseous and alternative fuels, advanced braking systems, asset management, energy networks and storage, simulation for manufacturing, risk assessment, automation, and retrofitting.

**Recommendation R3:**

Investigate existing technologies from other industries, including areas such as batteries, super-capacitors, simulation and analysis, low cost manufacturing processes and non-destructive testing to identify the value and applicability of these technologies to rail.

**Recommendation R4:**

Establish benchmarks against similar industries to drive competitiveness and efficiency in the rail supply sector.


NOW
2020
2030
2040
Governance
Standardisation & Regulation
Funding
Collaboration
Research
Policy
Government research grant schemes
CURRENT
On-track trials with industry partners and operators
CURRENT
New research collaboration model
Data standardisation
Adoption of automated systems
On Track to 2040 roadmap results
CURRENT
Condition monitoring/ asset monitoring
Live monitoring
Comprehensive data systems
Automation
Rail research groups in universities
CURRENT
High performance materials for heavy haul
Australian test track (like Transport Training Centre for road freight)
The CRC for Rail Innovation
CURRENT
New research program
Retrofit
Lower failures and lower risk
Existing industry partnerships
CURRENT
Advanced manufacturing
Improved reliability/ lower maintenance
New emerging partnerships
CURRENT
Advanced design
Market and opportunity research
R&D taxation credits
CURRENT

## Policy

Governments have a cross-sectoral position allowing influence and coordination to support the implementation of industry-level strategic programs. It is important that outcomes and objectives are communicated widely throughout government departments, using the roadmap as a key tool to promote "joined up government". Through effective policy, governments are able to link to otherwise disjointed objectives, including: regulation; skills and training; incentives and penalties; and standards.

### Objectives

Participants presented their key objective in this area and expressed a need, by 2015, to have an integrated national transport policy covering all modes. Strong support form all stakeholders was highlighted as critical to the achievement of such policy, with a strong industry champion having responsibility and accountability to drive the process indicated as particularly important. This champion would be closely tied to the governance group and its interfaces with other stakeholder groups like CSIRO, ARA, ICN, universities, federal and state governments, industry bodies and unions.

To achieve this goal, participants indicated policy formation and implementation to be needed across a number of relevant matters, including: research, safety, environment, procurement, innovation, interoperability, supply chain integration, skills formation and training.

### Recommendations

By examining enablers across all sections of the roadmaps, the following recommendations regarding policy are suggested.

Policy makers should:

**Recommendation P1:**

Define a national bipartisan rail industry policy agenda through state collaboration to position rail as being in the national interest in order for the industry to access more commonwealth resources.

**Recommendation P2:**

Establish a national rail development agency to promote and define a national approach to rail policy and promote rail within the national transport agenda.

**Recommendation P3:**

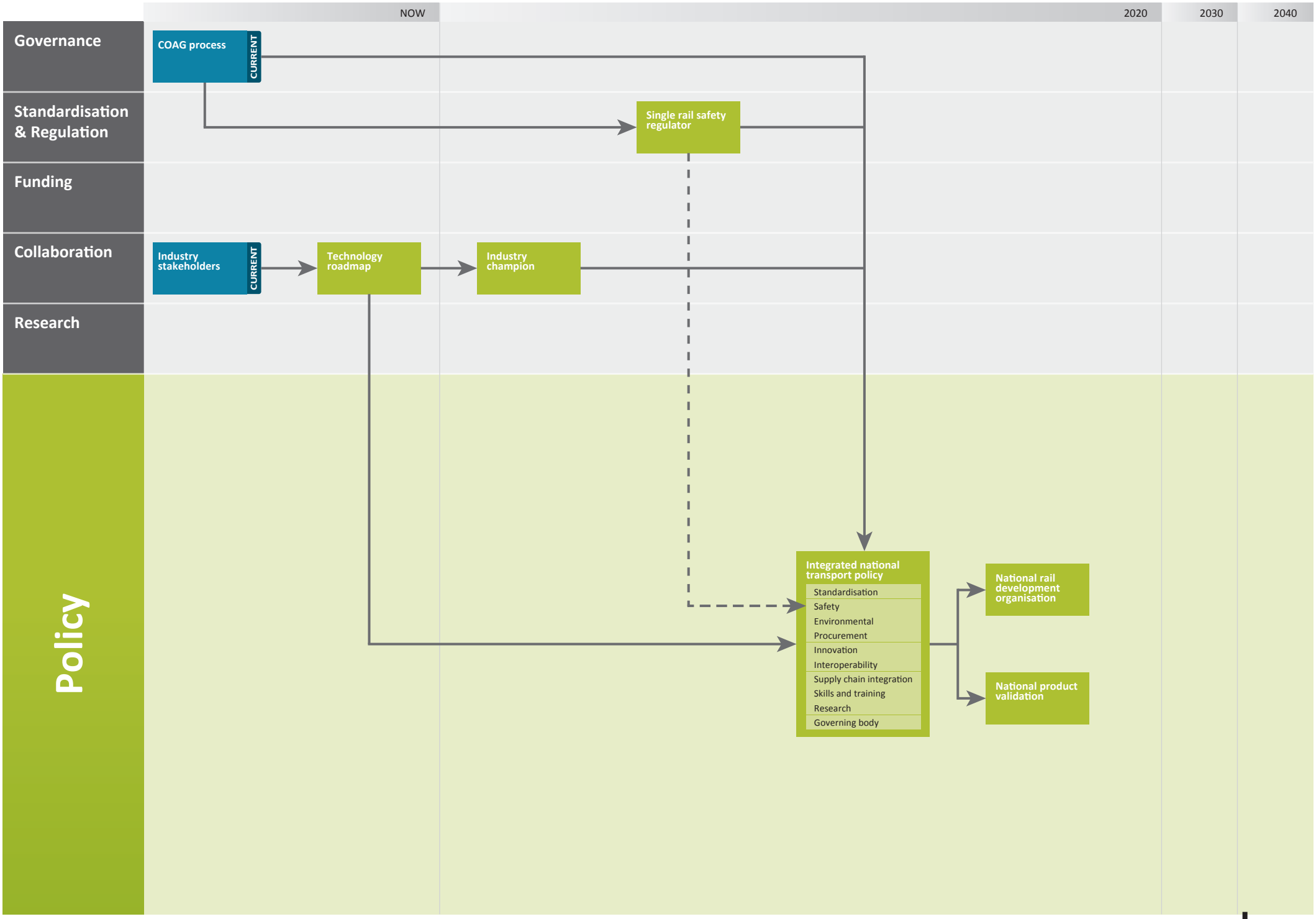
Establish a rail policy to provide incentives for strategic development and to support rail technology R&D.

**Recommendation P4:**

Prioritise engineering education and expand accreditation to include the fields such as systems engineering and simulation in the rail context.

**Recommendation P5:**

Work with operators to define network energy efficiency targets in order to encourage energy regeneration and other energy efficiency technologies.


NOW
2020
2030
2040
Governance
Standardisation & Regulation
Funding
Collaboration
Research
Policy
COAG process
CURRENT
Single rail safety regulator
Industry stakeholders
CURRENT
Technology roadmap
Industry champion
Integrated national transport policy
Standardisation
Safety
Environmental
Procurement
Innovation
Interoperability
Supply chain integration
Skills and training
Research
Governing body
National rail development organisation
National product validation

# Supporting technological priorities

**Both major sections of this report, taken together, should be viewed as the roadmap. The strategic implementation plans and priorities described in the preceding section enable the technological opportunities described in later sections of the report.**

When reviewing the detailed priority opportunities in the next section, it is useful to consider the linkages shown in the figure on the following page. These describe the relationships between opportunity areas, the specific opportunities they encompass and implementation areas.

Figure 12 summarises the impact of action in the implementation areas for each opportunity and priority. Some opportunities benefit more from particular implementation areas than others, or require concentration of strategic effort.

By using the chart in both directions, it is possible to find priority opportunities that derive the most benefit from a specific implementation area, or those implementation areas that provide the most benefit to a specific opportunity.

| | Governance | Standardisation & Regulation | Funding | Collaboration | Research | Policy | Page |
|---|---|---|---|---|---|---|---|
| **Materials and Manufacturing** | ○ | | | ● | ● | ○ | |
| Advanced Design | | ○ | | ○ | | | 40 |
| Low cost manufacturing systems | ● | | | ○ | ○ | ○ | 42 |
| High performance materials for heavy haul | ○ | | | ● | ○ | | 44 |
| Advanced manufacturing | ○ | ○ | | ○ | ● | ● | 46 |
| Advanced materials for lightweighting | | | ○ | ○ | ○ | ○ | 48 |
| Simulation for materials and manufacturing | | | ○ | ○ | ○ | ○ | 50 |
| **Monitoring and Management** | ○ | ● | | ● | ● | | |
| Automated health monitoring for smarter infrastructure | | ● | | | ○ | | 54 |
| Automated control & operations | | | | ○ | ○ | ○ | 56 |
| Advanced asset management systems | ○ | ○ | ○ | ○ | ○ | | 58 |
| Safety threat detection, intervention | ○ | ○ | | ● | ○ | ○ | 60 |
| Advanced data analysis and information systems | | | | ○ | ○ | | 62 |
| Advanced operations management systems | ● | ○ | ○ | ● | ● | | 64 |
| **Power and Propulsion** | ○ | ○ | ○ | ● | ● | | |
| Energy regeneration | ○ | ○ | ○ | ○ | ○ | ○ | 68 |
| Advanced braking systems | | ○ | | | ● | | 70 |
| Energy use management tools | | | | ● | | | 72 |
| Electric motors and systems | ○ | | ● | ○ | ○ | | 74 |
| Emissions reduction technologies | ○ | ○ | | ○ | ○ | | 76 |
| Gaseous fuels | ○ | ○ | ○ | ○ | ○ | ● | 78 |

● Above Average ○ Average

**FIGURE 12** LINKAGES BETWEEN STRATEGIC IMPLEMENTATION AREAS AND TECHNOLOGICAL PRIORITY OPPORTUNITIES. RELATIVE NUMBERS OF ENABLING ACTIONS ARE SHOWN.

# Priority Opportunities

**While there are many underlying themes apparent in the vision developed by the industry, a number of specific areas for further study in the development of the industry strategic technology direction were also identified.**

To aid this process, participants at the Vision Workshop were asked to define potential Applications – products or services building on available technology and capability – that respond to the most important trends and drivers to address the vision. Further input from participants was used to enhance and expand this list of potential opportunities, with input collected through background research, open surveys, interviews with key stakeholders and pre-workshop submissions from participants.

## Evaluation criteria

An evaluation framework enabled a more objective consideration of potential opportunities for the Australian rail supply industry. The development of these criteria was guided by industry leaders who identified key indicators that signal a strong opportunity.

For a technology application to be identified as an Opportunity, there are two high level measures that must be assessed: Attractiveness and Fit With Capability. A highly attractive opportunity might have a large market and address compelling needs, while strong fit with capability could be indicated by large, internationally competitive activity already taking place in the sector.

**Attractiveness criteria**

**TRIPLE BOTTOM LINE**

DOES THE OPPORTUNITY PROMOTE PROFITABILITY, SOCIAL AND ENVIRONMENTAL NEEDS TO ESTABLISH RAIL AS THE PREFERRED TRANSPORT MODE?

**INNOVATION**

IS THE OPPORTUNITY ITSELF INNOVATIVE, OR DOES IT REQUIRE NEW TECHNOLOGY SOLUTIONS TO BE FOUND IN OTHER INDUSTRIES OR DEVELOPED THROUGH RESEARCH?

**COHESIVENESS**

WILL THE APPLICATION REQUIRE CLOSE COLLABORATION BETWEEN AUSTRALIAN RAIL MANUFACTURERS TO BUILD A SENSE OF INDUSTRY?

**INTERNATIONAL RELEVANCE**

WILL THE OPPORTUNITY HAVE POTENTIAL OVERSEAS MARKETS TO HELP ACHIEVE INTERNATIONAL RELEVANCE AND ATTRACT GLOBAL PARTNERS?

**FIGURE 13** OPPORTUNITY ATTRACTIVENESS EVALUATION CRITERIA DESCRIPTIONS. DETAILS OF THE EVALUATION FRAMEWORK ARE AVAILABLE IN THE VISION REPORT[17].

**Fit with capability criteria**

**SIZE**

WHAT IS THE SCALE OF REQUIRED CAPABILITY THAT IS CURRENTLY AVAILABLE IN AUSTRALIA TO SUPPORT THE DEVELOPMENT AND REASLISATION OF THE OPPORTUNITY?

**UNIQUENESS**

DOES THE UNDERLYING CAPABILITY REQUIRED TO DELIVER THE OPPORTUNITY PROVIDE AUSTRALIA WITH A COMPETITIVE, DEFENSIBLE NICHE THAT LEVERAGES RESEARCH CAPABILITY AND CAN BE EXPLOITED INTERNATIONALLY?

**COMPETITIVENESS**

HOW DO COMPANIES PROVIDING REQUIRED CAPABILITIES IN AUSTRALIA COMPARE TO INTERNATIONAL COMPETITORS IN AREAS LIKE COST, QUALITY, AND RESPONSIVENESS?

**NATIONAL ADVANTAGE**

ARE UNDERLYING CAPABILITIES SUPPORTED BY THEIR RELEVANCE TO OTHER AREAS OF STRENGTH IN AUSTRALIA, LIKE: THE RESOURCE SECTOR, AGRICULTURE, OR FINANCIAL SERVICES?

**FIGURE 14** FIT WITH CAPABILITY EVALUATION CRITERIA DESCRIPTIONS. DETAILS OF THE EVALUATION FRAMEWORK ARE AVAILABLE IN THE VISION REPORT[17].

17 ANU Edge, *On Track to 2040 – Vision*, August, 2011.

## The prioritisation process

Three key market need themes can be seen in the vision: effective operations, efficient systems and quality service. These were used, in combination with the evaluation criteria described above, to conduct a wide search into potential opportunities for the Australian rail supply industry. More than 300 suggestions were received through surveys and interviews, and these were distilled into a list of the top 80 unique opportunities (without compromising confidentiality by identifying proprietary commercial technologies). Importantly, the 80 good opportunities presented in Appendix A, and the top 18 selected for detailed planning, should not be viewed as the only opportunities. They should be looked at as a number of the most promising opportunities, as defined by at least two industry stakeholders (to preserve anonymity and confidentiality).

The opportunities were reclassified along technical boundaries to define three Priority Areas where technical experts could make deeper assessments of the relative impact of opportunities on the evaluation criteria. Through the process, as more information was gained and more stakeholders became involved, the names and definitions of the opportunities evolved, but the top 80 have been preserved for reference in Appendix A – Opportunities.

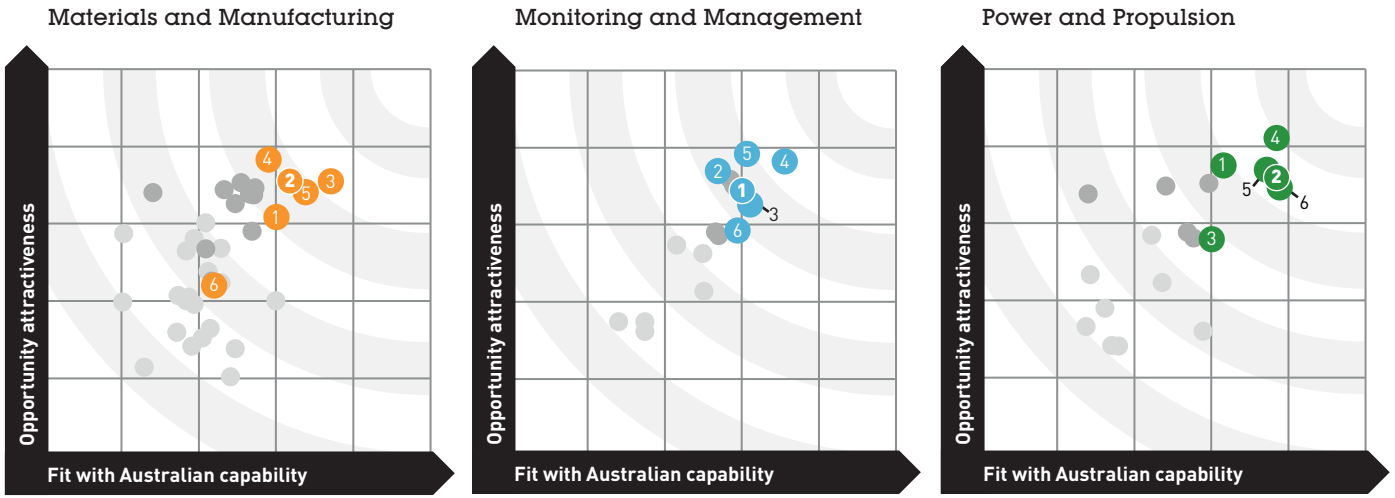
## Three priority areas

As the project continued, participants work focused around the three priority areas: Materials and Manufacturing; Monitoring and Management; and Power and Propulsion. Workshop attendees continued to inform their decisions based on the evaluation criteria measured earlier in the process. As more stakeholders provided input to define a potential path toward achieving the industry vision, 18 Priority Opportunities were selected for detailed roadmapping and prioritisation. These, in turn, informed the implementation process.

For completeness, capability and attractiveness scores were calculated for each of the final Priority Opportunities and these were plotted amongst the other top 40 and top 80 opportunities. As can be seen in Figure 16, participant selections are clearly amongst the strongest opportunities.

| MATERIALS AND MANUFACTURING | MONITORING AND MANAGEMENT | POWER & PROPULSION |
|---|---|---|
| ADVANCED DESIGN | AUTOMATED HEALTH MONITORING FOR SMARTER INFRASTRUCTURE | ENERGY REGENERATION |
| LOW COST MANUFACTURING SYSTEMS | AUTOMATED CONTROL AND OPERATIONS | ADVANCED BRAKING SYSTEMS |
| HIGH PERFORMANCE MATERIALS FOR HEAVY HAUL | ADVANCED ASSET MANAGEMENT SYSTEMS | ENERGY USE MANAGEMENT TOOLS |
| ADVANCED MANUFACTURING | SAFETY THREAT DETECTION, INTERVENTION | ELECTRIC MOTORS AND SYSTEMS |
| ADVANCED MATERIALS FOR LIGHTWEIGHTING | ADVANCED DATA ANALYSIS AND INFORMATION SYSTEMS | EMISSIONS REDUCTION TECHNOLOGIES |
| SIMULATION FOR MATERIALS AND MANUFACTURING | ADVANCED OPERATIONS MANAGEMENT SYSTEMS | GASEOUS FUELS |

**FIGURE 15** THE 18 PRIORITY OPPORTUNITIES SHOWN IN THE THREE PRIORITY AREAS.




1 Advanced design
2 Low cost manufacturing systems
3 High performance materials for heavy haul
4 Advanced manufacturing
5 Advanced materials for lightweighting
6 Simulation of materials and manufacturing
Other top 40
Other top 80

1 Automated health monitoring for infrastructure
2 Automated control and operations
3 Advanced asset management systems
4 Safety threat detection, intervention
5 Advanced data analysis and information system
6 Advanced operations management systems
Other top 40
Other top 80

1 Energy regeneration
2 Advanced braking systems
3 Energy use management tools
4 Electric motors and systems
5 Emmissions reduction technologies
6 Gaseous fuels
Other top 40
Other top 80

**FIGURE 16** OPPORTUNITIES FOR THE THREE PRIORITY AREAS.

# on track to 2040

1 Advanced design

2 Low cost manufacturing systems

3 High performance materials for heavy haul

4 Advanced manufacturing

5 Advanced materials for lightweighting

6 Simulation for materials and manufacturing

# Materials and Manufacturing

A key priority area for the Australian rail industry was identified around technology for delivering advanced materials, design and manufacturing. This area covers new materials, and design processes for lightweighting, improved performance and cost reduction. Also included are manufacturing process improvements, particularly relating to cost effective, short run solutions.

In particular, Australia's position of leadership in the heavy haul sector was identified as an opportunity to leverage complementary Australian strengths as a strategic advantage for the rail sector.

## Export opportunities

Australia's world leading position in the area of heavy haul provides strong export potential for Australian suppliers in this area. The demand for increased axle loads in the heavy haul sector provides the opportunity potential for Australian suppliers to develop capabilities in materials and technology to increase the capacity performance of heavy rail, which could be exported to international markets. There is a potential global market for competitive, high-quality short run solutions. In particular there is demand for retrofit products to extend the life of ageing equipment.

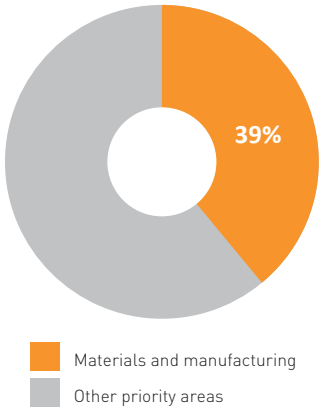



**FIGURE 17**
RESOURCE ALLOCATION FOR THE MATERIALS AND MANUFACTURING AREA

# Advanced design

## Exploit new approaches and computational methods to improve commercial outcomes of R&D

Better designs can improve the performance characteristics of most components and processes. Specific potential design improvements include improved slip resistance, acoustic isolation and extreme durability. Another example of advanced design is the modelling of the workings of the design before it is committed to allows one to predict variable option costings and gives one more freedom to experiment and innovate as well as meet cost targets, improve longevity and increase efficiency. Design is a focus in sectors like sport, automation and aerospace creating potential to leverage the engineering and design capabilities from other manufacturing sectors to develop unique world class solution for rail. The potential is large as design impacts every aspect of the rail system.

New design methods exist as do commercial tools and models for affordability and producibility modelling. The fundamental aim of this roadmap is to produce a "toolbox" that contains software and techniques for advanced design culminating in the idea of real-time telemetry with continuous feedback that allows highly accurate data for new designs to be modelled. Gaps appear around collaboration, as data from design experiments would need to be shared among all organisations to improve the toolbox over time, and by extension improve design standards in the industry.

Advanced design received the largest investment priority, though not the highest impact or assessment score. The triple bottom line and the size of Australia's capability suggest a possible rationale for the discrepancy.

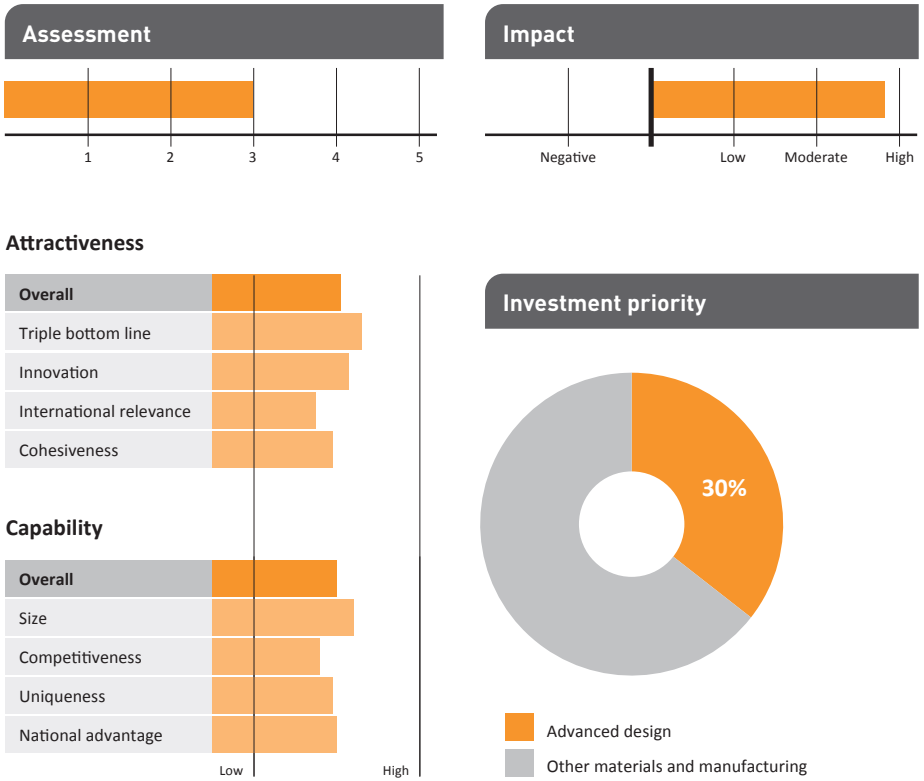
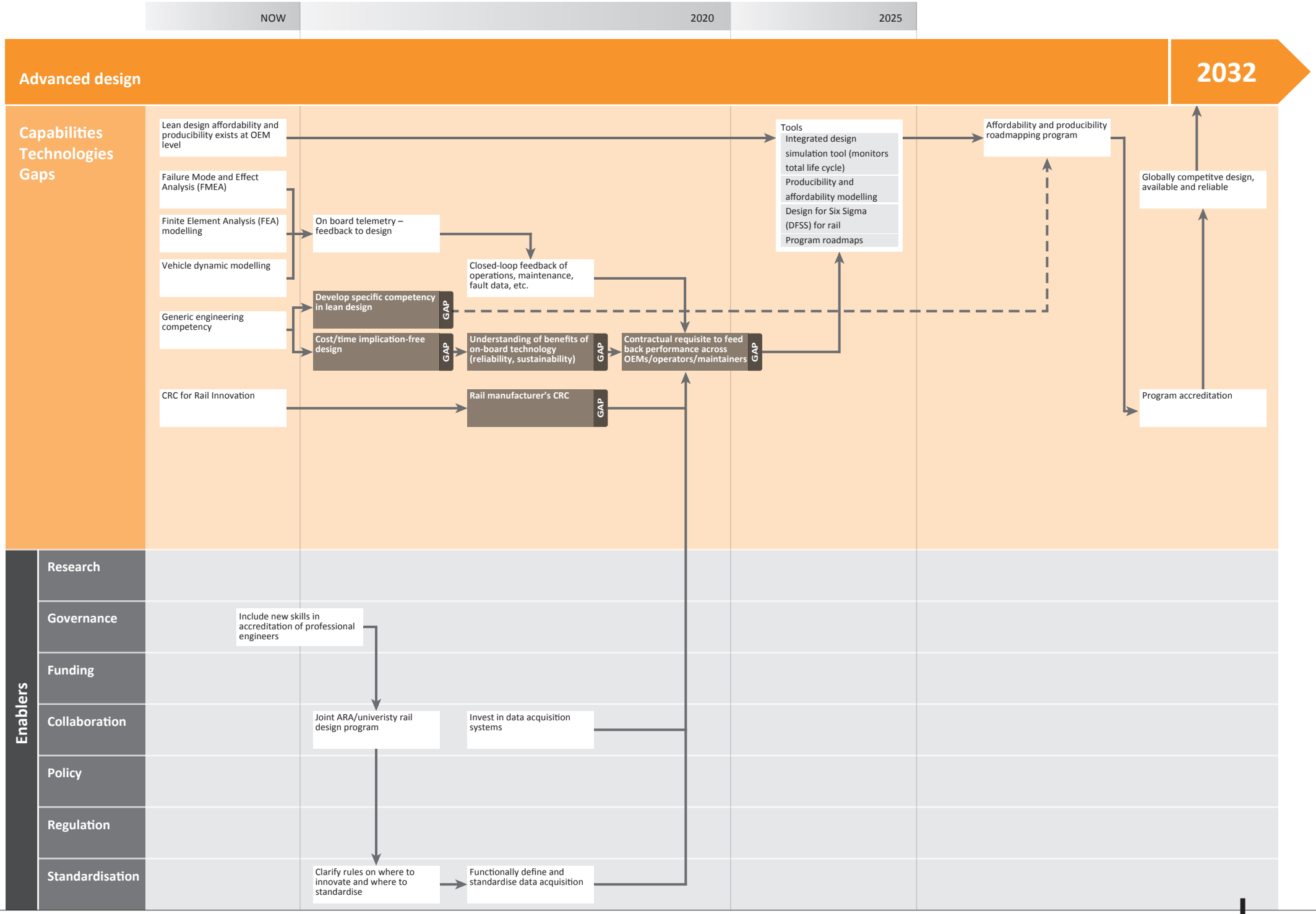



**FIGURE 18**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED DESIGN. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2020
2025
Advanced design
2032
Capabilities
Technologies
Gaps
Lean design affordability and producibility exists at OEM level
Failure Mode and Effect Analysis (FMEA)
Finite Element Analysis (FEA) modelling
Vehicle dynamic modelling
Generic engineering competency
CRC for Rail Innovation
On board telemetry – feedback to design
Closed-loop feedback of operations, maintenance, fault data, etc.
Develop specific competency in lean design
GAP
Cost/time implication-free design
GAP
Understanding of benefits of on-board technology (reliability, sustainability)
GAP
Contractual requisite to feed back performance across OEMs/operators/maintainers
GAP
Rail manufacturer's CRC
GAP
Tools
Integrated design simulation tool (monitors total life cycle)
Producibility and affordability modelling
Design for Six Sigma (DFSS) for rail
Program roadmaps
Affordability and producibility roadmapping program
Globally competitve design, available and reliable
Program accreditation
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Include new skills in accreditation of professional engineers
Joint ARA/univeristy rail design program
Invest in data acquisition systems
Clarify rules on where to innovate and where to standardise
Functionally define and standardise data acquisition

# Low cost manufacturing systems

## Improved processes to ensure competitiveness with low manufacturing volumes

Rail manufacturing is a low-margin, high-risk industry. Containing costs and maintaining flexibility is crucial because economic and operating conditions can change dramatically over long product lifecycles. This, coupled with increasing global competition, is adding significant pressure to local suppliers. To remain competitive, Tier 1 suppliers and their supply chain partners can deploy cost-saving processes and technologies. Relevant expertise and experience is available in other manufacturing industries (like automotive and defence), where the ability to gain competitive positioning has been demonstrated.

Participants proposed improved short run manufacturing as the mechanism to reduce cost. Many of the enablers in the roadmap are concerned with looking to other Australian industries that are capable of short-run manufacturing, or short run rail methods from other countries, that are suitable for Australia. This opportunity could be energised by new rail technologies that could themselves be produced in a low cost way.

Low cost manufacturing obtained the equal highest impact score, and this is reflected in a high investment priority. The relatively high assessment score is a compromise between a very high attractiveness, but lower existing capability available in this area.

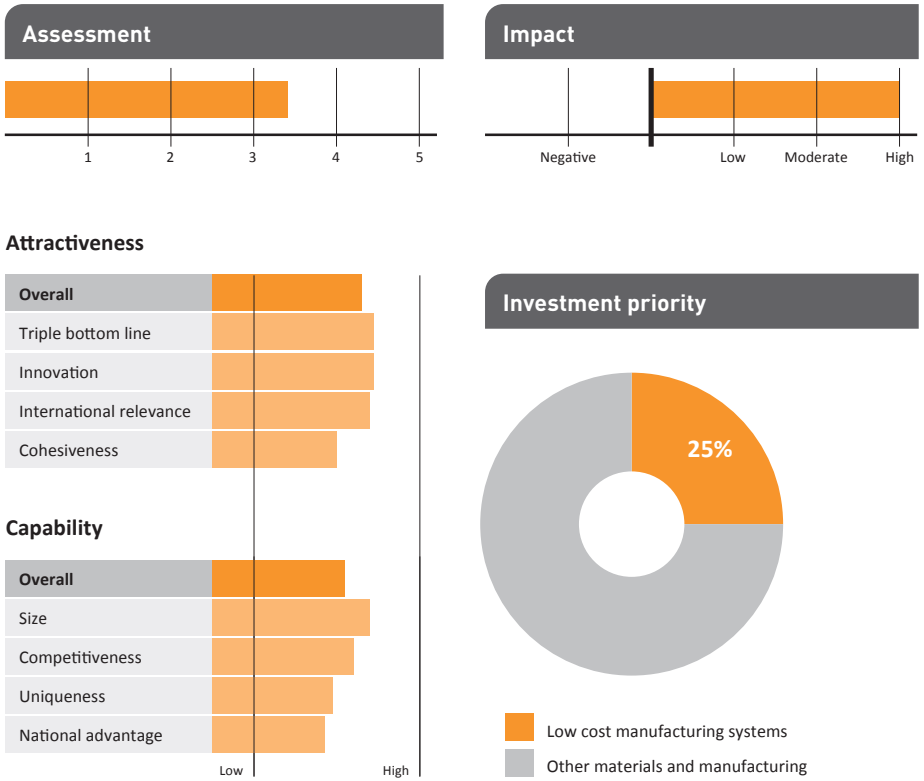
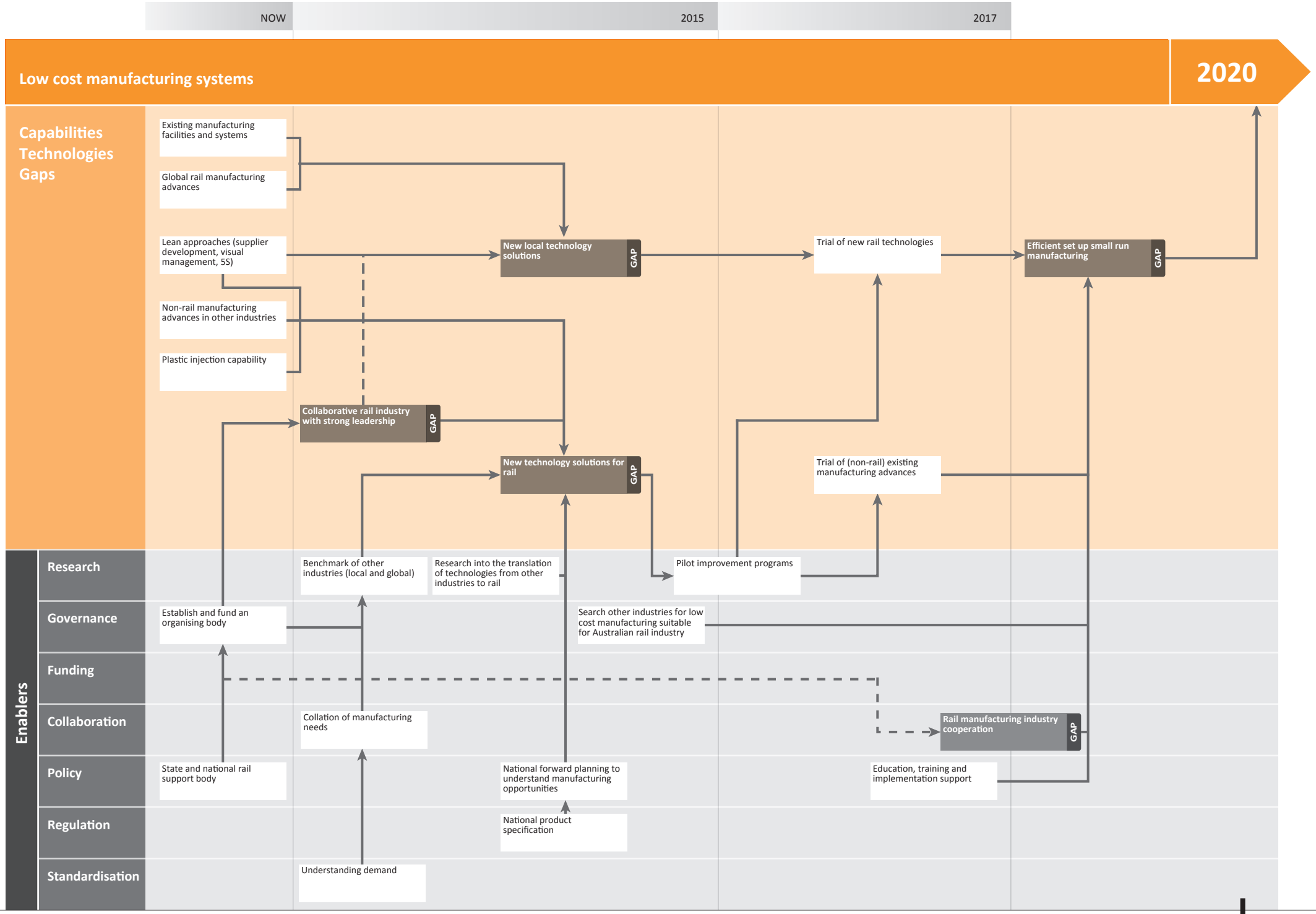



**FIGURE 19**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR LOW COST MANUFACTURING SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2017
Low cost manufacturing systems
2020
Capabilities
Technologies
Gaps
Existing manufacturing facilities and systems
Global rail manufacturing advances
Lean approaches (supplier development, visual management, 5S)
Non-rail manufacturing advances in other industries
Plastic injection capability
New local technology solutions
GAP
Trial of new rail technologies
Efficient set up small run manufacturing
GAP
Collaborative rail industry with strong leadership
GAP
New technology solutions for rail
GAP
Trial of (non-rail) existing manufacturing advances
Enablers
Research
Benchmark of other industries (local and global)
Research into the translation of technologies from other industries to rail
Pilot improvement programs
Governance
Establish and fund an organising body
Search other industries for low cost manufacturing suitable for Australian rail industry
Funding
Collaboration
Collation of manufacturing needs
Rail manufacturing industry cooperation
GAP
Policy
State and national rail support body
National forward planning to understand manufacturing opportunities
Education, training and implementation support
Regulation
National product specification
Standardisation
Understanding demand

# High performance materials for heavy haul

## Solutions to overcome physical limitations and allow capacity improvements up to 45T axle loads

Australia is one of the biggest exporters of bulk commodities, such as iron ore and coal, making it a centre of heavy haul railway expertise. There is a growing need for the development of better materials that will improve the capacity of track and increase productivity (load capacity, speed, train length) and extend service life within the heavy haul sector. A broad range of materials and applications are possible across rolling stock, infrastructure, materials handling and freight sectors. Potential materials and design expertise are available from related industries and sectors.

This opportunity requires new designs informed by benchmarking the materials that exist outside rail and outside Australia. Material limitations restrict the maximum carried load and so the roadmap suggests a goal of a 45 tonne load on each axle to increase heavy haulage. After improving knowledge and design, a concerted, collaborative effort to upgrade any infrastructure is required.

This opportunity has a high assessment score owing to Australia's global competitiveness in heavy haul, and the natural advantage Australia holds in its bulk commodities. However the opportunity has a weakness in cohesiveness which stems from the fact that very few manufacturers are currently working with materials research, or with each other to improve heavy haul performance.

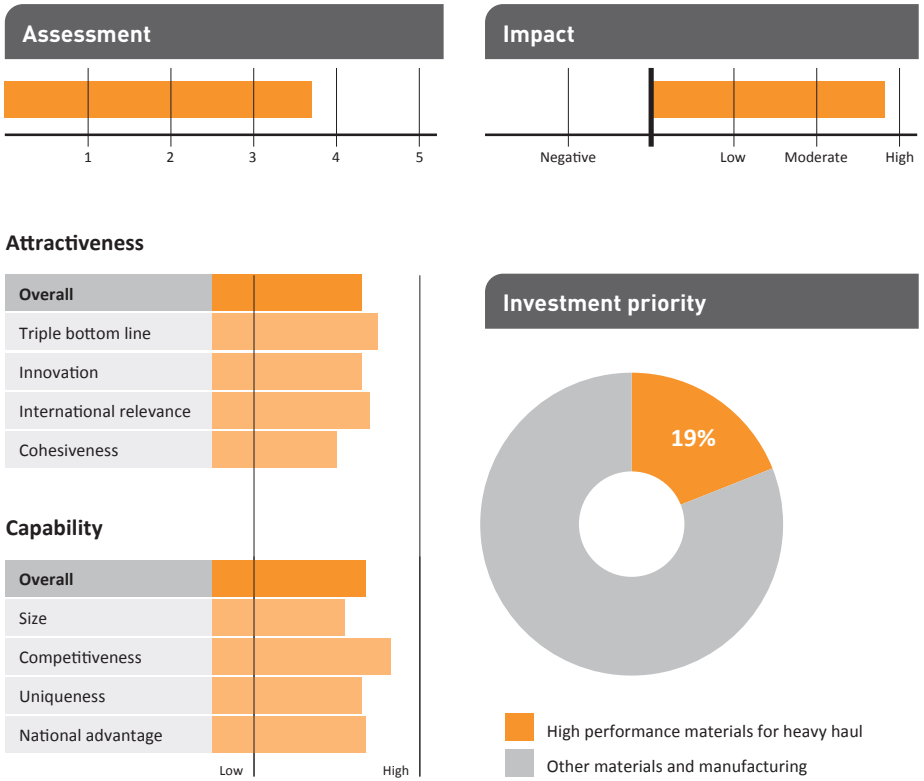
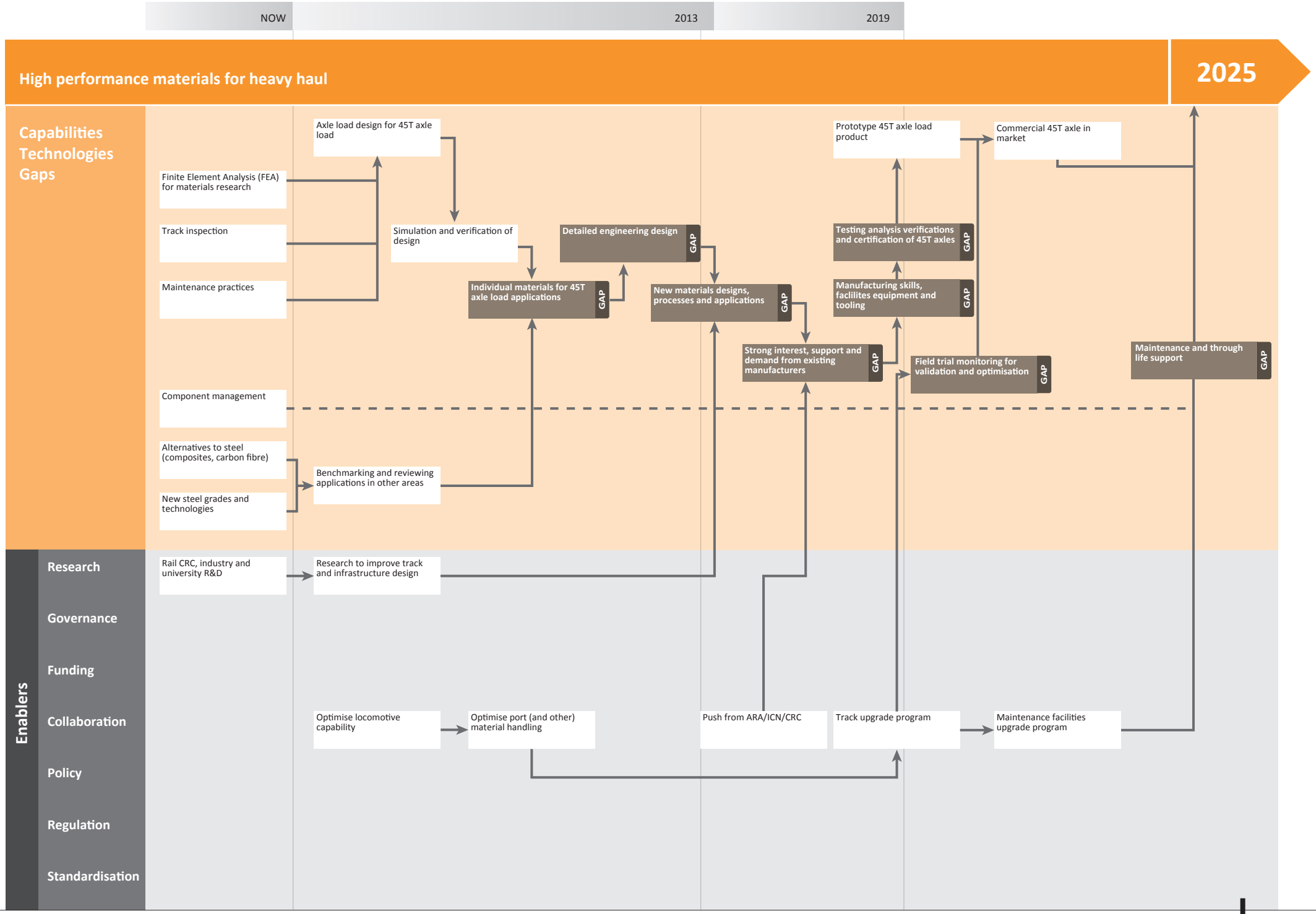



**FIGURE 20**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR HIGH PERFORMANCE MATERIALS FOR HEAVY HAUL. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2013
2019
High performance materials for heavy haul
2025
Capabilities Technologies Gaps
Axle load design for 45T axle load
Finite Element Analysis (FEA) for materials research
Track inspection
Maintenance practices
Simulation and verification of design
Detailed engineering design
GAP
Individual materials for 45T axle load applications
GAP
New materials designs, processes and applications
GAP
Prototype 45T axle load product
Commercial 45T axle in market
Testing analysis verifications and certification of 45T axles
GAP
Manufacturing skills, facilites equipment and tooling
GAP
Strong interest, support and demand from existing manufacturers
GAP
Field trial monitoring for validation and optimisation
GAP
Maintenance and through life support
GAP
Component management
Alternatives to steel (composites, carbon fibre)
New steel grades and technologies
Benchmarking and reviewing applications in other areas
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Rail CRC, industry and university R&D
Research to improve track and infrastructure design
Optimise locomotive capability
Optimise port (and other) material handling
Push from ARA/ICN/CRC
Track upgrade program
Maintenance facilities upgrade program

# Advanced manufacturing

## Develop processes that increase competitiveness and drive technology development in the supply sector

Advanced manufacturing processes are central to the vision of having a competitive rail industry because they drive R&D, generate leading edge technologies, improve workplace practices, and refine supply chain management, skills development and productivity. By integrating advanced manufacturing techniques with new design systems, better cost, time, quality and producibility outcomes can be ensured.

The first stages of this roadmap has much in common with the other Materials and Manufacturing roadmaps, but extends short run manufacturing to the manufacture of standard kits. Such kits would allow modular assembly of rail vehicles and quick "out of the box" retrofit upgrades for fast affordable manufacturing. These technological and engineering developments hinge on an industry-wide standardisation of materials and products, which will require state government collaboration, investment and policy.

Advanced Manufacturing was judged to be very important in making Australia more relevant in the international manufacturing industry. It has been judged attractive to the industry.

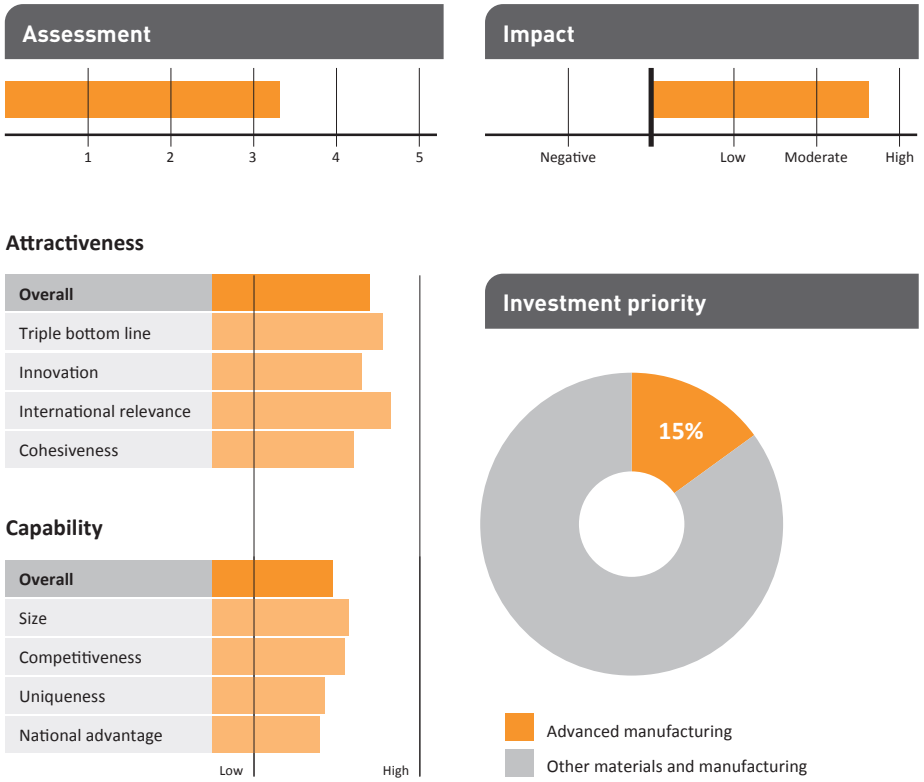
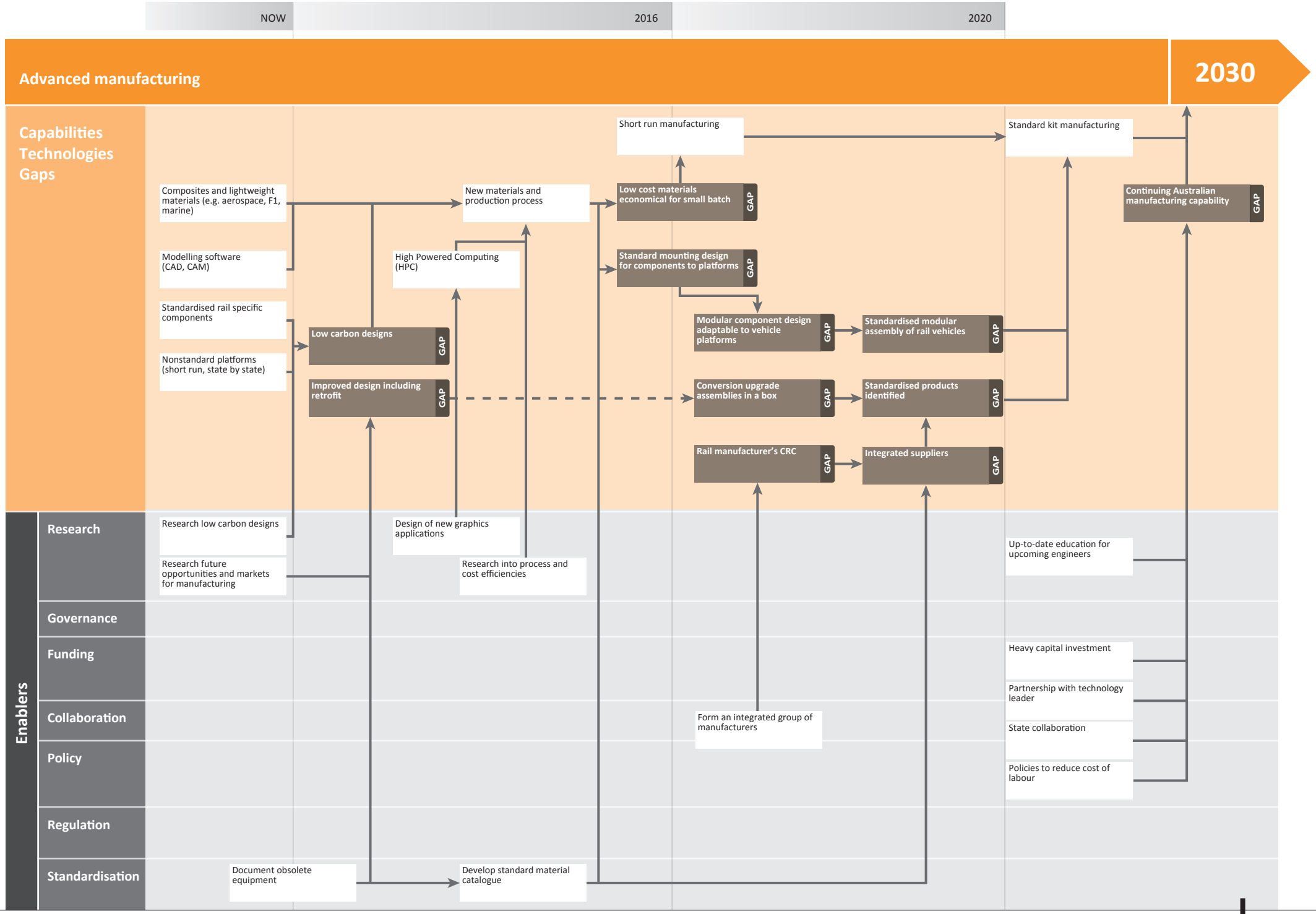



**FIGURE 21**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED MANUFACTURING. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2016
2020
Advanced manufacturing
2030
Capabilities Technologies Gaps
Composites and lightweight materials (e.g. aerospace, F1, marine)
Modelling software (CAD, CAM)
Standardised rail specific components
Nonstandard platforms (short run, state by state)
Low carbon designs GAP
Improved design including retrofit GAP
High Powered Computing (HPC)
New materials and production process
Short run manufacturing
Low cost materials economical for small batch GAP
Standard mounting design for components to platforms GAP
Modular component design adaptable to vehicle platforms GAP
Conversion upgrade assemblies in a box GAP
Rail manufacturer's CRC GAP
Standardised modular assembly of rail vehicles GAP
Standardised products identified GAP
Integrated suppliers GAP
Standard kit manufacturing
Continuing Australian manufacturing capability GAP
Enablers
Research
Research low carbon designs
Research future opportunities and markets for manufacturing
Design of new graphics applications
Research into process and cost efficiencies
Up-to-date education for upcoming engineers
Governance
Funding
Heavy capital investment
Partnership with technology leader
Collaboration
Form an integrated group of manufacturers
State collaboration
Policy
Policies to reduce cost of labour
Regulation
Standardisation
Document obsolete equipment
Develop standard material catalogue

# Advanced materials for lightweighting

## New substances that reduce weight without sacrificing cost or performance

For every kilogram of weight removed from a locomotive, there is the potential to add another kilogram of goods. It is possible to reduce vehicle body and chassis weight through the use of alternate materials or combinations of materials. This reduces the cost per tonne of transport and increases the overall efficiency. With advanced materials, this can be achieved without compromising other attributes such as safety, performance, recyclability, and cost. In passenger rail the lower weight helps to reduce fuel consumption. Rather than tweaking existing designs for improved performance, the introduction of lightweight materials fundamentally changes design considerations and limitations, opening up many possibilities for improvement.

Lightweight materials already exist in other industries, the opportunity is around how they can be used in rail. This roadmap suggests that by improving design simulation, material use and lifecycles can be optimised. With existing materials and new designs based on simulation, new products can be provided in the long term. There is also potential to produce environmentally responsible materials, and products designed for recycling. Recyclable products not only improve the environmental footprint, but can make manufacturing more efficient.

The Australian rail manufacturing industry has research interests relevant to lightweighting, but achieves lower size scores. However the opportunity is attractive, particularly because lightweight materials are in demand internationally.

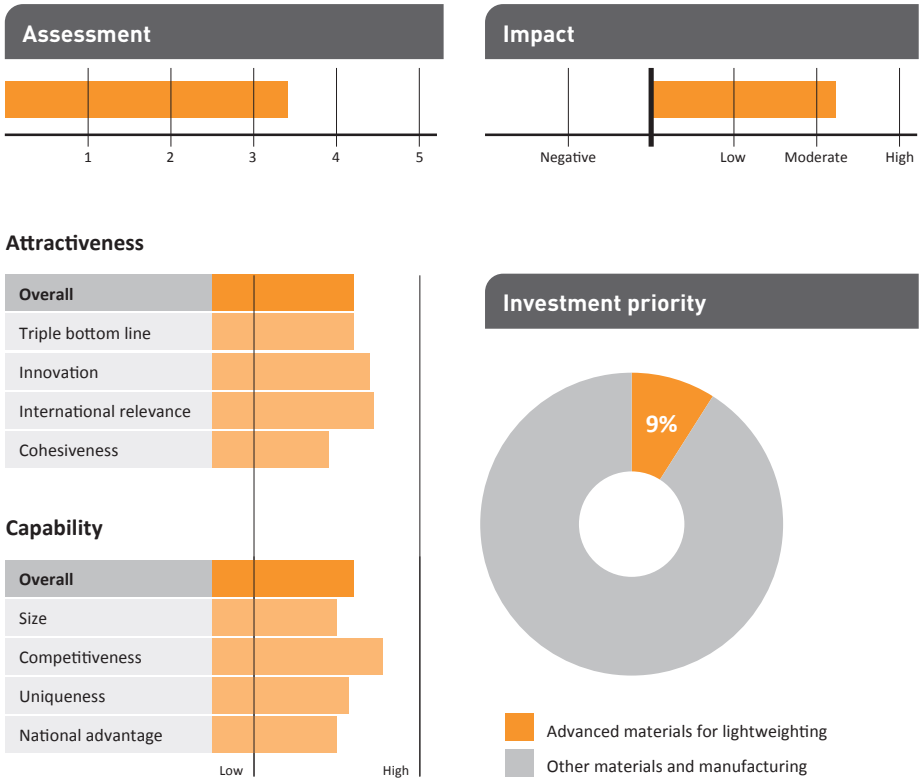
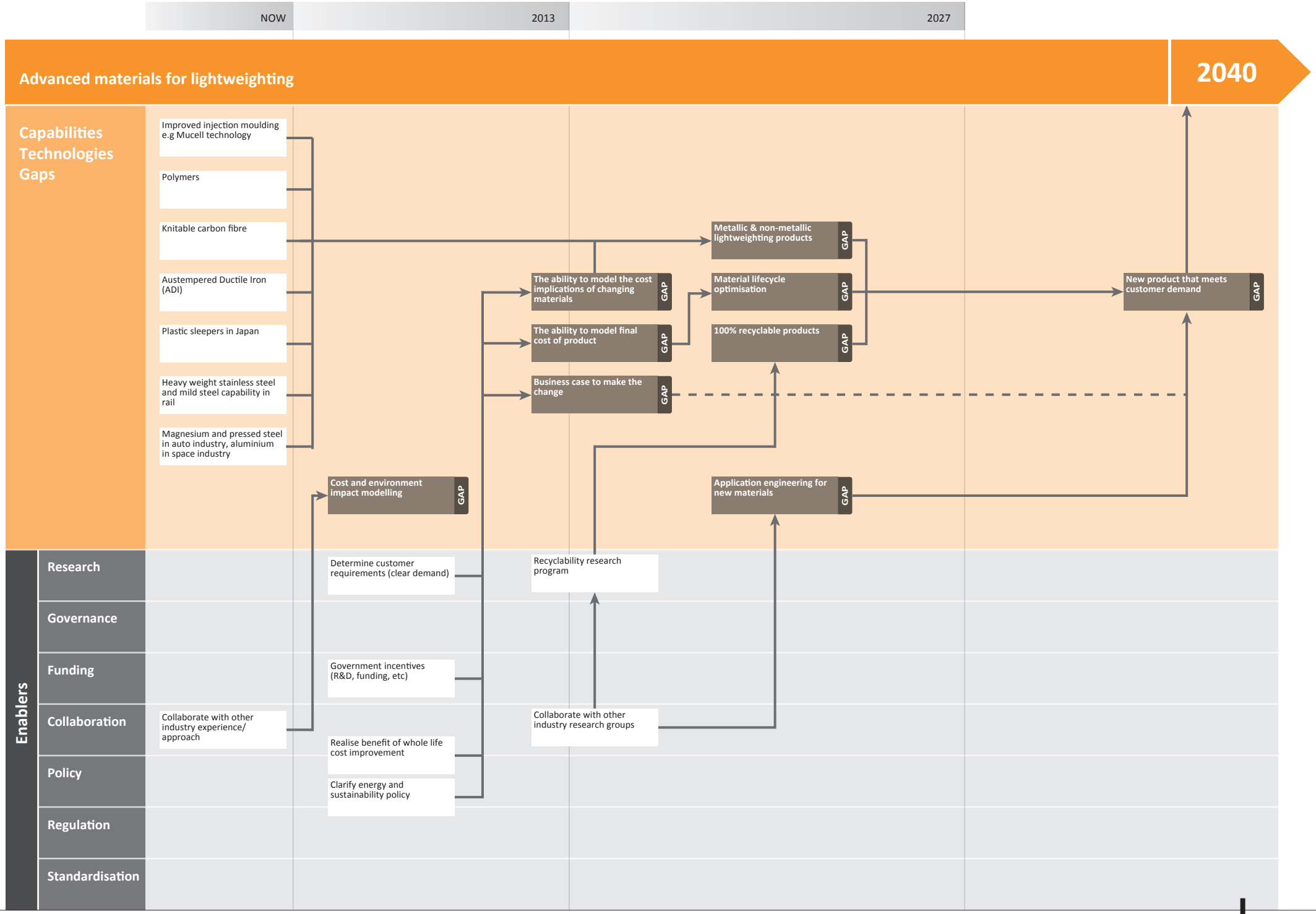



**FIGURE 22**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED MATERIALS FOR LIGHTWEIGHTING. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2013
2027
Advanced materials for lightweighting
2040
Capabilities Technologies Gaps
Improved injection moulding e.g Mucell technology
Polymers
Knitable carbon fibre
Austempered Ductile Iron (ADI)
Plastic sleepers in Japan
Heavy weight stainless steel and mild steel capability in rail
Magnesium and pressed steel in auto industry, aluminium in space industry
Metallic & non-metallic lightweighting products GAP
The ability to model the cost implications of changing materials GAP
Material lifecycle optimisation GAP
New product that meets customer demand GAP
The ability to model final cost of product GAP
100% recyclable products GAP
Business case to make the change GAP
Cost and environment impact modelling GAP
Application engineering for new materials GAP
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Determine customer requirements (clear demand)
Recyclability research program
Government incentives (R&D, funding, etc)
Collaborate with other industry experience/ approach
Collaborate with other industry research groups
Realise benefit of whole life cost improvement
Clarify energy and sustainability policy

# Simulation for materials and manufacturing

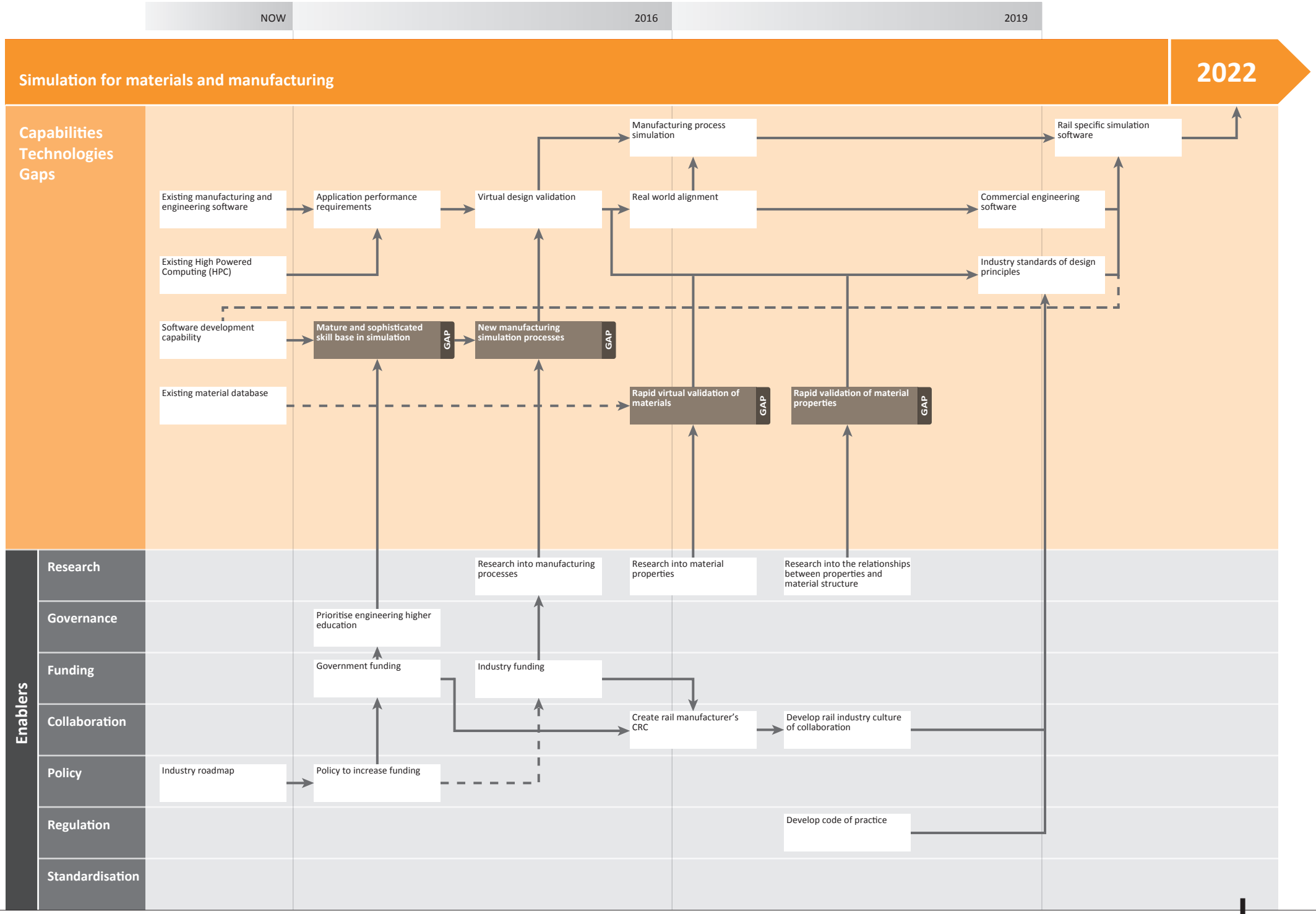
## Accurate techniques for digital verification of new designs, materials and methods before manufacture

New designs, materials and manufacturing methods can be improved and generated more effectively by simulating their performance computationally before time and money goes into building and testing. Such software and algorithms can reduce the cost of manufacture by reducing the need for prototypes, allowing designs and materials to be tested virtually on a computer and minimising investment risk.

The roadmap suggests utilising Australia's existing software development capability with research into new manufacturing processes, material properties and structural attributes of design. This new information would allow broader and more accurate simulation, using Australia's existing high powered computing capability. There is also an insufficient and immature skill base that needs to be addressed before new simulation software can be developed, and commercialised.

The simulation of materials and manufacturing is required by many of the opportunities that are a higher investment priority, including High Performance Materials For Heavy Haul and the number one opportunity Advanced Design. It was highlighted as a key priority even though much of the investment need is wrapped into achieving other goals.


**FIGURE 23**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR SIMULATION FOR MATERIALS AND MANUFACTURING. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MATERIALS AND MANUFACTURING TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2016
2019
2022
Simulation for materials and manufacturing
Capabilities
Technologies
Gaps
Manufacturing process simulation
Rail specific simulation software
Existing manufacturing and engineering software
Application performance requirements
Virtual design validation
Real world alignment
Commercial engineering software
Existing High Powered Computing (HPC)
Industry standards of design principles
Software development capability
Mature and sophisticated skill base in simulation
GAP
New manufacturing simulation processes
GAP
Existing material database
Rapid virtual validation of materials
GAP
Rapid validation of material properties
GAP
Enablers
Research
Research into manufacturing processes
Research into material properties
Research into the relationships between properties and material structure
Governance
Prioritise engineering higher education
Funding
Government funding
Industry funding
Collaboration
Create rail manufacturer's CRC
Develop rail industry culture of collaboration
Policy
Industry roadmap
Policy to increase funding
Regulation
Develop code of practice
Standardisation

# on track to 2040

1 Automated health monitoring for smarter infrastructure

2 Automated control and operations

3 Advanced asset management systems

4 Safety threat detection, intervention

5 Advanced data analysis and information systems

6 Advanced operations management systems

# Monitoring and Management

A second key priority area for the Australian rail industry was identified around technology for delivering improved asset and operations management. This area covers all aspects of management and safety systems: sensors (on-board and off); remote telemetry and communications; data management; analysis; systems design and integration; and safety solutions.

Opportunities in Monitoring and Management have high cohesiveness scores as the required interconnected systems necessarily lead to an industry that communicates and works well together.

## Export opportunities

The area of monitoring and management responds to many global trends and drivers such as reducing emissions, energy efficiency and increased capacity. These drivers are important to local rail projects but also present a large potential global market. The capabilities required to deliver these projects include many knowledge based and services capabilities.

These are highly exportable with global demand for capability in:

- Passenger movement design
- Asset management
- Asset monitoring
- Infrastructure upgrades
- Optimised train operations
- Level crossing upgrades
- Grade separation
- Demand management

These export market demands increase the size of the opportunities for Australian suppliers to provide products and services into the Monitoring and Management area.

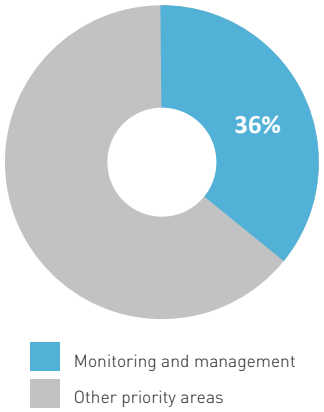



**FIGURE 24**
RESOURCE ALLOCATION FOR THE MONITORING AND MANAGEMENT AREA

# Automated health monitoring for infrastructure

## Remote, built-in health data monitoring systems to allow predictive maintenance of fixed assets

Predictive maintenance is often more cost efficient than fix-on-fail or planned maintenance strategies. Daily inspection of some structural assets is required to minimise risk, but frequent manual inspection is expensive. By applying sensor and data analysis techniques to infrastructure assets the industry can conduct non-intrusive, automated measurements to report faults and asset condition, allowing preventative maintenance or even automated self-correction. Automated health monitoring streamlines operational systems by providing rail operations with information such as scheduled and actual times, cargo, maintenance and downtime information; integrating all aspects of operational performance planning.

The required sensors and power sources already exist, as do examples of health monitoring software. The gaps revolve around system level design to link technologies together. Sensors need to be integrated with power supplies and be able to communicate in real time. In order to communicate, protocols and trigger levels (conditions at which automated systems are told to act on a measurement) must be agreed industry-wide. The first gaps should be addressed by 2013, with automated health monitoring systems becoming operational by 2016.

This opportunity received the maximum impact score, and the highest investment priority in the priority area.

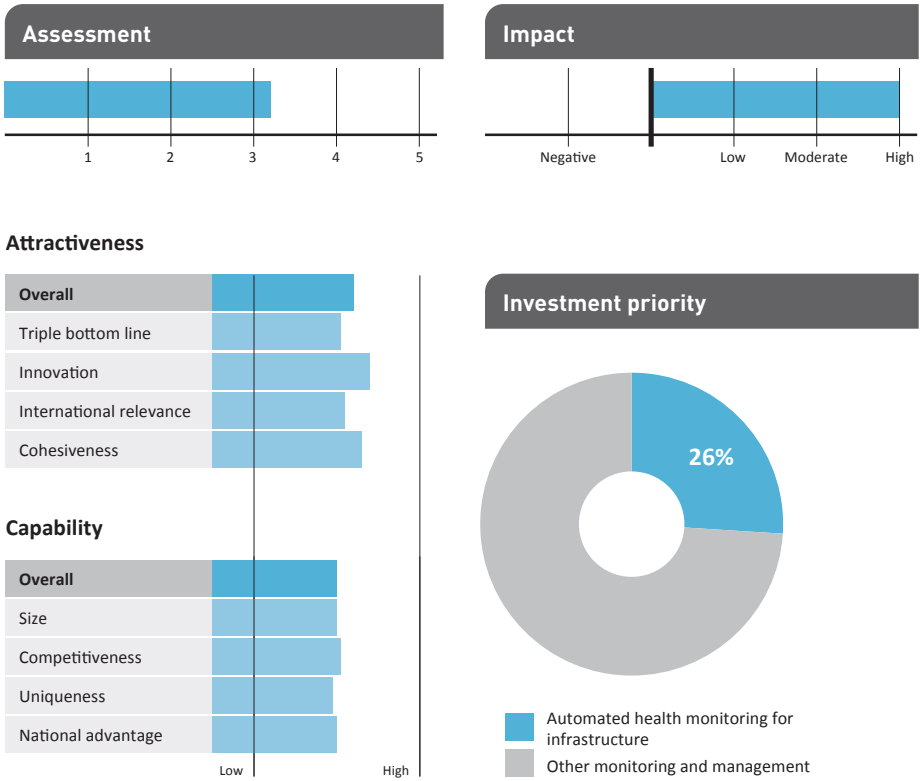
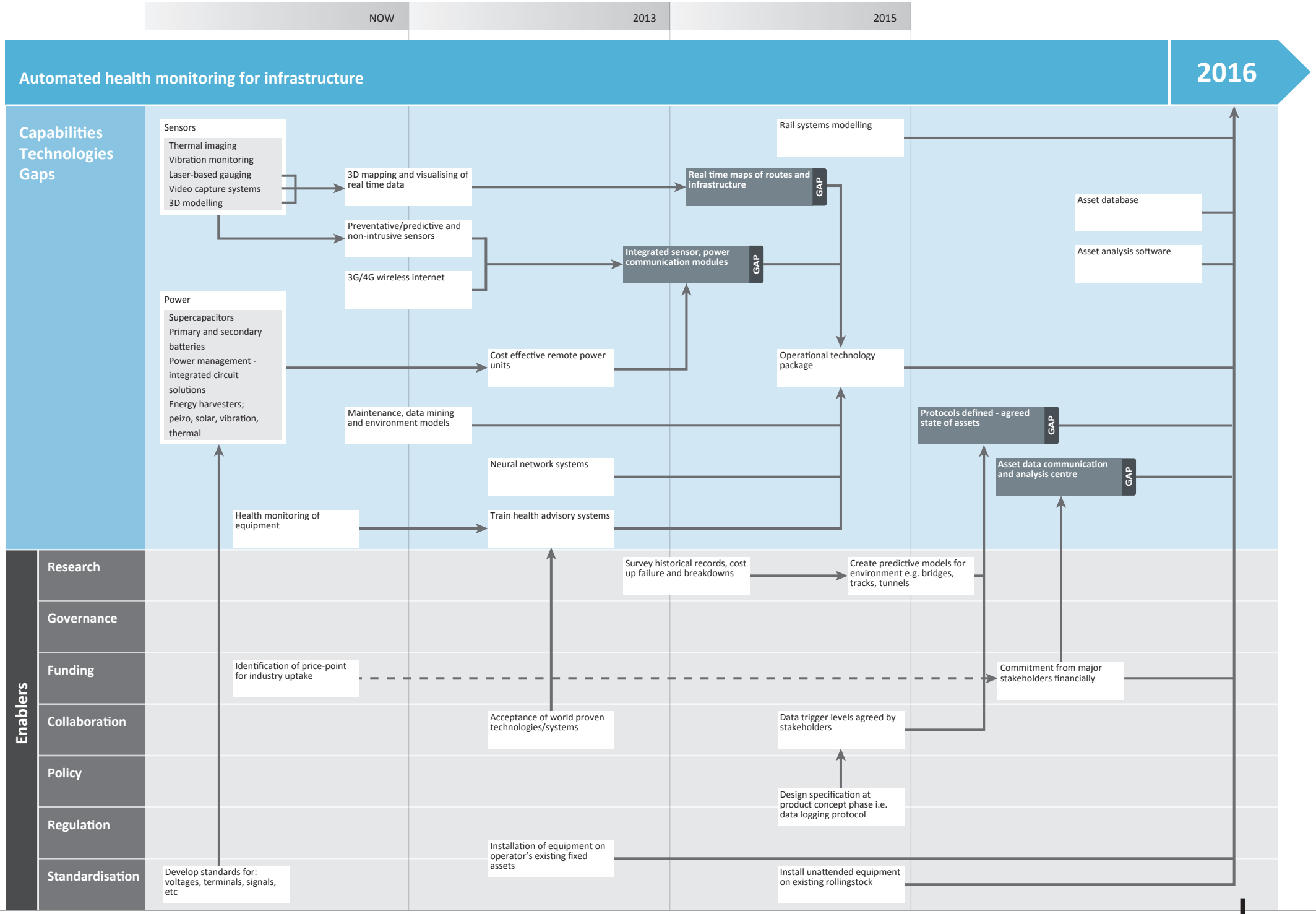



**FIGURE 25**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR AUTOMATED HEALTH MONITORING FOR INFRASTRUCTURE. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2013
2015
2016
Automated health monitoring for infrastructure
Capabilities
Technologies
Gaps
Sensors
Thermal imaging
Vibration monitoring
Laser-based gauging
Video capture systems
3D modelling
3D mapping and visualising of real time data
Real time maps of routes and infrastructure
GAP
Rail systems modelling
Asset database
Asset analysis software
Preventative/predictive and non-intrusive sensors
3G/4G wireless internet
Integrated sensor, power communication modules
GAP
Power
Supercapacitors
Primary and secondary batteries
Power management - integrated circuit solutions
Energy harvesters; peizo, solar, vibration, thermal
Cost effective remote power units
Operational technology package
Maintenance, data mining and environment models
Protocols defined - agreed state of assets
GAP
Neural network systems
Asset data communication and analysis centre
GAP
Health monitoring of equipment
Train health advisory systems
Enablers
Research
Survey historical records, cost up failure and breakdowns
Create predictive models for environment e.g. bridges, tracks, tunnels
Governance
Funding
Identification of price-point for industry uptake
Commitment from major stakeholders financially
Collaboration
Acceptance of world proven technologies/systems
Data trigger levels agreed by stakeholders
Policy
Design specification at product concept phase i.e. data logging protocol
Regulation
Installation of equipment on operator's existing fixed assets
Standardisation
Develop standards for: voltages, terminals, signals, etc
Install unattended equipment on existing rollingstock

# Automated control and operations

## Operator-less trains and operational systems

As more advanced detection and sensing technology is incorporated in rail systems, the automated control of all operational aspects can expand. Automation will increase staff productivity by reducing burdens on skilled workers, thus alleviating skill shortages in the industry. Automation can also be beneficial in achieving goals for safety, customer satisfaction and operational excellence such as minimal downtime, increased productivity, improved services and reduced exposure to litigation. Automation may allow disparate systems to be integrated; improving headway, safety and reliability.

Participants suggested that there is also the opportunity for the industry to lead this technological innovation and develop world's best practice in automated signalling and train control. Australia could develop a position of global leadership with an advanced technology platform to meet global needs.

The requisite data collection and communication systems exist, although the communication protocols need to be researched and made compatible with open software architecture. Mining the collected data, automating decisions and optimising the automation are all capabilities available now. Automated control systems would amount to a completely new way to run a rail system and so retraining would be needed for the new skill sets. The roadmap proposes some integrated, automated rail systems by 2020.

Automated control and operations had a high investment priority, but only a moderate impact and overall assessment score. The technology is very attractive, but international competitive pressures increase investment risk.

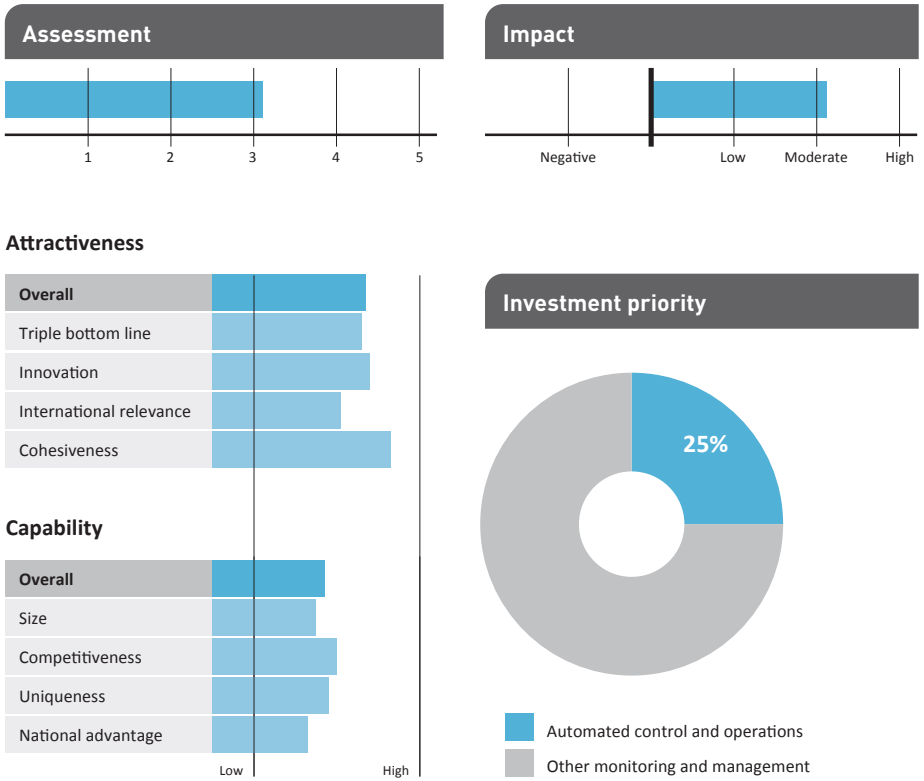
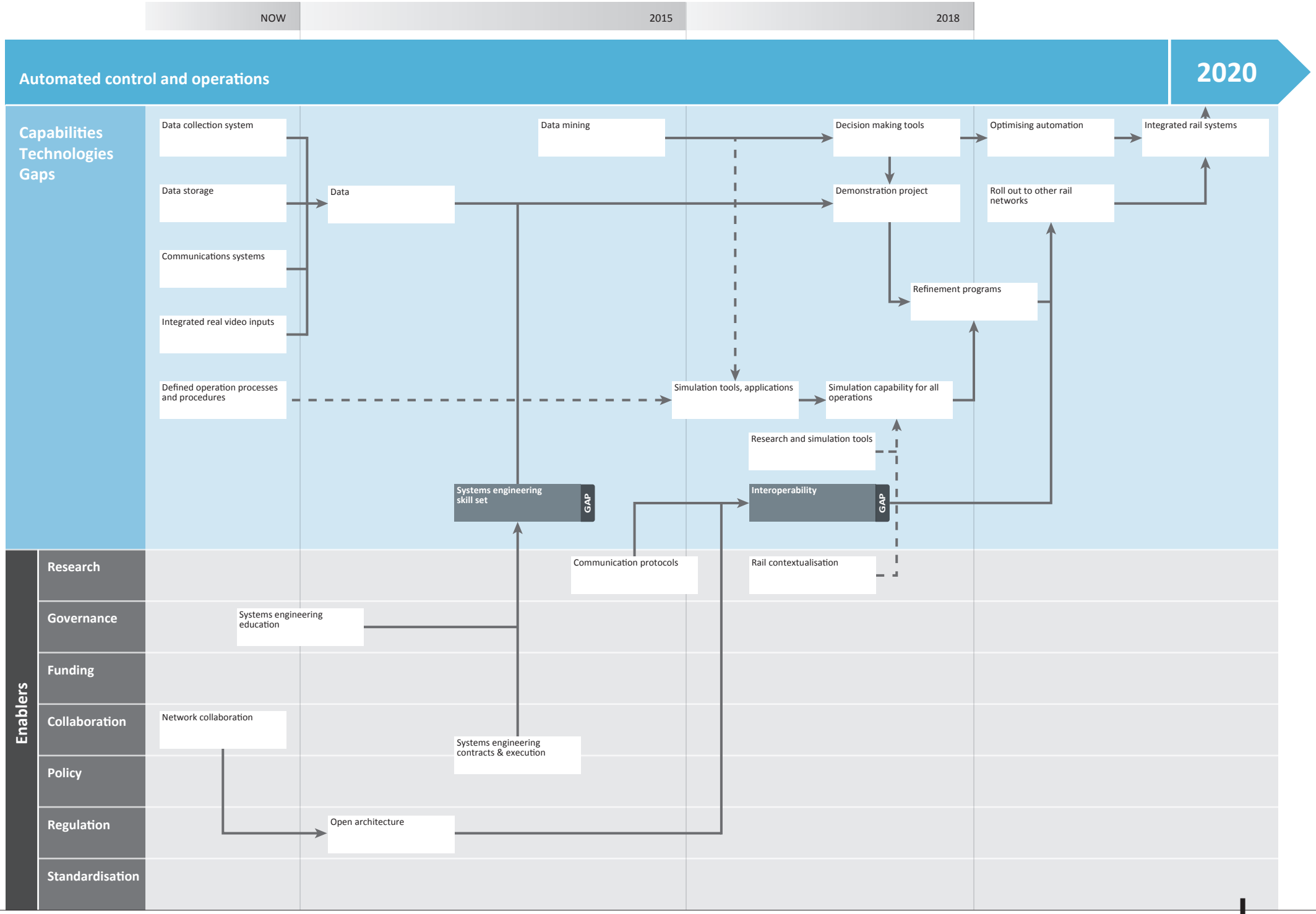



**FIGURE 26**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR AUTOMATED CONTROL AND OPERATIONS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2018
Automated control and operations
2020
Capabilities
Technologies
Gaps
Data collection system
Data storage
Communications systems
Integrated real video inputs
Defined operation processes and procedures
Data
Data mining
Decision making tools
Demonstration project
Optimising automation
Integrated rail systems
Roll out to other rail networks
Refinement programs
Simulation tools, applications
Simulation capability for all operations
Research and simulation tools
Systems engineering skill set
GAP
Interoperability
GAP
Communication protocols
Rail contextualisation
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Systems engineering education
Network collaboration
Systems engineering contracts & execution
Open architecture

# Advanced asset management systems

## Predictive maintenance (based on data) to drive increased asset utilisation and longer lifecycles

Asset management informs and automates decision making to enable maximal use of high cost assets by reducing the impact and lost revenue of unavailable equipment. It can also extend the lifecycle of parts with decision-making based on health, usage and timing. These cost-reducing advantages also help to minimise environmental and social impacts of rail by minimising waste. Complementary skills, technology, systems and processes are available in the petrochemical, power generation, infrastructure, and resources sectors, providing engineering validation of similar decision making processes. Balancing the different operational and functional requirements is important to provide a solution with long-term viability.

Existing sensors can be utilised, when combined with standardised communication protocols. The necessary ingredients for communication protocols exist, but proposed standards and an avenue through which to agree on them is needed. By leveraging technologies and systems from other industries, data can be collected, prioritised and processed. The roadmap suggests a demonstration project to occur soon after 2020, with the opportunity being realised in 2025.

Most of the attractiveness of this opportunity comes from the cohesiveness it will provide the industry. Integrated asset management systems provide standardised communication systems and predictable usage of parts. Such assumptions remove many of the variables of doing business and allow rail manufacturers to optimise their processes.

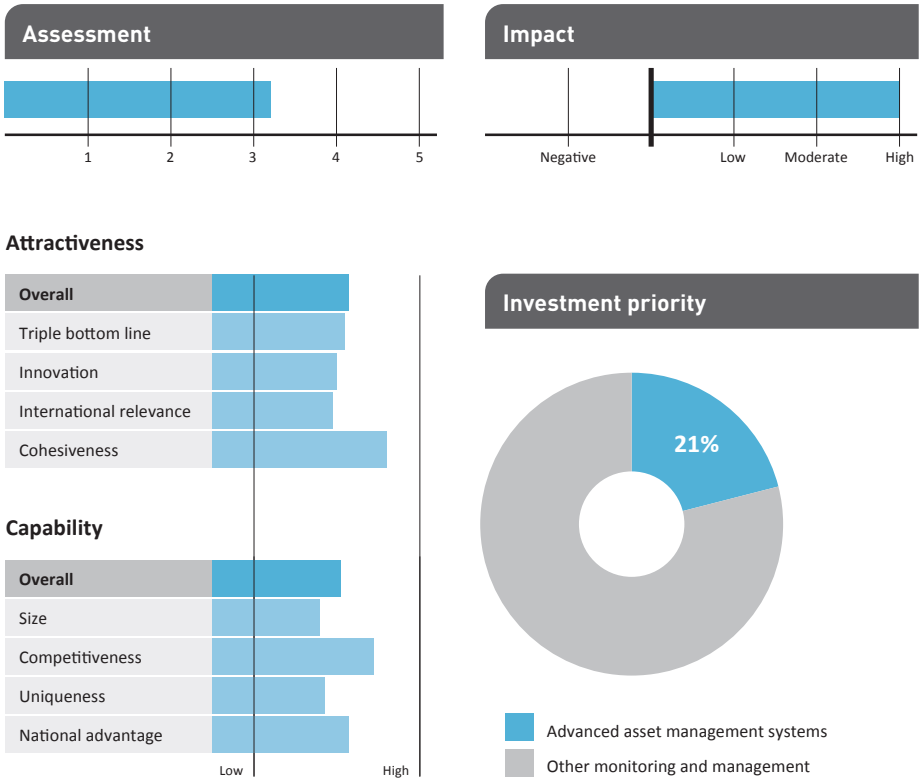
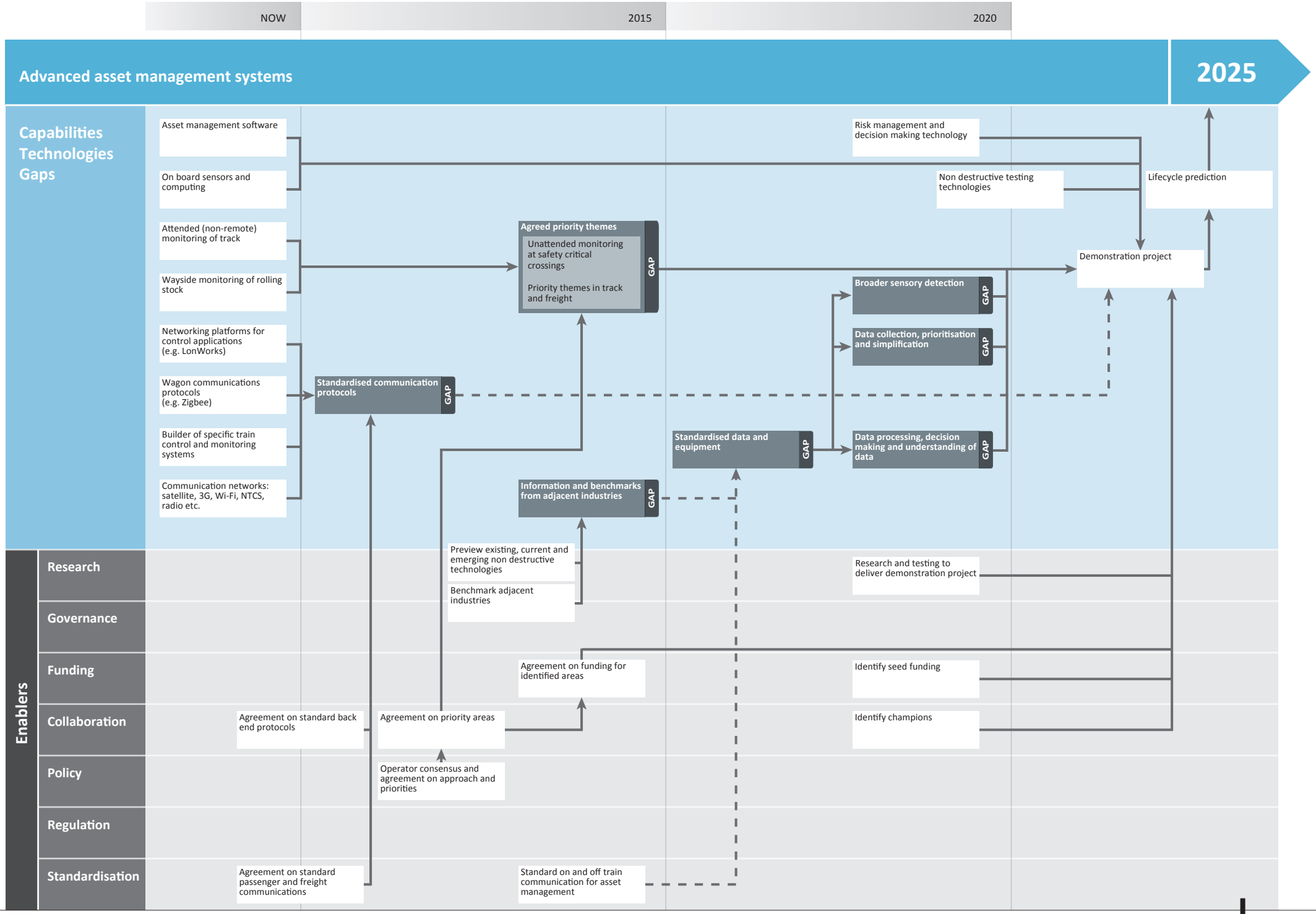



**FIGURE 27**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED ASSET MANAGEMENT SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2020
Advanced asset management systems
2025
Capabilities Technologies Gaps
Asset management software
On board sensors and computing
Attended (non-remote) monitoring of track
Wayside monitoring of rolling stock
Networking platforms for control applications (e.g. LonWorks)
Wagon communications protocols (e.g. Zigbee)
Builder of specific train control and monitoring systems
Communication networks: satellite, 3G, Wi-Fi, NTCS, radio etc.
Standardised communication protocols
GAP
Agreed priority themes
Unattended monitoring at safety critical crossings
Priority themes in track and freight
GAP
Risk management and decision making technology
Non destructive testing technologies
Lifecycle prediction
Demonstration project
Broader sensory detection
GAP
Data collection, prioritisation and simplification
GAP
Standardised data and equipment
GAP
Data processing, decision making and understanding of data
GAP
Information and benchmarks from adjacent industries
GAP
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Preview existing, current and emerging non destructive technologies
Benchmark adjacent industries
Research and testing to deliver demonstration project
Agreement on funding for identified areas
Identify seed funding
Agreement on standard back end protocols
Agreement on priority areas
Identify champions
Operator consensus and agreement on approach and priorities
Agreement on standard passenger and freight communications
Standard on and off train communication for asset management

# Safety threat detection, intervention

## Standardisation of data measurement, delivery and processing to improve safety outcomes

Early and accurate detection of all forms of safety threats (to property, life, business operation, fire, gas, security, and system malfunctions), combined with real-time assessment and evaluation prevents service interruption and loss. Despite current trackside monitoring, critical events still occur. Longer, faster trains pose particular problems in being able to quickly identify and react to critical failures. Technology implementation across the entire rail system, including real-time, train-fitted systems, will eliminate many risks. This advanced risk management and appraisal platform presents a high tech, low labour intensity opportunity to meet global rail industry needs.

Currently there exist many types of monitoring solutions, on board and trackside. The information from these sensors needs to be standardised, which includes decisions regarding standard trigger levels to dictate when the automated systems intervene. More advanced software and robust decision making systems will appear as a matter of course, but new standards, and the collaboration to ensure the data is well integrated (required for a fully developed threat intervention system) will not occur without leadership and coordinated action. The ultimate goal is to have open-source architecture in 2020 in order to enable low cost, extremely efficient and innovative threat detection and intervention system.

This opportunity had a higher impact score than the other Monitoring and Management opportunities, but had a markedly smaller investment priority than the previous opportunities. There is no intrinsic advantage to following this opportunity in Australia when compared to other countries, but the competitiveness and uniqueness scores indicate Australia already has strengths in this area and the high international relevance score indicates a strong global demand for safety threat reduction technologies.

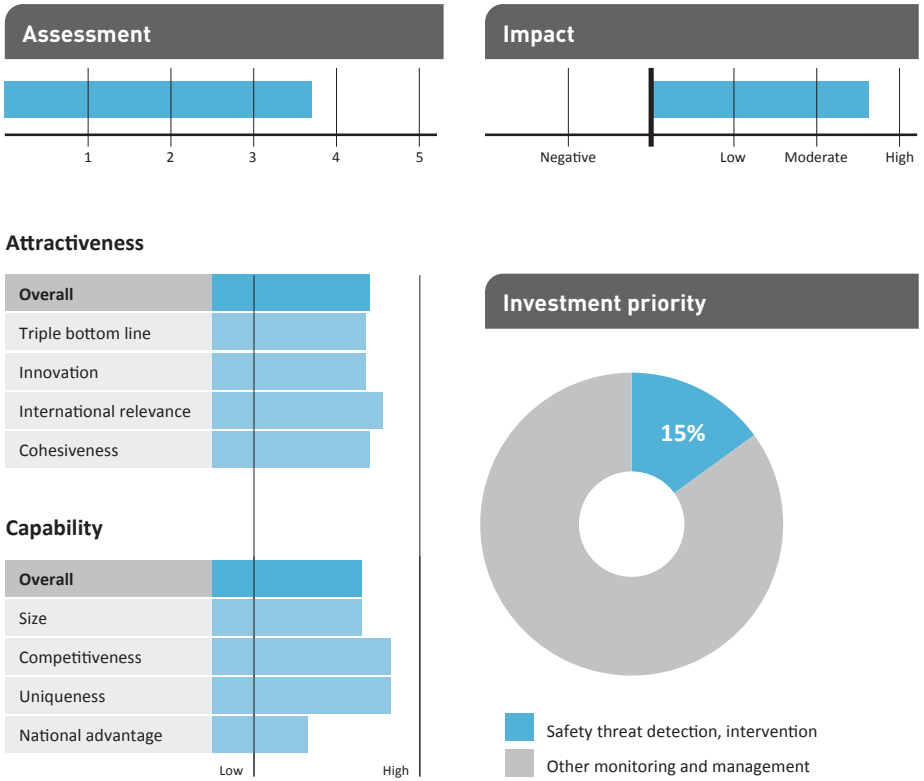
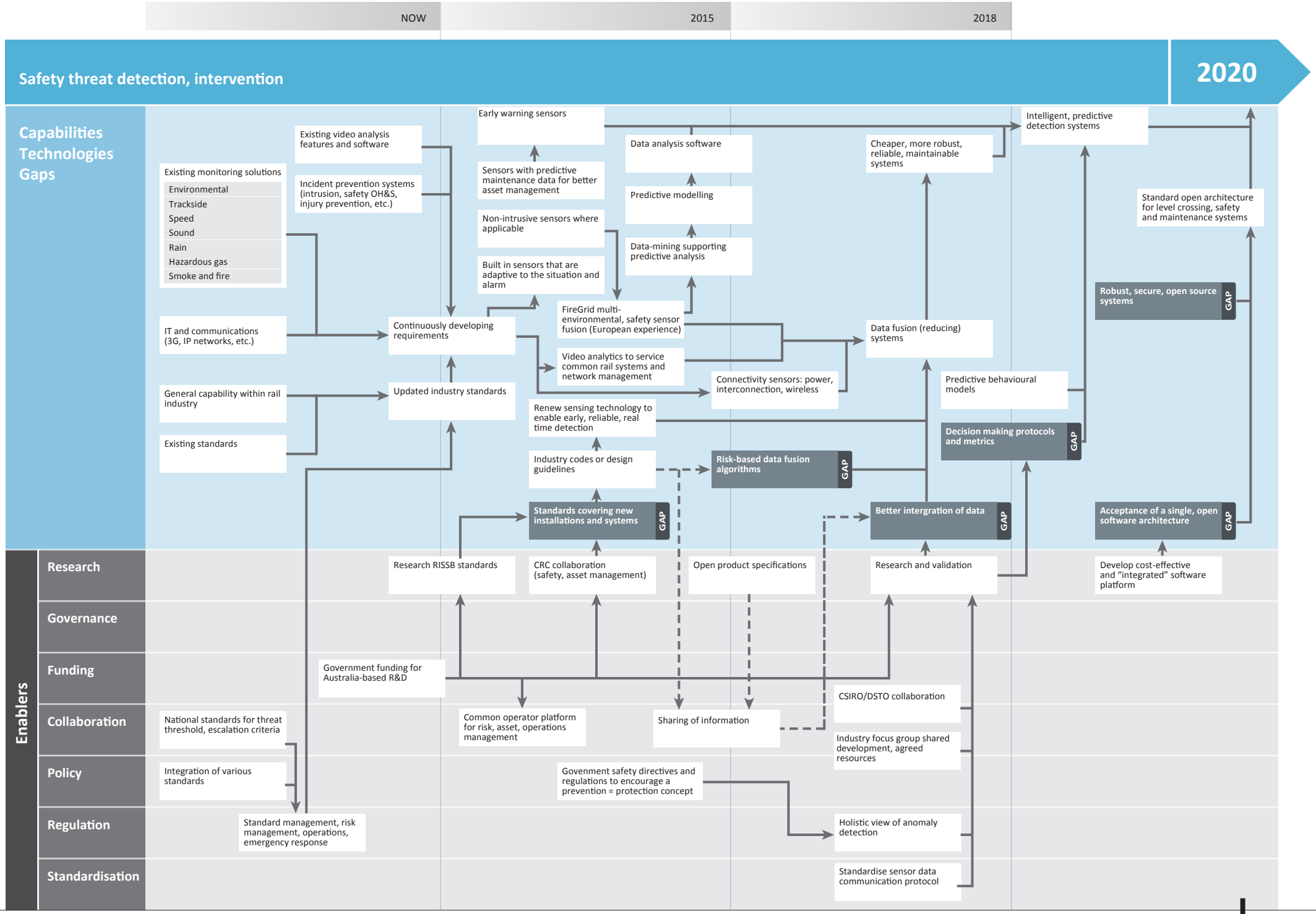



**FIGURE 28**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR SAFETY TREAT DETECTION, INTERVENTION. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2018
2020
Safety threat detection, intervention
Capabilities
Technologies
Gaps
Existing monitoring solutions
Environmental
Trackside
Speed
Sound
Rain
Hazardous gas
Smoke and fire
Existing video analysis features and software
Incident prevention systems (intrusion, safety OH&S, injury prevention, etc.)
IT and communications (3G, IP networks, etc.)
General capability within rail industry
Existing standards
Continuously developing requirements
Updated industry standards
Early warning sensors
Sensors with predictive maintenance data for better asset management
Non-intrusive sensors where applicable
Built in sensors that are adaptive to the situation and alarm
FireGrid multi-environmental, safety sensor fusion (European experience)
Video analytics to service common rail systems and network management
Renew sensing technology to enable early, reliable, real time detection
Industry codes or design guidelines
Standards covering new installations and systems
GAP
Data analysis software
Predictive modelling
Data-mining supporting predictive analysis
Connectivity sensors: power, interconnection, wireless
Risk-based data fusion algorithms
GAP
Cheaper, more robust, reliable, maintainable systems
Data fusion (reducing) systems
Better intergration of data
GAP
Intelligent, predictive detection systems
Predictive behavioural models
Decision making protocols and metrics
GAP
Standard open architecture for level crossing, safety and maintenance systems
Robust, secure, open source systems
GAP
Acceptance of a single, open software architecture
GAP
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Research RISSB standards
CRC collaboration (safety, asset management)
Open product specifications
Research and validation
Develop cost-effective and "integrated" software platform
Government funding for Australia-based R&D
National standards for threat threshold, escalation criteria
Common operator platform for risk, asset, operations management
Sharing of information
CSIRO/DSTO collaboration
Industry focus group shared development, agreed resources
Integration of various standards
Govenment safety directives and regulations to encourage a prevention = protection concept
Standard management, risk management, operations, emergency response
Holistic view of anomaly detection
Standardise sensor data communication protocol

# Advanced data analysis and information systems

## Algorithms and processing methodologies to intelligently manage and interpret available data

Data, such as fuel consumption and operational performance, are available at the moment, but are not efficiently and consistently utilised. After data collection the information can be correlated, analysed, manipulated and communicated to increase rail operation efficiency, as well as stored for future reference. Additionally, there is opportunity to provide better information to commuters and the public in the passenger sector and customers in the freight sector. By effectively managing data, improvements can be made to the operation of the rail system, including downtime analysis and the effectiveness of maintenance procedures. This leads to increasing asset performance and a more globally competitive Australian rail network.

As in many of the Monitoring and Management opportunities, much of the required technology exists. Data is already collected (or the collection is currently feasible) and networks exist for communication. Tools for the analysis of the data and the optimisation of the operations are currently being developed and will be available in the near future. However, the opportunity requires the detailed understanding of data requirements as well as legal, regulatory and privacy issues. The industry must also standardise their systems to make data compatible, leading to seamless data communication and analysis.

This opportunity was one of the most attractive across all priority areas, this is driven by not only by a strong international demand for such systems, but by the opportunity's tendency to improve cohesiveness within the rail industry.

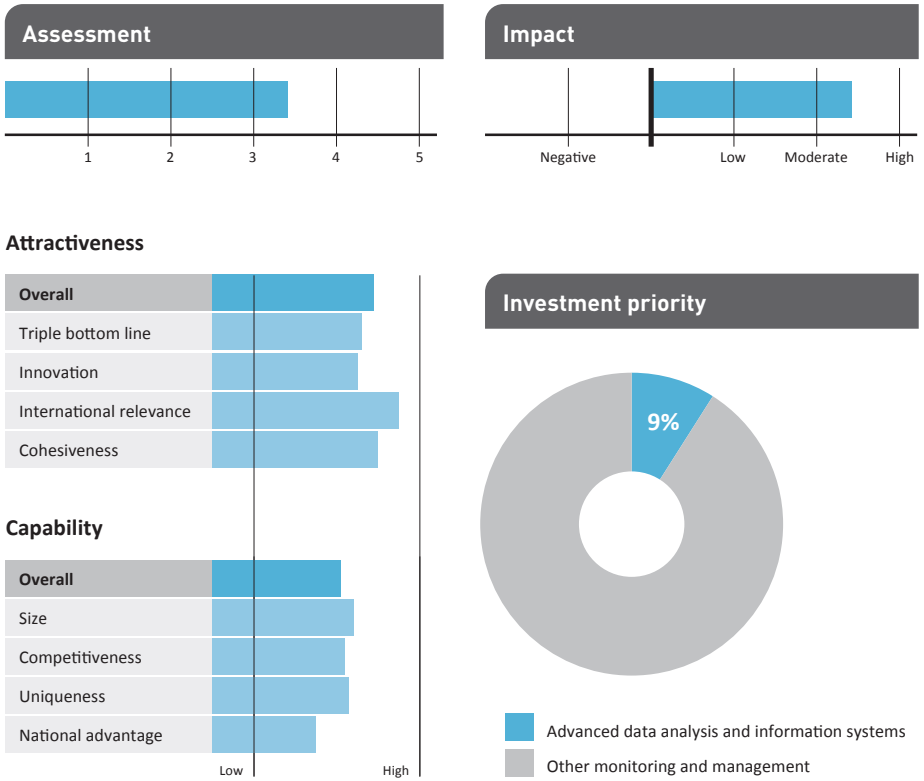
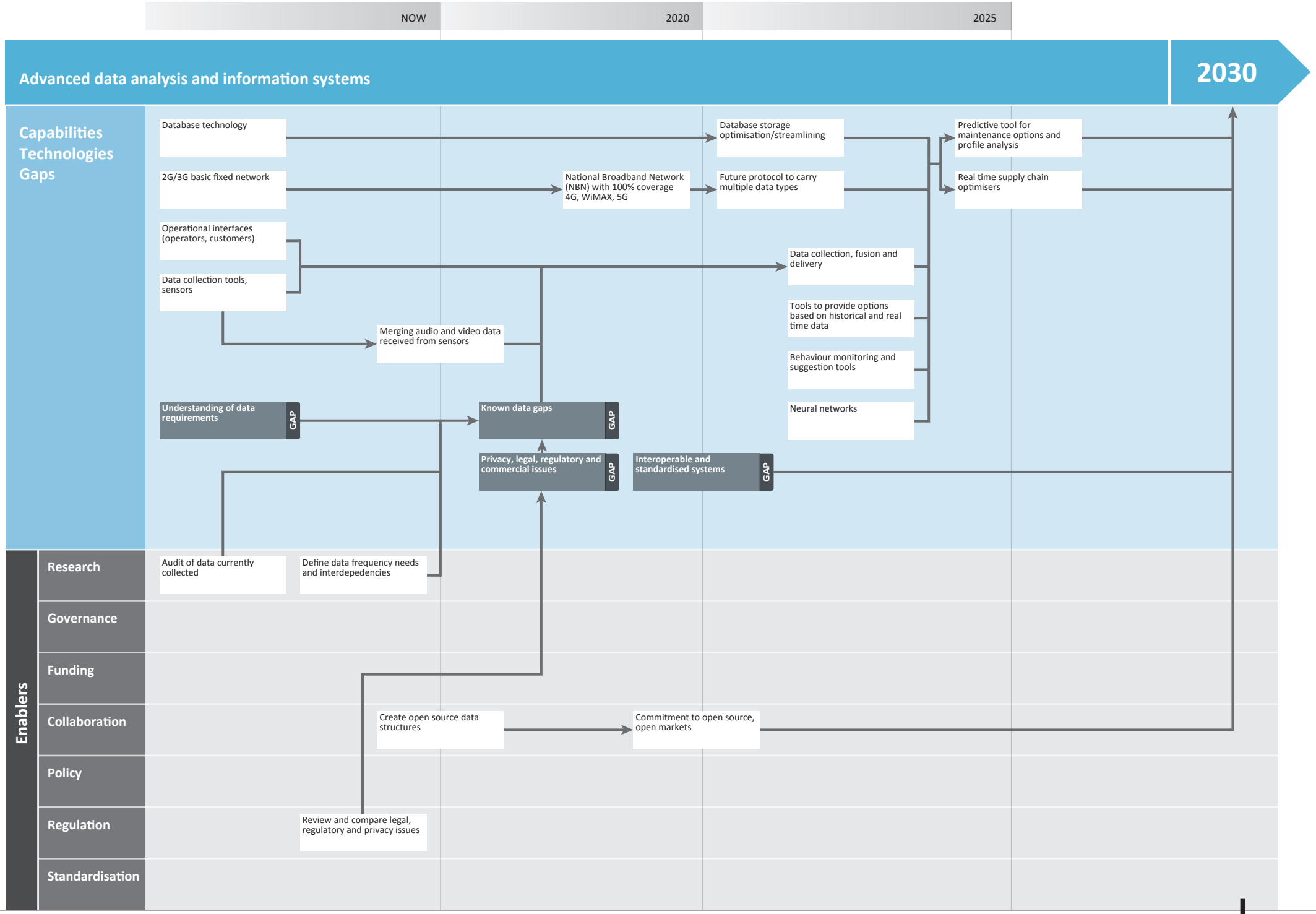



**FIGURE 29**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED DATA ANALYSIS AND INFORMATION SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2020
2025
Advanced data analysis and information systems
2030
Capabilities
Technologies
Gaps
Database technology
2G/3G basic fixed network
Operational interfaces (operators, customers)
Data collection tools, sensors
Merging audio and video data received from sensors
Understanding of data requirements
GAP
Known data gaps
GAP
Privacy, legal, regulatory and commercial issues
GAP
Interoperable and standardised systems
GAP
National Broadband Network (NBN) with 100% coverage 4G, WiMAX, 5G
Database storage optimisation/streamlining
Future protocol to carry multiple data types
Data collection, fusion and delivery
Tools to provide options based on historical and real time data
Behaviour monitoring and suggestion tools
Neural networks
Predictive tool for maintenance options and profile analysis
Real time supply chain optimisers
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Audit of data currently collected
Define data frequency needs and interdepedencies
Create open source data structures
Commitment to open source, open markets
Review and compare legal, regulatory and privacy issues

# Advanced operations management systems

## Tools and approaches to use available data to improve and automate operational performance

Operations management allows streamlined operational systems by providing operators with information such as schedule cargo, maintenance and downtime information to integrate all aspects of operational performance planning. For example: maintenance, mine, port and supply chain performance measures can be linked to prevent unnecessary operation interruption. Along with sensor data, advanced monitoring systems and early safety threat detection, there is an opportunity to lead the technological development and deployment of global best-practice operational systems.

There is significant expertise available in adjacent industries like shipping and airlines and also within the rail industry itself, specifically in heavy haul. All required technology currently exists. The major missing element is a strategic, coordinated development plan, the importance of which is highlighted by a large number of enablers supporting the realisation of the opportunity.

Advanced operations management received lower capability and attractiveness scores. The exception is cohesiveness as the opportunity will necessarily require collaboration. Some aspects, like automated passenger operations and autonomous freight loading, require a strategic and coordinated development plan.

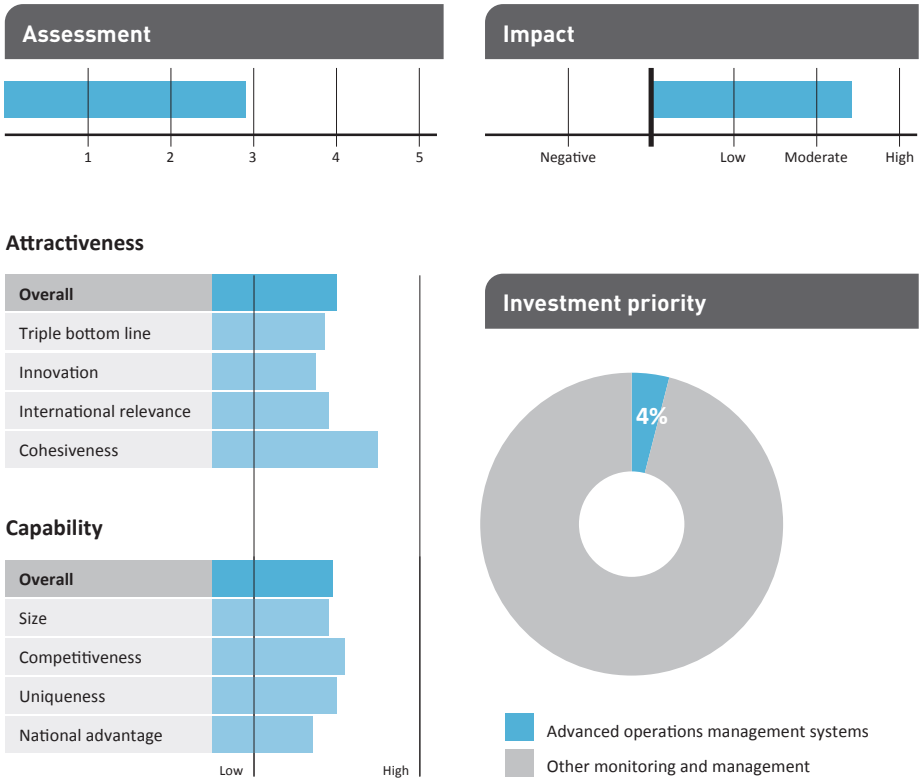
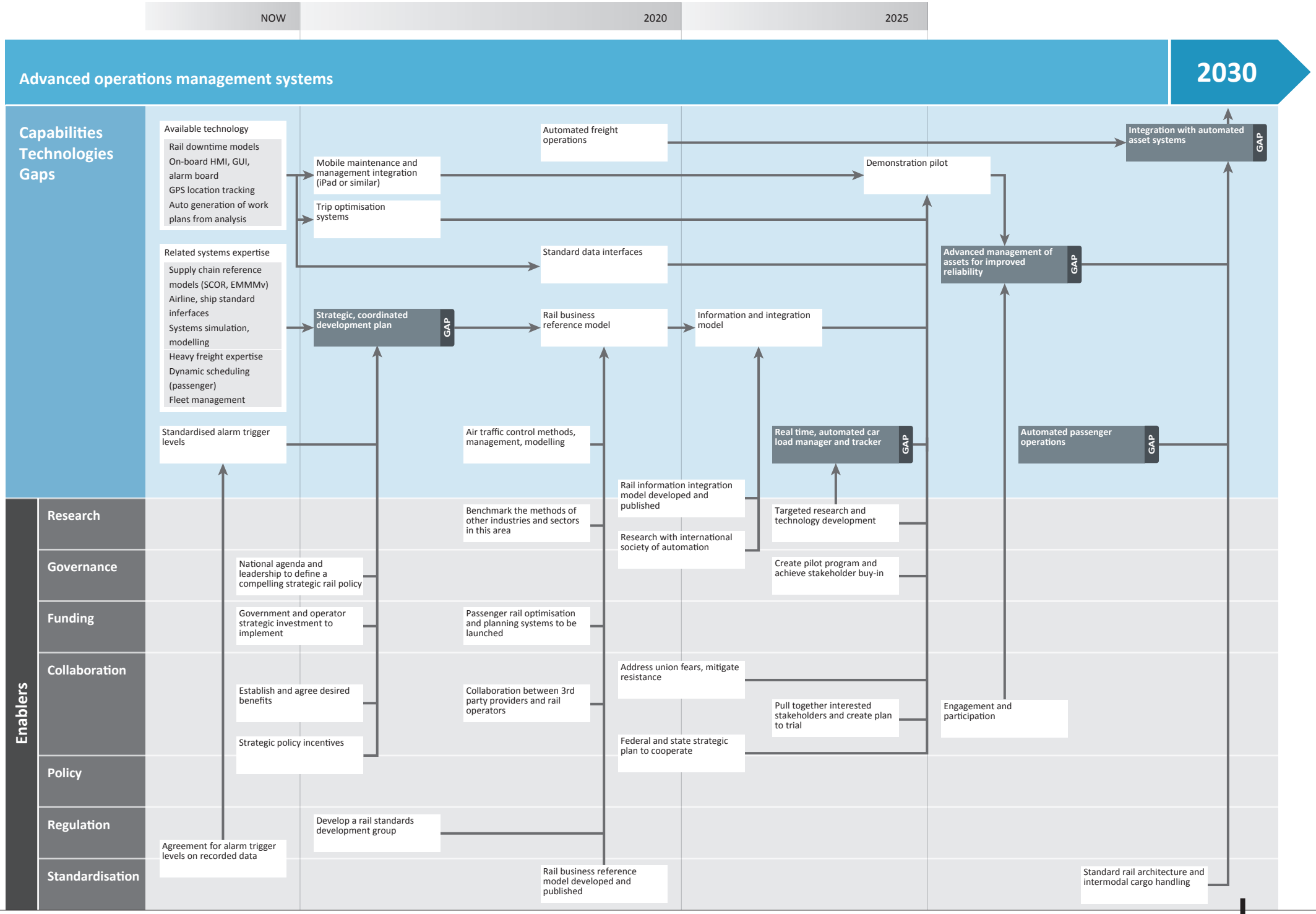



**FIGURE 30**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED OPERATIONS MANAGEMENT SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN MONITORING AND MANAGEMENT TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2020
2025
2030
Advanced operations management systems
Capabilities Technologies Gaps
Available technology
Rail downtime models
On-board HMI, GUI, alarm board
GPS location tracking
Auto generation of work plans from analysis
Related systems expertise
Supply chain reference models (SCOR, EMMMv)
Airline, ship standard inferfaces
Systems simulation, modelling
Heavy freight expertise
Dynamic scheduling (passenger)
Fleet management
Standardised alarm trigger levels
Mobile maintenance and management integration (iPad or similar)
Trip optimisation systems
Standard data interfaces
Strategic, coordinated development plan
GAP
Automated freight operations
Rail business reference model
Information and integration model
Demonstration pilot
Advanced management of assets for improved reliability
GAP
Integration with automated asset systems
GAP
Air traffic control methods, management, modelling
Real time, automated car load manager and tracker
GAP
Automated passenger operations
GAP
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Benchmark the methods of other industries and sectors in this area
Rail information integration model developed and published
Research with international society of automation
Targeted research and technology development
National agenda and leadership to define a compelling strategic rail policy
Create pilot program and achieve stakeholder buy-in
Government and operator strategic investment to implement
Passenger rail optimisation and planning systems to be launched
Establish and agree desired benefits
Collaboration between 3rd party providers and rail operators
Address union fears, mitigate resistance
Pull together interested stakeholders and create plan to trial
Engagement and participation
Strategic policy incentives
Federal and state strategic plan to cooperate
Develop a rail standards development group
Agreement for alarm trigger levels on recorded data
Rail business reference model developed and published
Standard rail architecture and intermodal cargo handling

# on track to 2040

# Power and Propulsion

The third priority area for the Australian rail industry was identified around technology for delivering more efficient and effective power and propulsion systems. This area covers all elements of fuel and energy delivery, storage, management and regeneration; as well as braking systems, emissions reduction technology and general equipment efficiency.

With increasing demand for improved fuel efficiencies and alternative energy sources, there is a global market for products and services in the area of Power and Propulsion. These services look to reduce the energy foot print of the transportation and reduce the associated running costs.

The project has identified some indigenous Australian capabilities in area of alternative fuels and energy capture and storage. These high technology capabilities are able to provide solutions to the global rail industry in reducing energy consumption and fuel costs. This can be achieved through the leveraging of Australian research and development expertise.

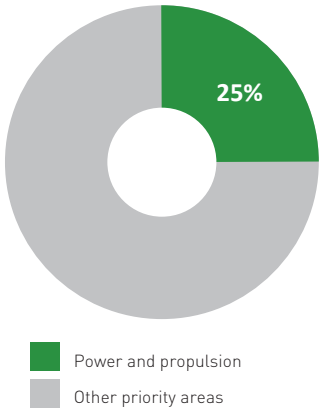



**FIGURE 31**
RESOURCE ALLOCATION FOR THE POWER AND PROPULSION AREA

# Energy regeneration

## Recovery of waste heat and kinetic energy for reuse on-board or in trackside applications

Energy is wasted in the form of heat when a train slows down, but this energy can be reclaimed and stored (either on-board or wayside) and used to reduce the energy required to accelerate again. This regenerative braking and energy storage covers one type of energy recovery, but utilisation of heat from exhaust, engine and other sources provides other efficiency gains. By replacing the current resistive locomotive brakes with regenerative ones (perhaps beginning with electrified urban systems), energy can be driven back into the locomotive or the supply grid. This reduces power consumption, improving voltage stability and reducing substation and cabling requirements – secondary benefits that lower infrastructure costs.

The software aspects of this opportunity already exist. Energy regeneration technology also exists and is being used internationally. There is still some development of energy storage to be undertaken. With a better understanding of the economic options, and the energy needs, some funding will enable the installation of regenerative technologies and the development of required management software.

Energy regeneration has a high attractiveness from international demand and the collaboration that would result from implementation. This opportunity is the highest investment priority within Power and Propulsion.

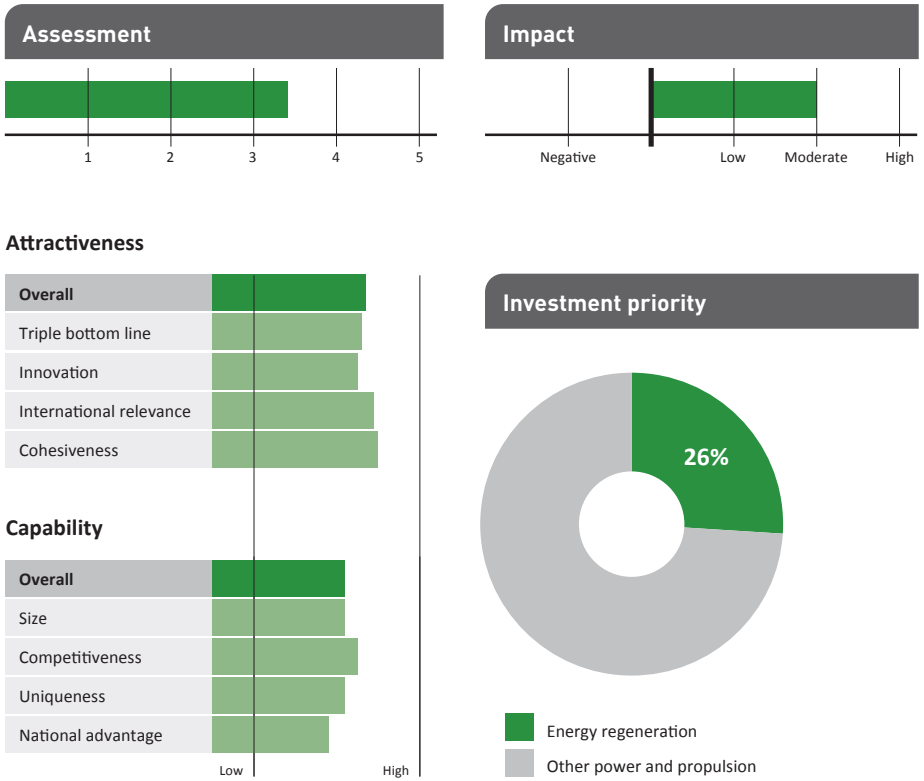
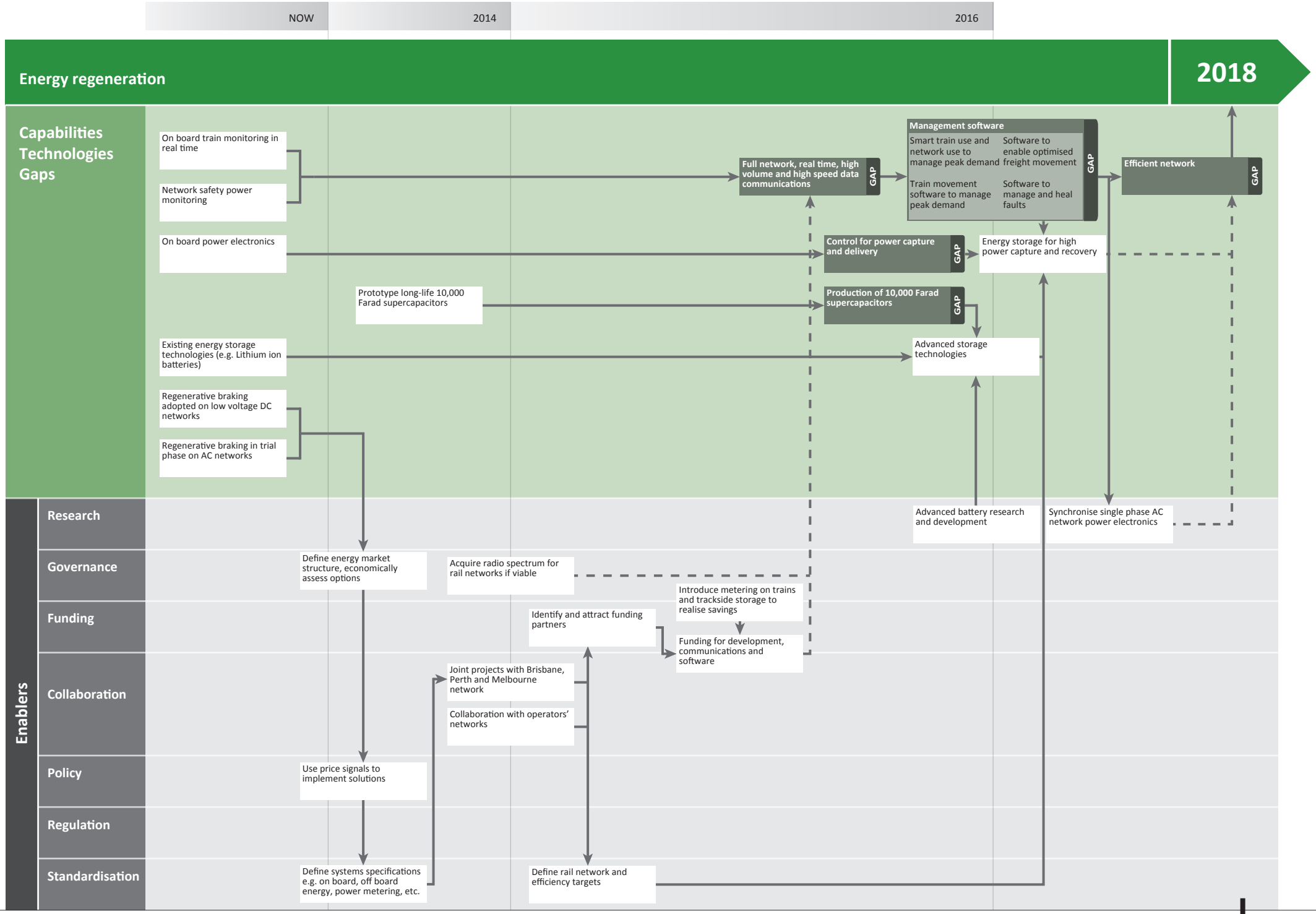



**FIGURE 32**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ENERGY REGENERATION. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2014
2016
Energy regeneration
2018
Capabilities
Technologies
Gaps
On board train monitoring in real time
Network safety power monitoring
On board power electronics
Prototype long-life 10,000 Farad supercapacitors
Existing energy storage technologies (e.g. Lithium ion batteries)
Regenerative braking adopted on low voltage DC networks
Regenerative braking in trial phase on AC networks
Full network, real time, high volume and high speed data communications
GAP
Management software
Smart train use and network use to manage peak demand
Software to enable optimised freight movement
Train movement software to manage peak demand
Software to manage and heal faults
GAP
Efficient network
GAP
Control for power capture and delivery
GAP
Energy storage for high power capture and recovery
Production of 10,000 Farad supercapacitors
GAP
Advanced storage technologies
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Advanced battery research and development
Synchronise single phase AC network power electronics
Define energy market structure, economically assess options
Acquire radio spectrum for rail networks if viable
Introduce metering on trains and trackside storage to realise savings
Identify and attract funding partners
Funding for development, communications and software
Joint projects with Brisbane, Perth and Melbourne network
Collaboration with operators' networks
Use price signals to implement solutions
Define systems specifications e.g. on board, off board energy, power metering, etc.
Define rail network and efficiency targets

# Advanced braking systems

## Rollout and retrofit of electronically controlled pneumatic (ECP) and regenerative braking systems

Electronically Controlled Pneumatic braking systems result in the synchronised braking of wagons, reducing the in-train forces, which improve lifespan and reduce the energy required to brake. Intelligent computer systems could also improve braking, and even allow individual control of each axle to minimise slip, increasing brake efficiency and lifetime. Improved braking technology also increases the safety of rail lines. Specifically, operational experience shows advanced braking systems leading to decreases in fuel consumption (over 5%), and reduced brake wear (over 20%), with wheel flats almost eliminated. Other positives include greater wagon availability and increased wagon life. Modern braking systems are also designed to be lighter, reducing the train's mass.

A cost effective ECP conversion solution is expected to be available so that conversion of existing fleets can occur soon after 2015. Backed by a business case and low cost sensor solutions, ECP park brakes will ensure advanced braking systems achieving their promised benefits by 2017. The roadmap displays a parallel path requiring client confidence for the rollout before a demonstration is made in partnership with an Australian operator soon after 2017. ECP braking systems can be combined with energy regeneration braking for added impact.

This opportunity received the highest score for capability among priority opportunities. Though the size of the relevant Australian industry is relatively small, the companies in Australia are highly competitive. This indicates much potential for growth.

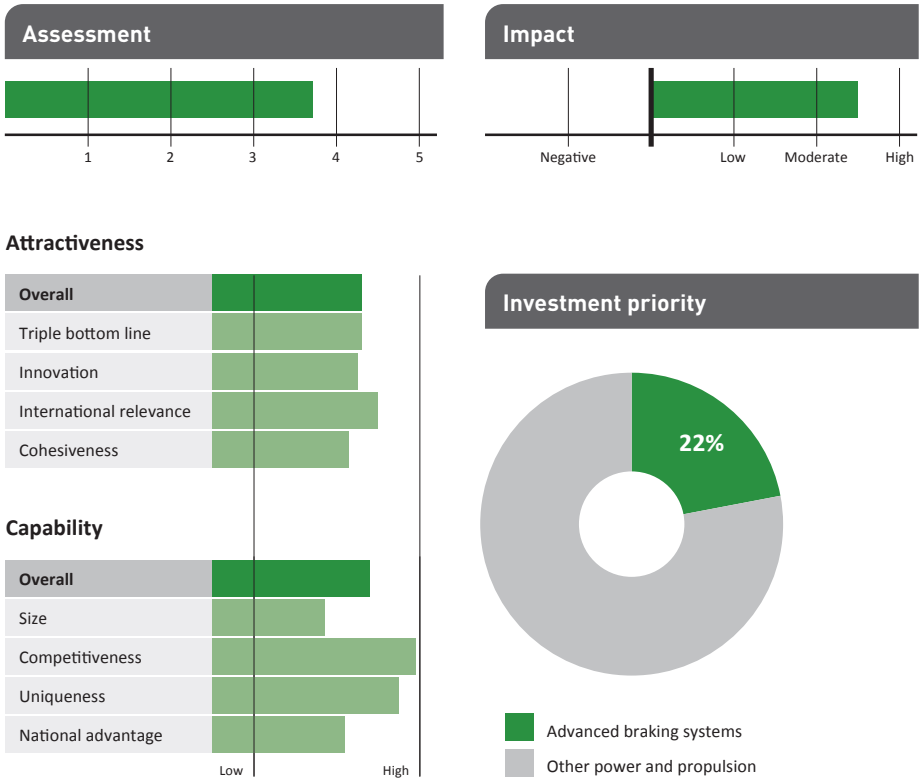
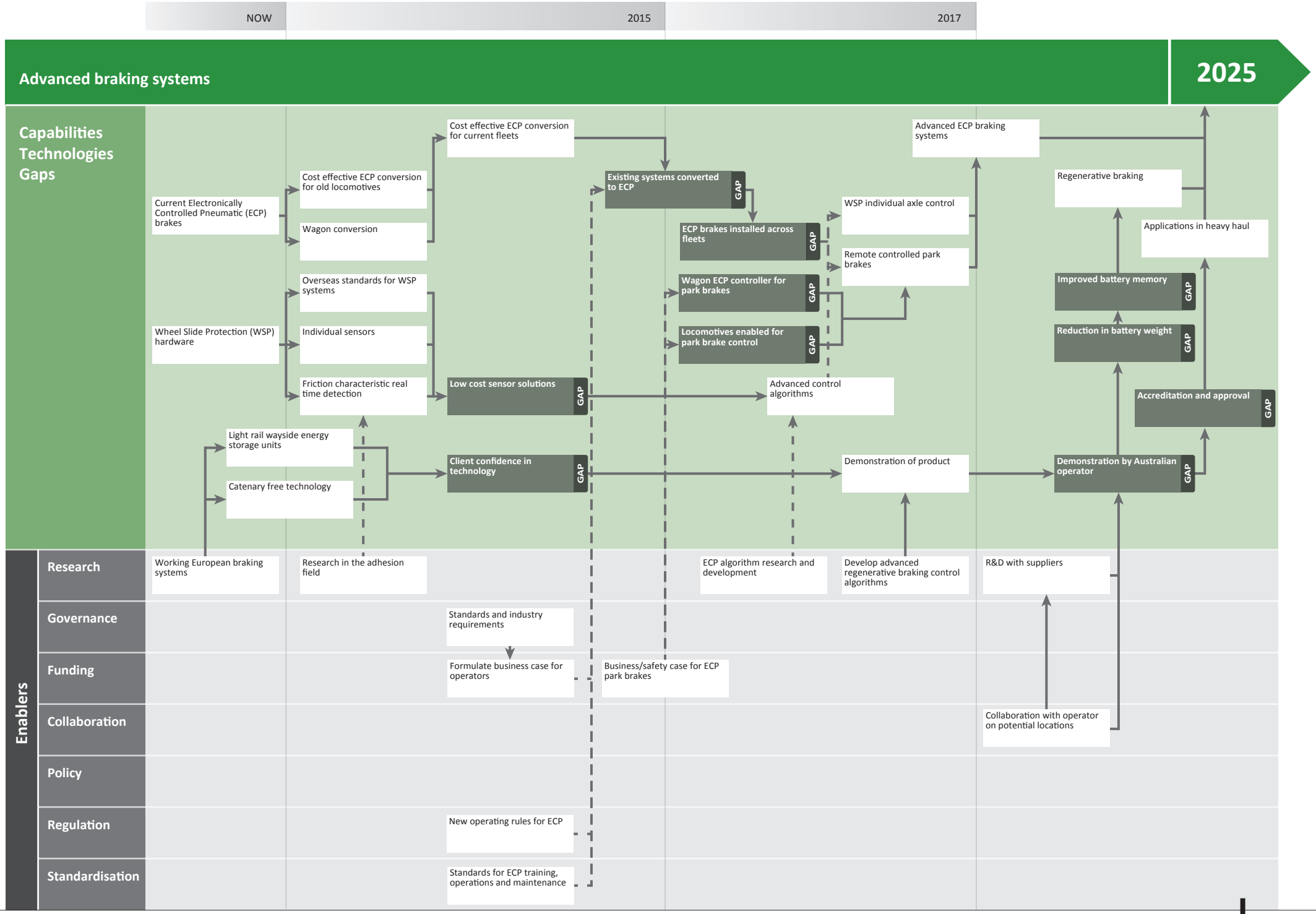



**FIGURE 33**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ADVANCED BRAKING SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2017
2025
Advanced braking systems
Capabilities
Technologies
Gaps
Current Electronically Controlled Pneumatic (ECP) brakes
Cost effective ECP conversion for old locomotives
Wagon conversion
Cost effective ECP conversion for current fleets
Existing systems converted to ECP
GAP
ECP brakes installed across fleets
GAP
WSP individual axle control
Remote controlled park brakes
Advanced ECP braking systems
Regenerative braking
Applications in heavy haul
Wheel Slide Protection (WSP) hardware
Overseas standards for WSP systems
Individual sensors
Friction characteristic real time detection
Wagon ECP controller for park brakes
GAP
Locomotives enabled for park brake control
GAP
Low cost sensor solutions
GAP
Advanced control algorithms
Improved battery memory
GAP
Reduction in battery weight
GAP
Accreditation and approval
GAP
Light rail wayside energy storage units
Catenary free technology
Client confidence in technology
GAP
Demonstration of product
Demonstration by Australian operator
GAP
Enablers
Research
Working European braking systems
Research in the adhesion field
ECP algorithm research and development
Develop advanced regenerative braking control algorithms
R&D with suppliers
Governance
Standards and industry requirements
Funding
Formulate business case for operators
Business/safety case for ECP park brakes
Collaboration
Collaboration with operator on potential locations
Policy
Regulation
New operating rules for ECP
Standardisation
Standards for ECP training, operations and maintenance

# Energy use management tools

## Approaches and software to intelligently minimise energy consumption in driven and driverless trains

Energy management tools can be added to new and existing trains to tell the driver how to best use fuel and reduce in-train forces. This has potential to reduce energy use and carbon emissions by over 20%. Additionally, energy management will make the trip smoother, which improves reliability and part lifespan. Automated approaches to energy use management have a demonstrated history of efficiency improvement in electricity-intensive industries like smelting and refining. The technologies required for this opportunity could be further developed to support complete train automation, and have a strong export potential as there is likely to be an increasing market around the world for these systems.

This roadmap, like advanced braking systems, considers energy regeneration as a parallel development to capitalise on the opportunities' similar requirements, while achieving additive payoffs. With industry cooperation including the sharing of route data and of necessary infrastructure, electronic versions of the routes can be combined with existing Australian energy management solutions to produce a trial. From this trial the industry can undergo a risk assessment and, after acceptance or mitigation of the risks, energy management software can be in widespread operation by 2020.

Energy use management tools has the highest impact score in this priority area. This is related to its widespread potential benefits.

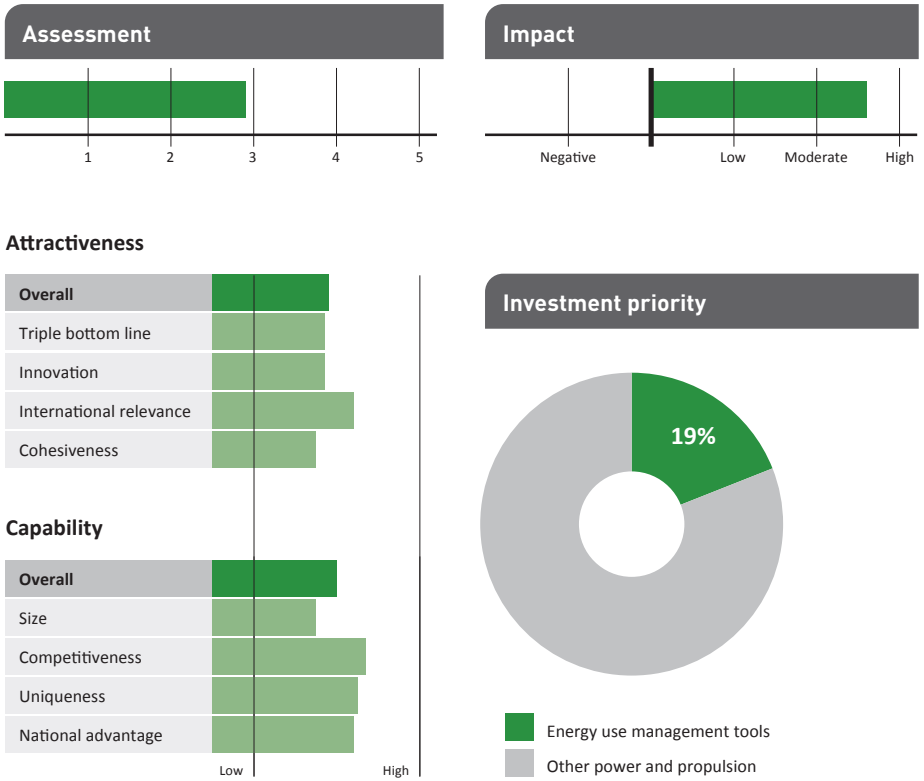
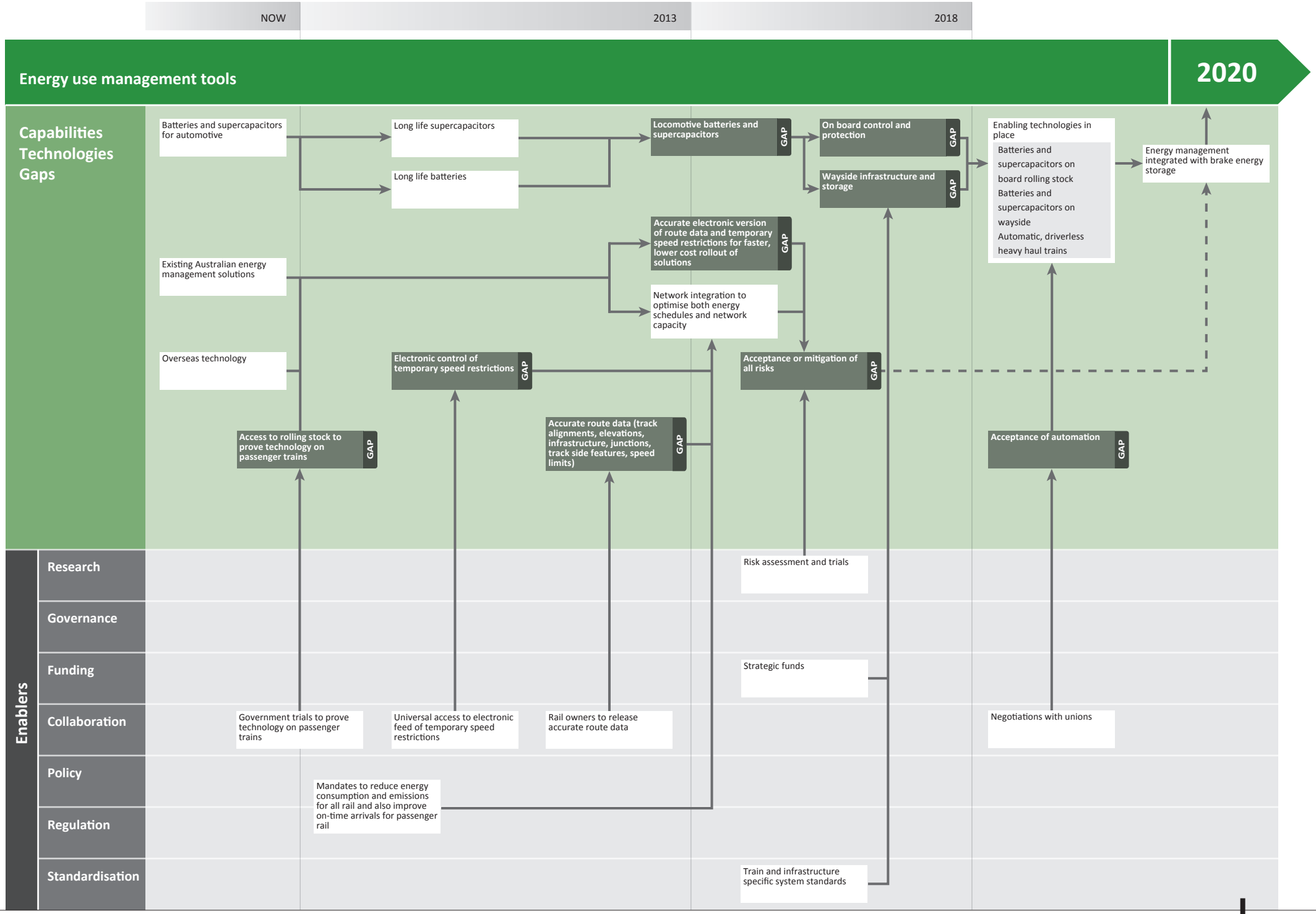



**FIGURE 34**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ENERGY USE MANAGEMENT TOOLS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2013
2018
2020
Energy use management tools
Capabilities Technologies Gaps
Batteries and supercapacitors for automotive
Long life supercapacitors
Long life batteries
Locomotive batteries and supercapacitors
GAP
On board control and protection
GAP
Wayside infrastructure and storage
GAP
Enabling technologies in place
Batteries and supercapacitors on board rolling stock
Batteries and supercapacitors on wayside
Automatic, driverless heavy haul trains
Energy management integrated with brake energy storage
Existing Australian energy management solutions
Accurate electronic version of route data and temporary speed restrictions for faster, lower cost rollout of solutions
GAP
Network integration to optimise both energy schedules and network capacity
Overseas technology
Electronic control of temporary speed restrictions
GAP
Acceptance or mitigation of all risks
GAP
Access to rolling stock to prove technology on passenger trains
GAP
Accurate route data (track alignments, elevations, infrastructure, junctions, track side features, speed limits)
GAP
Acceptance of automation
GAP
Enablers
Research
Governance
Funding
Collaboration
Policy
Regulation
Standardisation
Risk assessment and trials
Strategic funds
Government trials to prove technology on passenger trains
Universal access to electronic feed of temporary speed restrictions
Rail owners to release accurate route data
Negotiations with unions
Mandates to reduce energy consumption and emissions for all rail and also improve on-time arrivals for passenger rail
Train and infrastructure specific system standards

# Electric motors and systems

## Retrofit installation of AC traction and high-efficiency power electronic systems for locomotives

Electric motors remove the need for fuel, but take their power from the external power distribution network. Alternatively they can be combined with conventional engines to create hybrid locomotives. As electric systems, these motors are easily combined with energy monitoring and regeneration opportunities. Although trains that are partially or fully electrified exist, there are improvements that can be made. Hybridisation also has been instigated in other industries and the lessons from these can be applied to rail. The system around the electric motor is also of great importance. The entire electric powertrain can be made more efficient by moving from DC to AC traction while reducing the weight and size of power electronic equipment. Electrification is an emerging opportunity in other industries as well, representing large potential secondary markets for improved electrification technology.

It is currently possible to build a prototype AC locomotive retrofit, though a full demonstration capable of starting a rollout requires improved high powered inverters and supercapacitor storage systems or batteries. With these technological advances it should be possible to fit electric motors or hybrid systems to existing stock with the support of operators with co-investments by industry and governments. A large-scale manufacturing base of electric machines could be developed to provide motors to Australia and the world.

Electric motors and systems have great potential to promote innovation in the Australian rail supply industry. The opportunity achieved the strongest overall assessment score, being the single most attractive with strong existing and emerging Australian capability. The high scores for competitiveness, uniqueness and national advantage indicate strong potential for growth.

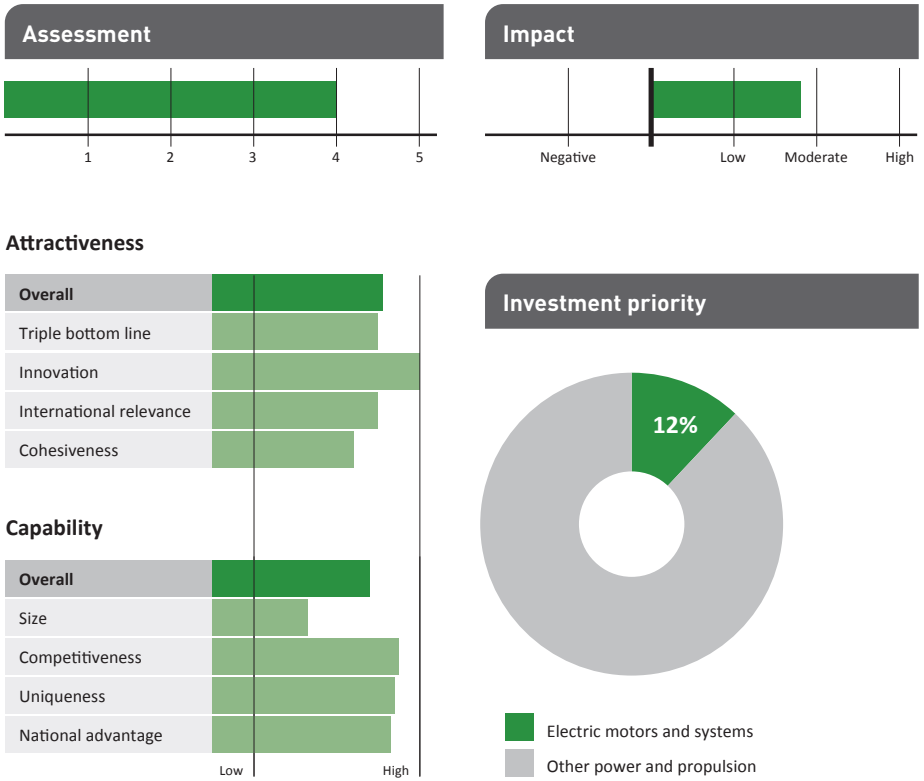
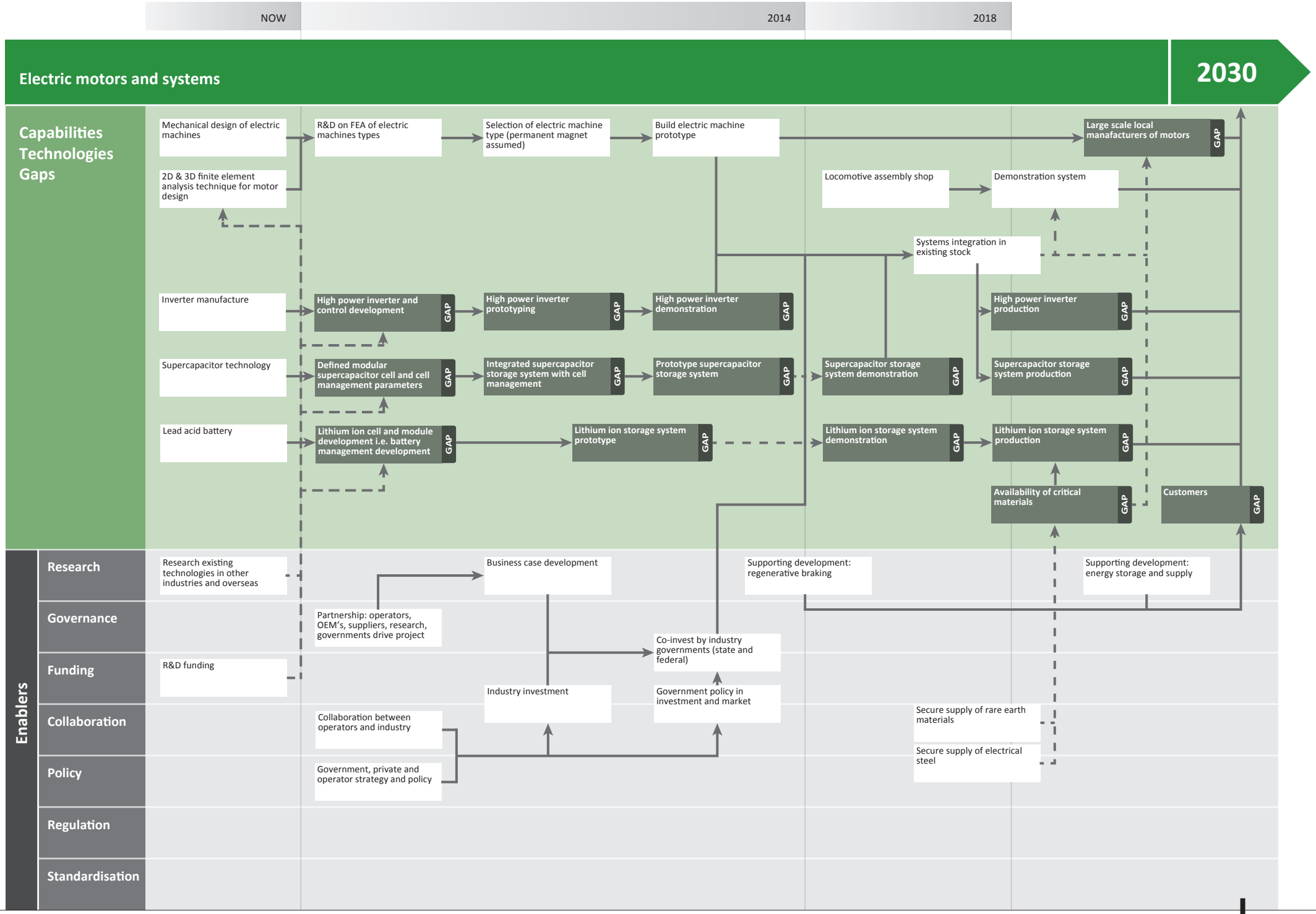



**FIGURE 35**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ELECTRIC MOTORS AND SYSTEMS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2014
2018
Electric motors and systems
2030
Capabilities Technologies Gaps
Mechanical design of electric machines
R&D on FEA of electric machines types
Selection of electric machine type (permanent magnet assumed)
Build electric machine prototype
Large scale local manafacturers of motors
GAP
2D & 3D finite element analysis technique for motor design
Locomotive assembly shop
Demonstration system
Systems integration in existing stock
Inverter manufacture
High power inverter and control development
High power inverter prototyping
High power inverter demonstration
High power inverter production
Supercapacitor technology
Defined modular supercapacitor cell and cell management parameters
Integrated supercapacitor storage system with cell management
Prototype supercapacitor storage system
Supercapacitor storage system demonstration
Supercapacitor storage system production
Lead acid battery
Lithium ion cell and module development i.e. battery management development
Lithium ion storage system prototype
Lithium ion storage system demonstration
Lithium ion storage system production
Availability of critical materials
Customers
Enablers
Research
Research existing technologies in other industries and overseas
Business case development
Supporting development: regenerative braking
Supporting development: energy storage and supply
Governance
Partnership: operators, OEM's, suppliers, research, governments drive project
Funding
R&D funding
Co-invest by industry governments (state and federal)
Industry investment
Government policy in investment and market
Collaboration
Collaboration between operators and industry
Secure supply of rare earth materials
Secure supply of electrical steel
Policy
Government, private and operator strategy and policy
Regulation
Standardisation

# Emissions reduction technologies

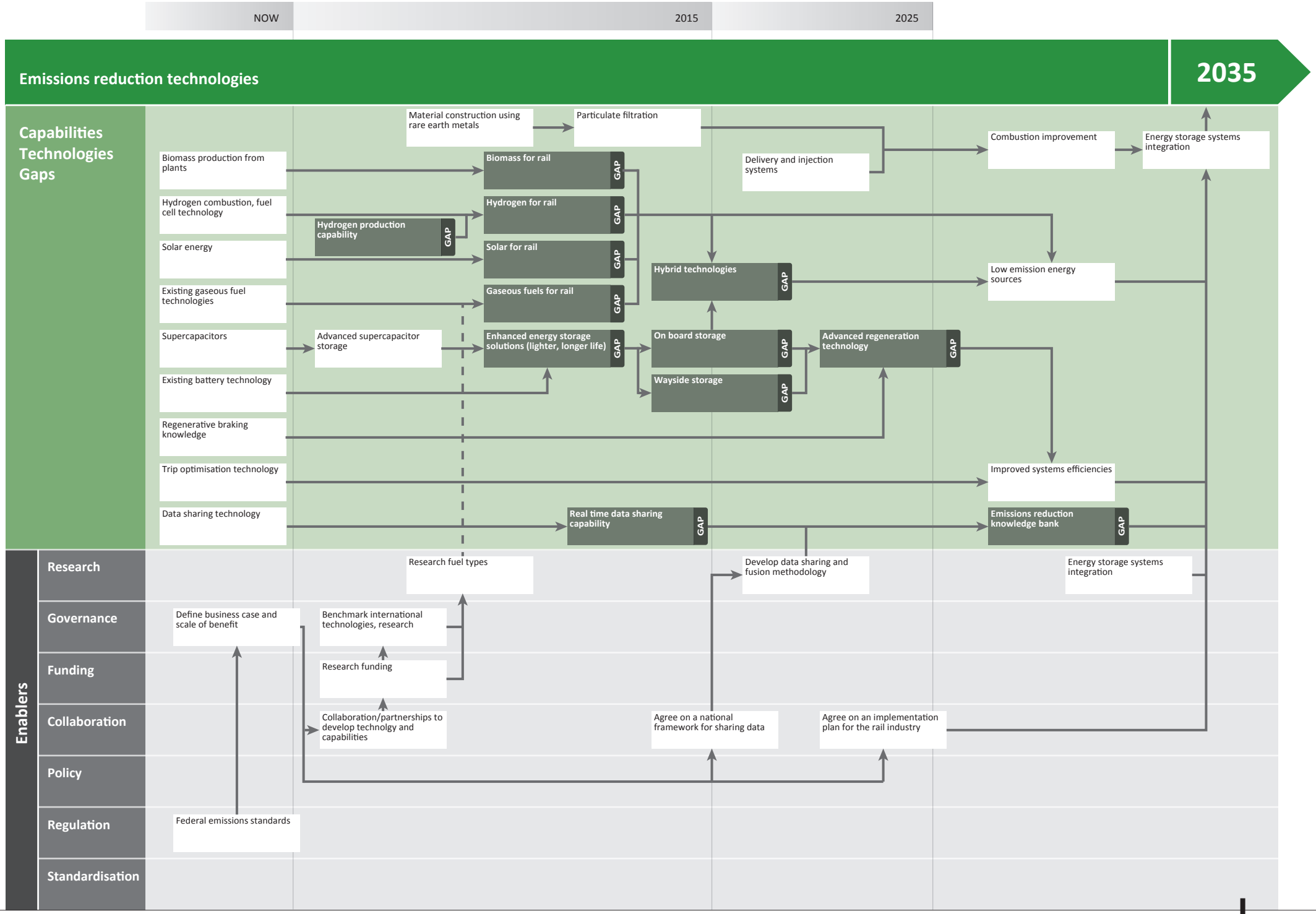
## Alternative and renewable fuels, and systems to reduce non-carbon emissions

Changing the fuel type for locomotives, or improving efficiency, is not the only way to reduce emissions. There are non-$CO_2$ emissions that are not reduced by simple fuel efficiency measures. For example, diesel particulate filters and catalytic converters are used to reduce other harmful emissions. Increasing social and regulatory pressures to reduce all type of emissions overseas are likely to arrive in Australia. Some rail networks may be further required to reduce noise, which could be done with new materials or electric motors. At the same time, strengthening European regulations are creating international demand of low emission technologies.

There are many types of power sources that can reduce harmful emissions. Their appropriateness in the rail sector is yet to be determined. These power sources need to be researched and this relies on benchmarking international technologies and research funding and collaboration. With investigation into all possibilities, and opportunities for combinations of many in the form of hybrids, low emission energy solutions can be created. This roadmap overlaps with many of the Monitoring and Management opportunities that suggest the sharing of data for trip optimisation and improved efficiency. With additional low emissions improvements to the combustion engine, the emissions reduction opportunity could be realised by 2035.

The Australian industry is highly competitive, owing to strong export results and innovation investments in this area among Australian companies. This is echoed by high uniqueness, and leads to the highest capability score achieved of all the priority opportunities. This strong capability is similar to Electric Motors and Systems and Gaseous Fuels, but in contrast Emissions Reductions Technologies has a higher impact rating.


**FIGURE 36**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR ENERGY REDUCTION TECHNOLOGIES. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2025
2035
Emissions reduction technologies
Capabilities
Technologies
Gaps
Material construction using rare earth metals
Particulate filtration
Combustion improvement
Energy storage systems integration
Biomass production from plants
Biomass for rail
GAP
Delivery and injection systems
Hydrogen combustion, fuel cell technology
Hydrogen for rail
GAP
Hydrogen production capability
GAP
Solar energy
Solar for rail
GAP
Hybrid technologies
GAP
Low emission energy sources
Existing gaseous fuel technologies
Gaseous fuels for rail
GAP
Supercapacitors
Advanced supercapacitor storage
Enhanced energy storage solutions (lighter, longer life)
GAP
On board storage
GAP
Advanced regeneration technology
GAP
Existing battery technology
Wayside storage
GAP
Regenerative braking knowledge
Trip optimisation technology
Improved systems efficiencies
Data sharing technology
Real time data sharing capability
GAP
Emissions reduction knowledge bank
GAP
Enablers
Research
Research fuel types
Develop data sharing and fusion methodology
Energy storage systems integration
Governance
Define business case and scale of benefit
Benchmark international technologies, research
Funding
Research funding
Collaboration
Collaboration/partnerships to develop technolgy and capabilities
Agree on a national framework for sharing data
Agree on an implementation plan for the rail industry
Policy
Regulation
Federal emissions standards
Standardisation

# Gaseous fuels

## Development and implementation of LPG or LNG locomotives and supporting infrastructure

Natural gas is cheap and abundant in Australia and some supply infrastructure currently exists (though some infrastructure limitations still need to be addressed). As a solution unique to the Australian environment, it has the multiplicative effect of stimulating local industry through new technologies, while providing a global technology for an export market. Much of the required technology for rail applications already exists and the move to gaseous fuels will lower the industry's carbon footprint and reduce fuel cost. Concern over the impending energy security issues around oil-based fuels accelerates the drive for alternatives. Building on abundant gas reserves, new technologies will be developed that could be sold, along with the gaseous fuel itself, to the global rail market.

The roadmap for gaseous fuels requires an understanding of the infrastructure and energy requirements of such an opportunity. Then a clear policy is needed from the government to ensure industry buy-in. With this an LNG pilot can be demonstrated. At the same time engaging with a major gas partner could result in productised gas systems and storage that the rail industry, and the country as a whole, can market overseas for a broader benefit.

Gaseous fuels has the highest natural advantage score as the country has a strong gas industry and large reserves. Attractiveness is also relatively high, but the opportunity has limited applicability to suburban passenger rail networks.

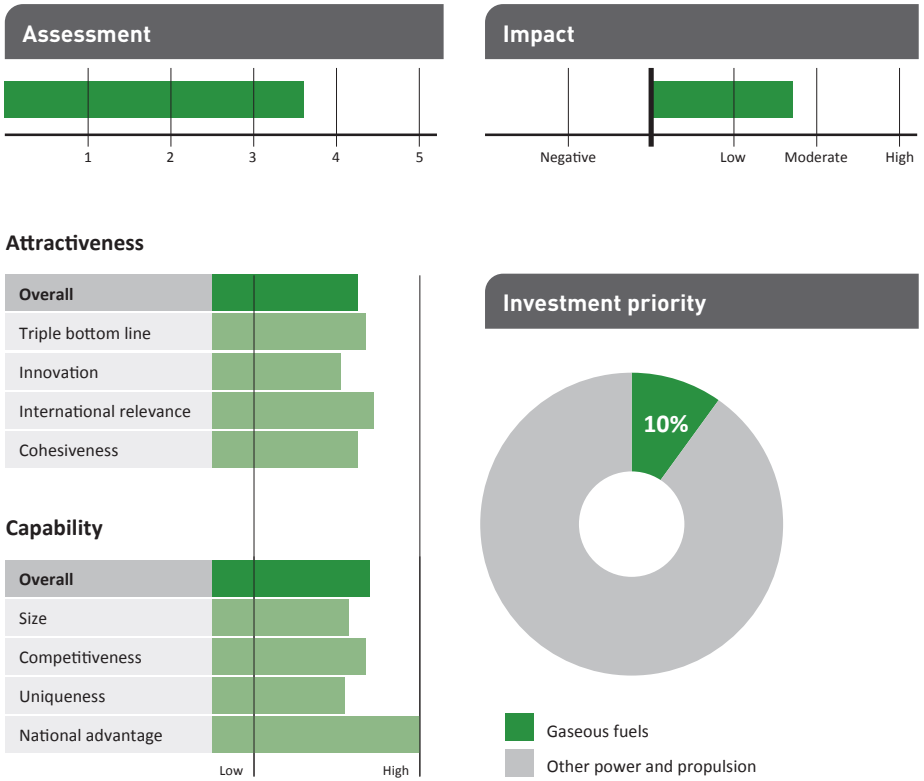
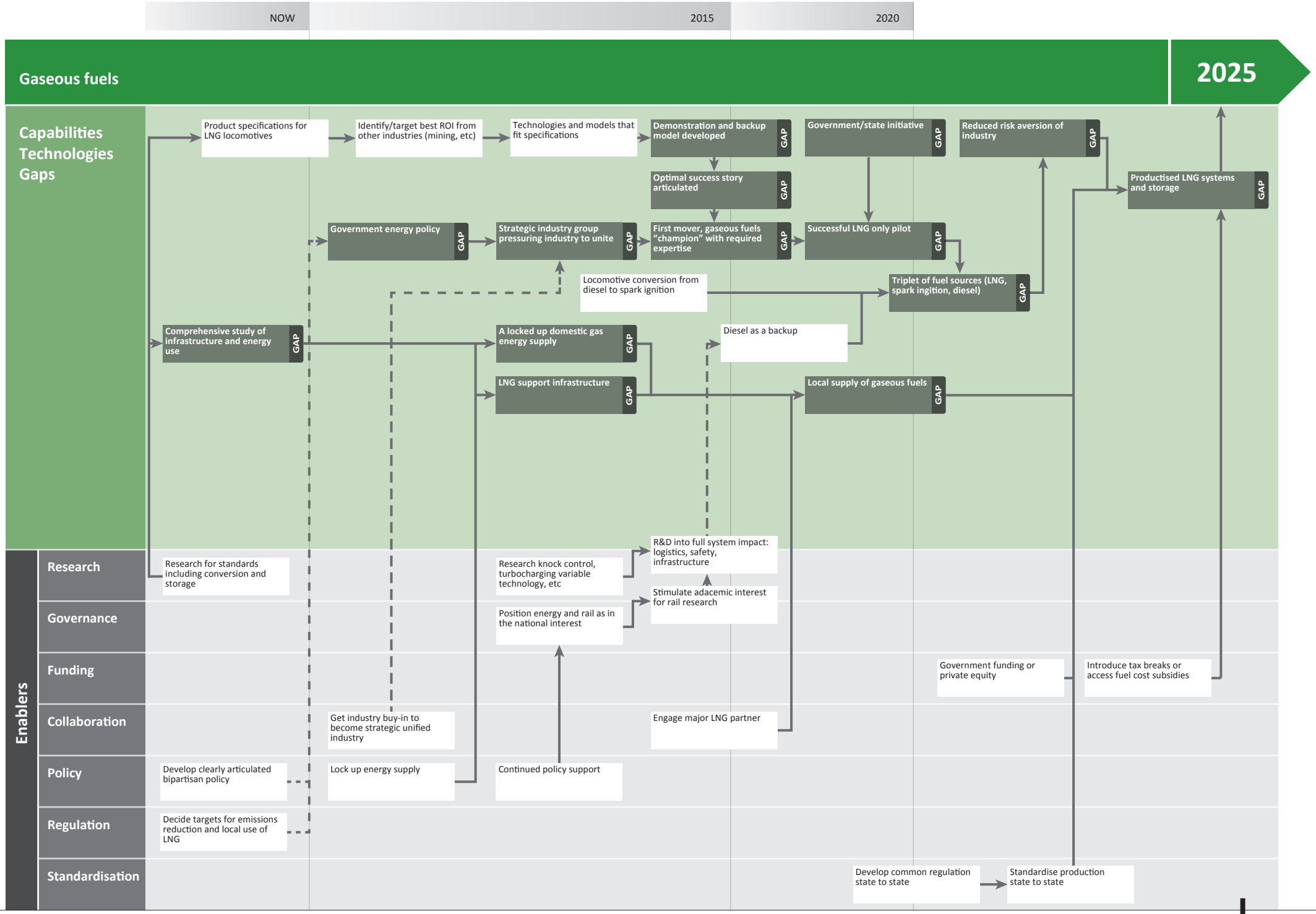



**FIGURE 37**
ASSESSMENT, IMPACT AND INVESTMENT PRIORITY SCORES FOR GASEOUS FUELS. DETAILS OF THE ASSESSMENT METHODOLOGY ARE AVAILABLE ON PAGE 35. IMPACT AND INVESTMENT SCORES WERE SELECTED BY WORKSHOP PARTICIPANTS TO SHOW THE RELATIVE POTENTIAL IMPACT OF EACH OPPORTUNITY ON THE INDUSTRY AND THE SUGGESTED PROPORTION OF INVESTMENT RESOURCES IN POWER AND PROPULSION TO BE ALLOCATED TO THE OPPORTUNITY.


NOW
2015
2020
Gaseous fuels
2025
Capabilities Technologies Gaps
Product specifications for LNG locomotives
Identify/target best ROI from other industries (mining, etc)
Technologies and models that fit specifications
Demonstration and backup model developed GAP
Government/state initiative GAP
Reduced risk aversion of industry GAP
Optimal success story articulated GAP
Productised LNG systems and storage GAP
Government energy policy GAP
Strategic industry group pressuring industry to unite GAP
First mover, gaseous fuels "champion" with required expertise GAP
Successful LNG only pilot GAP
Locomotive conversion from diesel to spark ignition
Triplet of fuel sources (LNG, spark ingition, diesel) GAP
Comprehensive study of infrastructure and energy use GAP
A locked up domestic gas energy supply GAP
Diesel as a backup
LNG support infrastructure GAP
Local supply of gaseous fuels GAP
Enablers
Research
Research for standards including conversion and storage
Research knock control, turbocharging variable technology, etc
R&D into full system impact: logistics, safety, infrastructure
Stimulate adacemic interest for rail research
Governance
Position energy and rail as in the national interest
Funding
Government funding or private equity
Introduce tax breaks or access fuel cost subsidies
Collaboration
Get industry buy-in to become strategic unified industry
Engage major LNG partner
Policy
Develop clearly articulated bipartisan policy
Lock up energy supply
Continued policy support
Regulation
Decide targets for emissions reduction and local use of LNG
Standardisation
Develop common regulation state to state
Standardise production state to state

# Appendix A – Opportunities

The following lists of opportunities were highlighted by survey respondents and interviewed organisations. These surveys and interviews measured data and scored each opportunity against attractiveness and capability measures (as described on page 35), before a final review by industry experts in a workshop determined the opportunities to undergo detailed roadmapping.

## Evaluated opportunities

This list contains the 40 opportunities selected by participants for further consideration in Phase 3 of the project. These opportunities were selected by examining initial capability and attractiveness assessment scores for all 80 opportunities shown in this section. Later, in the workshops, participants were asked to compare the opportunities through an objective ranking process against the evaluation criteria to determine the order of priority shown at right.

Throughout the process, participants considered this sample of 40 opportunities. The definitions and descriptions of these opportunities evolved as more information became available and more participants became involved. This evolution resulted in the 18 priority opportunities detailed in the report.

1 IMPROVED EQUIPMENT EFFICIENCY
2 HEAVY HAUL
3 SAFETY THREAT DETECTION, INTERVENTION
4 SUPPLY OF SYSTEMS, CLUSTERING
5 FUEL EFFICIENCY SOLUTIONS
6 GASEOUS FUELS
7 LOW COST CROSSING PROTECTION
8 ENERGY STORAGE AND REGENERATION
9 MATERIAL SUBSTITUTION
10 DESIGN FOR ASSET MANAGEMENT
11 DATA ANALYSIS AND INFORMATION MANAGEMENT
12 LIGHTWEIGHT COMPONENTS
13 LOW COST, SHORT RUN MANUFACTURING
14 STANDARDISATION OF INFRASTRUCTURE
15 ENERGY STORAGE, REGENERATION
16 SMARTER INFRASTRUCTURE
17 RENEWABLE ENERGY SOLUTIONS
18 INTEGRATED SUPPLY CHAIN
19 CCTV FOR PASSENGER PROTECTION
20 ADVANCED SYSTEMS FOR ASSET MANAGEMENT
21 TOTAL QUALITY MANAGEMENT SYSTEMS
22 LIGHTWEIGHT ROLLING STOCK
23 AUTOMATED HEALTH MONITORING FOR EQUIPMENT
24 ENHANCED SIGNALLING SYSTEMS
25 EXTENSION OF ASSET LIFE
26 TELECOMMUNICATIONS AND INFORMATION CONVERGENCE
27 PASSENGER SAFETY INFORMATION SYSTEMS
28 MOVING MAINTENANCE PERSONNEL FROM DANGER
29 INNOVATIVE, MULTIMODAL TRANSPORT
30 ALTERNATIVE (AND RENEWABLE) FUELS
31 LEAN AND VISUAL MANAGEMENT
32 IMPROVED PASSENGER INFORMATION SYSTEMS
33 FULLY AUTOMATED RAIL SYSTEMS
34 GRID STABILISATION
35 STANDARDISATION OF CABLE SPECIFICATION
36 AESTHETIC ENHANCEMENTS FOR URBAN RAIL
37 INTERMODAL INTEGRATION
38 CLOUD COMPUTING
39 HIGH SPEED RAIL
40 HIGH PERFORMANCE COMPUTING

**FIGURE 38** TOP 40 OPPORTUNITIES SELECTED FOR EVALUATION BY PARTICIPANTS.

## Further opportunities

Another 40 Opportunities were presented to participants in Phase 3, but these opportunities were not selected for prioritisation through the objective sorting process. Therefore, the opportunities have been listed here in order of their overall initial assessment scores as determined through survey and interview data.

It is important to remember that these opportunities are still important. Hundreds of potential opportunities were suggested through surveys and workshops. Of these, more than 160 unique opportunities were evaluated – each of these having been highlighted as an important opportunity for at least two stakeholders. While not every opportunity could be practically examined in detail by participants, they have been recorded here for reference as roadmap implementation is undertaken.

1 SUSTAINABLE TRANSPORT SYSTEMS
2 SMART GRID
3 VIDEO PROCESSING (EXISTING CAMERAS)
4 SYSTEMS DESIGN, CONSTRUCTION
5 REMOTE TELEMETRY AND MONITORING
6 MATERIAL SUBSTITUTION (ENVIRONMENTAL)
7 EFFICIENT TUNNELLING SOLUTIONS
8 MATERIALS FOR INCREASED LOAD CAPABILITY
9 ENERGY MANAGEMENT TOOLS
10 IMPROVED, SMART OPERATIONS MANAGEMENT
11 DRIVERLESS TRAINS
12 SYSTEMS DESIGN AND INTEGRATION
13 STEP-CHANGE IN TRAIN CONTROL SYSTEMS
14 ADVANCED EMERGENCY INFORMATION SYSTEMS
15 IMPROVED EFFICIENCY ELECTRICITY DISTRIBUTION
16 LOCAL, SHARED TEST/DEVELOPMENT FACILITIES
17 AESTHETIC INFRASTRUCTURE
18 EVACUATION SOLUTIONS
19 CONGESTION AND INCIDENT MONITORING
20 TRAIN AND STATION SECURITY
21 COMMUNICATION BASED TRAIN CONTROL (CBTC)
22 AUTONOMOUS TRACK CONDITION MONITORING
23 PROJECT MANAGEMENT AUTOMATION
24 UNDERGROUND URBAN RAIL SYSTEM
25 ADVANCED RISK ASSESSMENT
26 EMERGENCY RESPONSE/RECOVERY SOLUTIONS
27 CONTACTLESS THIRD RAIL
28 HEAT ENERGY RECOVERY
29 AUTOMATED INTERMODAL TRANSFERS
30 PACKAGED SIGNALLING AND CONTROL SOLUTIONS
31 INNOVATIVE LOADING SYSTEMS
32 IMPROVED TRIBOLOGY
33 IMPROVED TECHNICAL SUPPORT SERVICES
34 IMPROVED APPROACHES TO CONDITION ASSESSMENT
35 SAFETY-INTEGRATED DESIGN AND MANAGEMENT
36 DESIGN FOR MAINTENANCE
37 DATA CONNECTIVITY SOLUTIONS
38 SAFER SUBSTATION POWER SWITCHING
39 MAINTENANCE AUTOMATION
40 ELECTRIFICATION

**FIGURE 39** 40 FURTHER OPPORTUNITIES IDENTIFIED THROUGH THE PROCESS.

# Appendix B – Stakeholder Participation

The uptake and ultimate success of any industry collaboration and strategy exercise is determined, in large part, by broad participation and input by stakeholders. The On Track to 2040 roadmap has involved many organisations and individuals representing a broad cross-section of industry; from rail manufacturers themselves and their customers (governments and operators); to service providers; researchers and non-rail organisations with allied expertise and interest.

## Participation

More than 210 participants from over 110 organisations contributed in excess of 2200 hours of direct engagement through surveys, interviews and workshops to the development of this roadmap. A breakdown of participants is shown here:

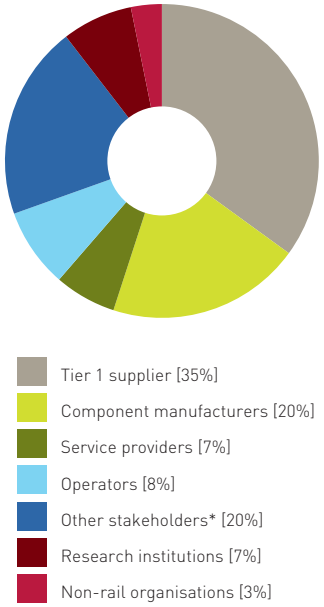



**FIGURE 40**
BREAKDOWN OF REPRESENTATIVE HOURS BY STAKEHOLDER GROUP. *OTHER STAKEHOLDERS INCLUDES: GOVERNMENTS, INDUSTRY BODIES, UNIONS AND SUPPORT AGENCIES.

## Feedback

Feedback was collected at all stages of the process, asking participants to rate process performance against criteria such as make-up of participants, opportunity for contribution, and process design. The amalgamated feedback data shows very good overall satisfaction, with participants generally feeling their contribution and project outcomes were worthwhile.

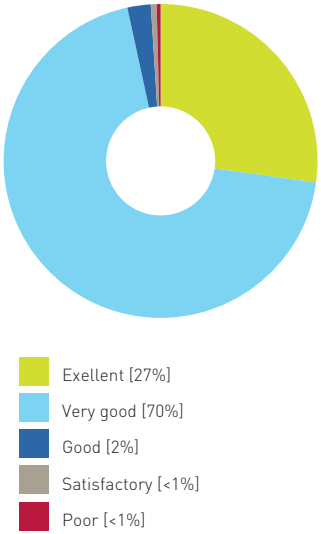



**FIGURE 41**
SUMMARY OF FEEDBACK RECEIVED THROUGH ALL STAGES OF THE ON TRACK TO 2040 ROADMAPPING PROCESS.

## Participating organisations

Opportunity for input into the roadmap was provided through interviews, surveys and workshops. Through these avenues, the following organisations provided vital insights, to help the industry understand its current strengths and prepare for future challenges and growth.

A&G PRICE
ABB AUSTRALIA
ABIGROUP
AUSTRALIAN INDUSTRY GROUP (AIG)
AJILON AUSTRALIA
ALSTOM
ANSALDO STS
ARM GROUP AUSTRALIA
AUSTRALIAN STAGING AND RIGGING (ASR)
ATLAS RAIL
AURECON
AUSTBRECK
AUSTRADE (AUSTRALIAN TRADE COMISSION)
AUSTRAK
AUSTRALASIAN RAILWAY ASSOCIATION (ARA)
AUSTRALIAN MANUFACTURING WORKERS UNION (AMWU)
AUSTRALIAN RAIL TECHNOLOGY (ART)
AUSTRALIAN RAIL TRACK CORPORATION (ARTC)
AUSTRALIAN RAILWAY INDUSTRY CORPORATION (ARIC)
AUTOMOTIVE COMPONENTS LIMITED
B&W GROUP
BAKER & PROVAN
BALFOUR BEATTY
BOMBARDIER TRANSPORTATION AUSTRALIA (BT)
BRADKEN
BROENS
CAF RAIL AUSTRALIA
CAP – XX
CATTEN INDUSTRIES
CENTRAL QUEENSLAND UNIVERSITY (CQU)
CHESS INDUSTRIES
CMI FORGE
COMMONWEALTH GOVERNMENT, DEPARTMENT OF INDUSTRY, INNOVATION, SCIENCE, RESEARCH AND TERTIARY EDUCATION (DIISRTE)
COMMONWEALTH GOVERNMENT, DEPRATMENT OF INFRASTRUCTURE AND TRANSPORT (DIT)
CRC FOR RAIL INNOVATION
CSIRO
CUMMINS SOUTH PACIFIC
DEPARTMENT OF BUSINESS AND INNOVATION, VICTORIA
DEPARTMENT OF STATE DEVELOPMENT, INFRASTRUCTURE AND PLANNING, QUEENSLAND
DEPARTMENT OF PLANNING, TRANSPORT AND INFRASTRUCTURE, SOUTH AUSTRALIA
DOWNER EDI RAIL
DRIVETRAIN POWER AND PROPULSION
DTI GROUP
ELECTRO-MOTIVE DIESEL (EMD)
FAIVELEY TRANSPORT
GE TRANSPORTATION (AUSTRALIA & NZ)
GHD
GLASSHAPE
HUBER AND SUHNER (AUSTRALIA)
INDUSTRY CAPABILITY NETWORK (ICN)
INTERCAST & FORGE
INVENSYS
IOMNISCIENT
ITL ENGINEERING
KNORR-BREMSE AUSTRALIA
LAING O'ROURKE
LEAN DESIGN AUSTRALIA
LIBERTY OIL
LOCKHEED MARTIN
LOGICA
MACKAY INDUSTRIES
MAGIC MOBILITY
MAXWELL ENGINEERING
MCCONAGHY AUSTRALIA
METRO TRAINS MELBOURNE (MTM)
NEW MACEY
NEW SOUTH WALES DEPARTMENT OF TRADE AND INVESTMENT, REGIONAL INFRASTRUCTURE AND SERVICES
NINE SIGMA
OEM TECHNOLOGY SOLUTIONS
OGIS ENGINEERING
OLEX CABLES
ONESTEEL
ORBITAL CORPORATION
PACIFIC NATIONAL
PANDROL AUSTRALIA
PARSONS BRINCKERHOFF
POSITION PARTNERS
QR NATIONAL
QUEENSLAND RAIL
REGUPOL
RIO TINTO
RAIL INDUSTRY SAFETY AND STANDARDS BOARD (RISSB)
ROCLA
ROLLINGSTOCK DIAGNOSTICS
SANDVIK
SCHAFFLER
SHARP BUSINESS SOLUTIONS
SIEMENS
THE SIGMA RAIL
SOUTHPORT ENGINEERING
STRATEGIC CONNECTIONS GROUP
SUSTAINABLE TRANSPORT SOLUTIONS
SWINBURNE UNIVERSITY OF TECHNOLOGY
TASRAIL
THALES
TRAKBLAZE
TRANSPORT FOR NSW
TTG TRANSPORTATION TECHNOLOGY
ULTIMATE TRANSPORTATION (AUSTRALIA)
UNIPART RAIL
UNITED GROUP LIMITED (UGL)
UNIVERSITY OF SOUTH AUSTRALIA
UNIVERSITY OF WOLLONGONG
VICTORIAN PARTNERSHIP FOR ADVANCED COMPUTING
VIPAC
WABTEC AUSTRALIA
WESTRAC
PUBLIC TRANSPORT AUTHORITY OF WESTERN AUSTRALIA (PTA)
WILSON TRANSFORMER COMPANY
WORLEY PARSONS
WOTHINGTON INDUSTRIES
XTRALIS

**FIGURE 42** PARTICIPANTS IN THE ON TRACK TO 2040 ROADMAP (THROUGH WORKSHOPS, INTERVIEWS AND SURVEYS) LISTED ALPHABETICALLY.

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STRATEGIC CONNECTIONS GROUP

Australian Government
Department of Industry Innovation, Science, Research and Tertiary Education

NSW GOVERNMENT

Queensland Government

State Government Victoria

AUSTRALASIAN RAILWAY ASSOCIATION