

Technology Readiness Assessment Methodology

ATSE

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ATSE Technology Readiness Assessment Methodology (TRAM)

Introduction

The Australian Academy of Technology and Engineering (ATSE) undertook an ARC-funded Learned Academies Special Project (LASP) on industry technology readiness in Australia from 2017-2020. Throughout that project, ATSE developed, applied and refined the methodological approach to assessing industry technology readiness described in this paper, and has since adapted and applied the methodology as a lens to assess other issues including potential impact of research commercialisation.

ATSE's TRAM project aimed to identify suitable measures for technology awareness, adoption and impact in Australia, and allow measurement of the progress of Australian businesses and governments against defined criteria, metrics and indicators. It was important to ATSE that the methodology and our assessments could be replicated – for example as a progress tracking mechanism, or to evaluate a policy intervention.

As a Learned Academy of independent experts, ATSE's mission is to help Australians understand and use technology to solve complex problems. At the conclusion of this project, ATSE is making our methodology publicly available so that any entity or person can use and adapt it to conduct their own assessments, using this method as a lens to assess any sector's readiness for a future scenario, and construct a narrative which identifies key opportunities and barriers.

During our ARC-funded project ATSE developed and successfully applied this technology readiness assessment methodology to three key Australian industry sectors – transport, healthcare, and waste and resource recovery. The key output of this work was an analysis of the technology potential, applications and opportunities across the sectors in the decade 2020-2030, including factors that are enabling or impeding technology uptake.

From this work, ATSE developed three roadmaps in the areas of transport, healthcare and waste and resource recovery, identifying what these Australian industry sectors needed in order to maintain currency with new technologies and fully integrate these technologies to maximise competitive advantage. ATSE's three reports also identified technology research areas to address cutting-edge industry problems and guide investment decisions for developing workforce capabilities. These reports will help guide the implementation of programs by government, industry and research organisations, and ensure a higher quality workforce with skills matched to future demand.

Importantly, ATSE consulted widely with industry, government and research stakeholders through surveys, workshops and full-day discussions to inform our assessments of technology readiness in each industry. This consultation ensured our findings were objective, robust and could be used equally to start conversations with policy-makers, industry leaders and research bodies.

The diversity of these sectors and applications, their needs, trajectories, regulatory environments and workforces, demonstrates very clearly the versatility and functionality of this methodology. ATSE warmly invites others to use and adapt it, and would be delighted to assist or engage with anyone interested in doing so.

Many ATSE Fellows and staff contributed to this project. We particularly thank the members of the Steering Committee and expert working groups, and former Policy Directors Matt Wenham and Alix Ziebell from the ATSE Secretariat.

Kathryn Fagg AO FTSE

Co-Chair, Project Steering Committee

Drew Clarke AO PSM FTSE

Co-Chair, Project Steering Committee

Approach & methodology

The key objectives of ATSE's technology readiness assessment project were to:

- Examine the readiness of three industry sectors to use technology to address existing and emerging challenges, as case studies for Australia's broader technology readiness
- Highlight future research opportunities to address the challenges that these sectors will face in the decade to come, and identify common challenges and opportunities across the economy
- Provide advice and recommendations to policy makers, industry and the research sector to assist with uptake of technologies, address key issues, and seize emerging opportunities.

In ATSE's project, **technology readiness** was defined as industry readiness to develop, adapt or adopt applicable technology to improve competitiveness and productivity.

ATSE selected the three industry sectors based on their critical importance to the Australian economy as a whole and the extent to which technology would be a positively disruptive factor over the decade 2020-2030. These three sectors selected were:

- Transport
- Healthcare
- Waste and resource recovery



In framing our analysis of these sectors, ATSE was informed by three key questions:

- Are Australian industries ready to develop, adapt or adopt technology that will help them to meet the major challenges of the coming decade?
- What are the barriers to technology readiness and what can be done to remove them?
- What are the opportunities and enablers of technology readiness?

ATSE's three case studies provide an overview of the development and applications of emerging and existing technologies, and identify Australia's research and industry strengths and weaknesses in the development and deployment of these technologies. The three reports provide a concise assessment of Australia's readiness to develop, adopt, or adapt technological solutions to support Australia's successful future.

These case studies provide insight into Australia’s ability to genuinely participate in the emerging digital economy that will rely on technologies such as artificial intelligence, robotics, advanced manufacturing, augmented reality, automation, big data and user interfaces.

Developing the Methodology

ATSE reviewed similar technology foresight research in developing the methodology for this project, and incorporated a range of successful aspects from these approaches.

This included, but was not limited to:

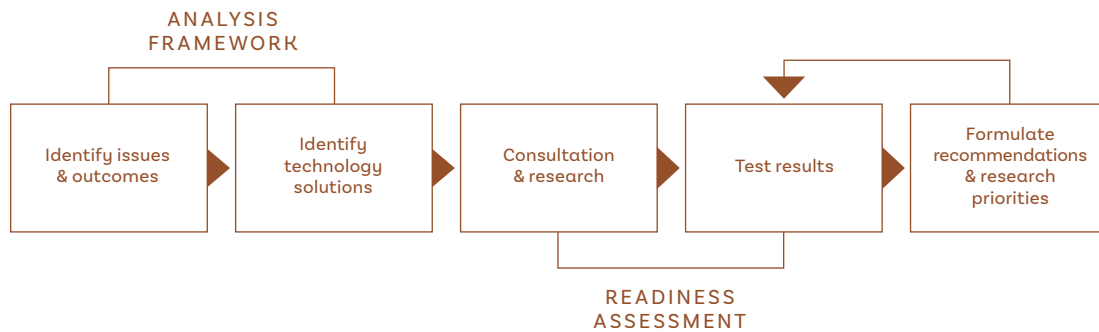
- ACOLA Securing Australia’s Future (SAF) projects:
 - AF04: Role of S,T&I in lifting Australian productivity
 - SAF09: Translating research for economic & social benefit
 - SAF10: Skills and capabilities for Australian enterprise innovation
 - SAF13: Review of Australia’s Research Training System
- CSIRO (2016), Australia 2030 – Navigating our uncertain future
- IMD (2017) World Competitiveness Yearbook
- Cornell University, INSEAD, WIPO (2017) Global Innovation Index
- Hajkovicz, S. A. C. et al (CSIRO, 2012), Our Future World: Global megatrends that will change the way we live
- Office for Science (UK) (2017) Technology and Innovation Futures 2017.

ATSE’s methodology incorporates a range of effective approaches from these projects, including:

- quantitative and qualitative data collection surveys
- a literature review combined with modelling (CSIRO, 2016)
- input provided by experts in academia, industry, and government networks (Hajkovicz, 2012)
- roundtables with experts from industry (Office for Science UK, 2017)
- analyses of key indicators of innovation (Global Innovation Index, 2017).

ATSE also took into account the knowledge priorities and sector competitiveness plans of Australia’s Industry Growth Centres, and relevant work by other bodies (for example the Australian Academy of Science’s decadal plans for scientific disciplines).

FIGURE 1
ATSE
Technology
Readiness
Assessment
Methodology –
process



ATSE’s methodology is summarised in **Figure 1** and explained in detail in the following section. Briefly, the methodology begins with the development of an overarching analysis framework which includes identification of key issues within an industry sector and potential emerging or enabling technology solutions. Following this, consultation is undertaken with a diverse range of key stakeholders whose input guides research and informs the development of a list of key recommendations and research priorities which could address the key sectoral issues identified. Finally, these recommendations are stress-tested through a final round of consultation with key stakeholders to ensure that the proposed recommendations are credible, impactful, and achievable. Accompanying the final recommendations are a set of research priorities designed to address broader or more complex challenges for which a recommendation can be made.

Analysis Framework

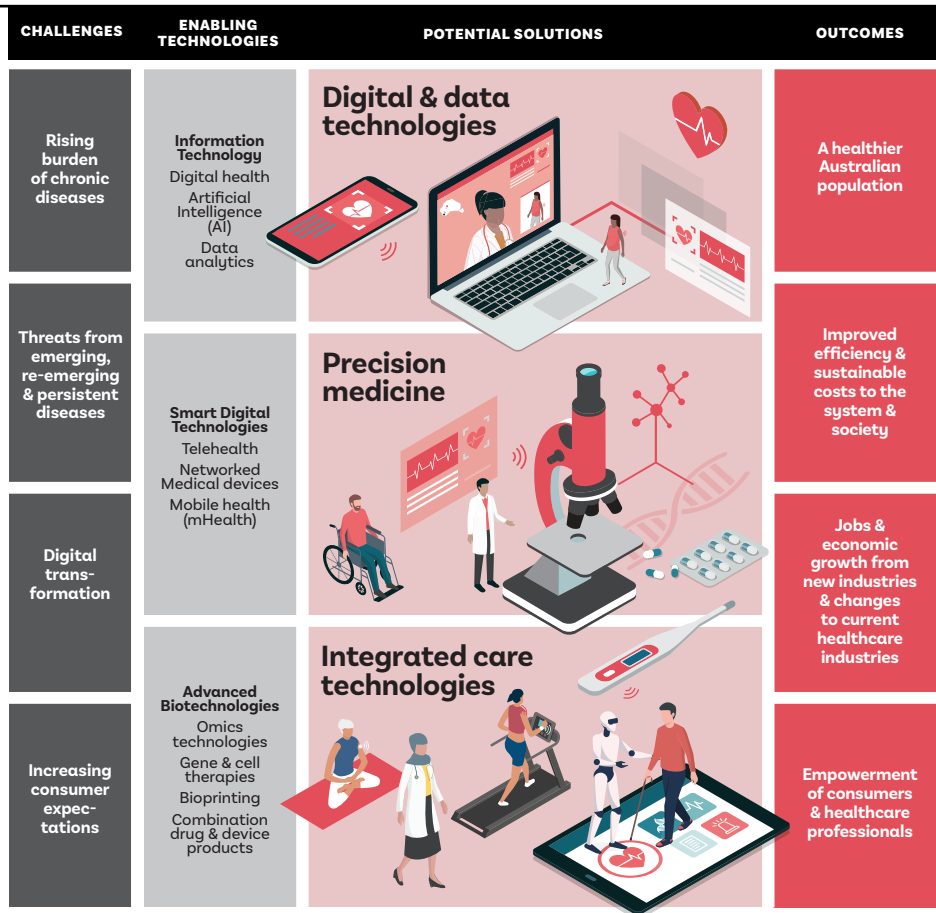
For each selected sector, ATSE considered key issues and identified the desired future state for the sector in Australia, through discussions with expert Fellows and sector stakeholders. This desired future state was iteratively adjusted throughout the consultation process.

In each project, secondary research was used to gain an understanding of technologies being used in different sectors and industries, the types of available and emerging technology solutions, and key information about issues and opportunities in the sector. Data was sourced from a wide variety of government, industry, consultant and academic publications and data collections.

ATSE project staff analysed this data and, supported by expert working groups of ATSE’s Fellows, identified a preliminary range of existing and emerging technologies that could support the desired outcomes. Based on these, ‘potential technology solutions’ were then developed, again in consultation with the expert working group and also the project steering committee. ATSE’s potential technology solutions are platforms, collections of technology, or approaches to technology that could directly address the key issues and support the desired outcomes. These potential technology solutions, and their definitions within the project, would later also be tested and refined through consultation with a wide range of experts.

This framework underpinning ATSE’s analysis is summarised overleaf in **Figure 2**:

FIGURE 2
Example framework used in the project on the health sector

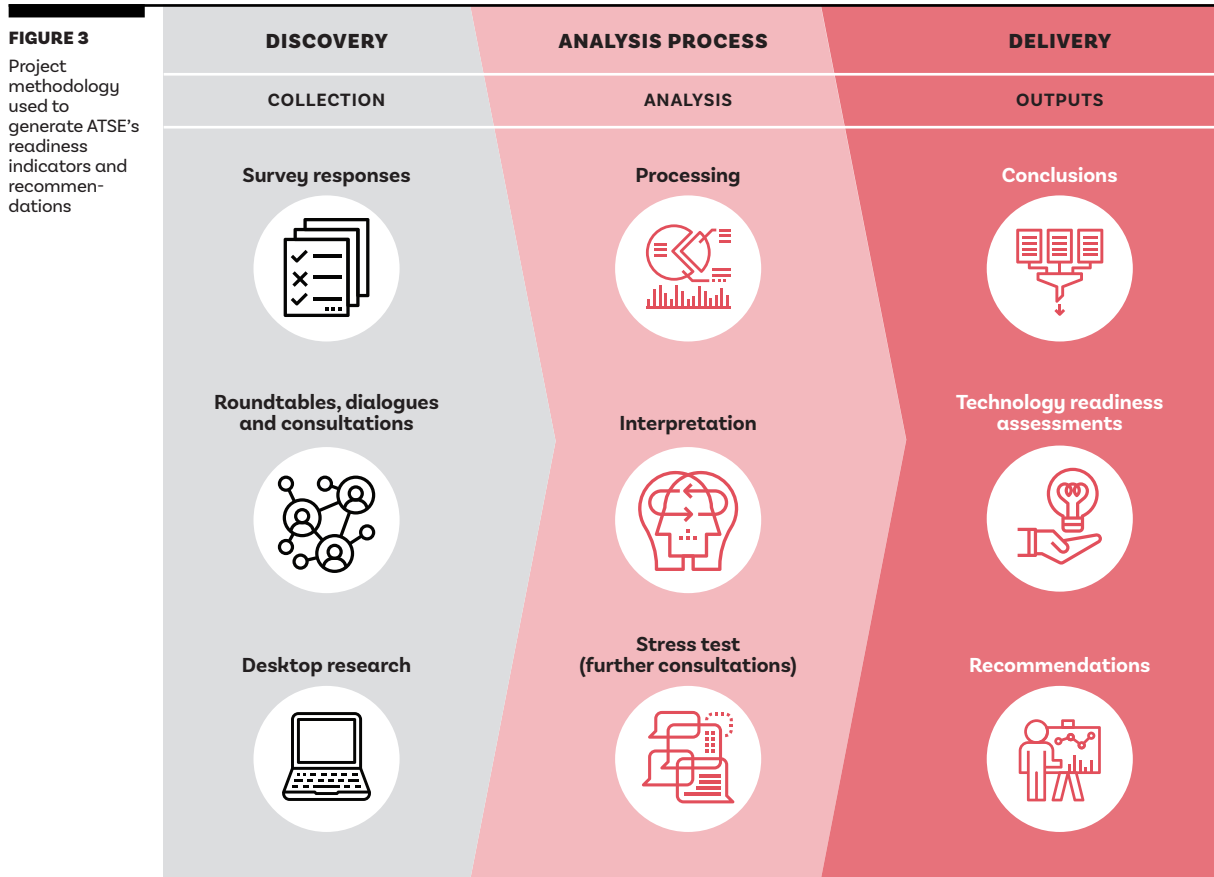


Readiness assessment

Each of the potential technology solutions was then assessed for readiness on five metrics, selected as a distillation of a range of indicators applicable across the economy, including workforce capability planning, skills mixing, collaboration, digital infrastructure, investment pipelines, and preparedness for market or technology disruptions:

- **Infrastructure readiness:** including networks, technology platforms, physical equipment, availability of technology, and sector-specific infrastructure.
- **Skills readiness:** including depth of skills, digital literacy, talent acquisition, and education and research pipelines.
- **Social readiness:** Attitudes to new technologies within businesses and communities includes willingness to take up new technologies, openness and drive to change, and demonstrated behavioural changes.
- **Economic and commercial feasibility:** including the ability to spend capital on new technology, timeframe to market, investment appeal, right business strategies, new business models, and fostering entrepreneurialism.
- **Policy and regulatory readiness:** including policy settings, policy certainty, appropriate regulation and legislation, and adaptive and flexible regulation.

ATSE’s readiness assessments were informed by qualitative and quantitative data from a range of sources, including desktop research, surveys, interviews, workshops, and full-day conferences, using a mixed-method convergent design, represented in **Figure 3**.



An initial ‘Dialogue’ event was held prior to consultations in the transport and health projects. The purpose of the event was to encourage debate and discussion, testing the initial framework content, and to continue identifying the technologies and innovations that stakeholders felt would affect the sector. It also sought to draw out key policy actions and research questions that should be addressed over the next decade. During the waste and resource recovery project, the Dialogue event was held as part of the consultations due to COVID-19 impacts and was used primarily to test preliminary findings and raise awareness of the project.

In all three projects, a survey was sent to key sector stakeholders, which aimed to establish a baseline readiness assessment for each potential technology solution. Survey respondents were selected so as to comprise as complete a representation of each industry sector as possible.

Survey respondents were asked to rate the readiness – based on the five readiness parameters – of the relevant sector for the three potential technology solutions, on a scale of zero to four, with zero being not ready, and four being ready. This readiness scale is represented in **Table 1** below, using Harvey Balls. Survey respondents were also asked to provide reasons for their ratings, identify any key technology barriers and strengths, and highlight any specific policy and research opportunities.

TABLE 1 Readiness indicator scale	SCALE	NOT READY	MORE WORK REQUIRED			READY
	READINESS INDICATOR SCALE					

Survey response numbers varied from just a few in the transport project, to over 100 in the health project. These numbers were broadly representative of engagement levels for each sector, and each sector showed a preference for a different way of engaging. For example, the transport and waste and resource recovery sectors preferred a 1-1 interview approach, although for the waste and resource recovery sector the survey was equally engaging. Rates of successful stakeholder engagement also increased commensurate with audience increase and awareness of the overall project.

Given few responses were received to the transport survey, interviews and further research were conducted to obtain a baseline preliminary readiness assessment. For the next two projects (health and waste and waste and resource recovery), the project team took a different approach to the survey, sending it out much more widely (approximately 500 recipients) and promoting it actively in specialist media, social media and through ATSE's networks. This resulted in a much higher survey response level (approximately 100 responses), as well as significantly raising awareness of the work and participation level by stakeholders overall. In these two projects, ATSE used the quantitative data collected through the survey as a baseline technology readiness assessment to discuss, test and refine during stakeholder consultations.

An example of how this preliminary readiness assessment was presented in ATSE's consultations and reports is shown below at **Table 2**.

TABLE 2 Example technology readiness assessment	ASSESSMENT					
		Infrastructure readiness	Skills readiness	Social readiness	Economic & commercial feasibility	Policy & regulatory readiness
Potential Technology Solution A						
Potential Technology Solution B						
Potential Technology Solution C						
Potential Technology Solution D						

ATSE's preliminary technology readiness assessments were tested through stakeholder consultations with four key groups:

- the specific project's Expert Working Group
- ATSE's Policy Forums (topic-based groups of ATSE Fellows)
- the Project Steering Committee
- key external stakeholders and experts in the sector.

Where possible, consultations were balanced so as to receive input from approximately equivalent numbers of stakeholders from government, industry and research.

ATSE's consultations included interviews, workshops, roundtables and full-day conferences, conducted and facilitated by the project team and members of the expert working groups. Interviews focused in greater detail on issues identified during the survey, and on gathering insight into key factors enabling uptake, integration and future requirements of technology in business practices. The workshops and roundtables were critical in testing the results and highlighting similarities and differences in opinion in parts of the sector. The full day events helped to broadly identify barriers and enablers, and to coalesce and refine the full picture for each sector.

In total, ATSE consulted with 376 external stakeholders, in addition to our 900 expert Fellows.

$$\begin{array}{ccccccc} 46 & + & 230 & + & 100 & = & 376 \\ \text{TRANSPORT} & & \text{HEALTH} & & \text{WASTE} & & \text{TOTAL} \end{array}$$

Based on our consultations and further research, ATSE adjusted the readiness metrics and recorded any convergence and/or divergence in an appendix to the main report. The final readiness metrics were then used to identify sector-level strengths and weaknesses, which were compared with barriers and opportunities identified during ATSE's consultations and research. On this basis the ATSE project team and expert working group identified preliminary recommendations to government, industry and research.

Recommendations & research priorities

Preliminary recommendations were collected thematically through ATSE's consultations, as well as through identification of key barriers and opportunities for technology uptake in each sector. Clear correlation was observed between a low readiness score on a given parameter for a potential technology solution, and the strength and cohesiveness of stakeholder sentiment regarding recommendations to address the issue.

During consultations for each project, a clear short list of three to five recommendations coalesced, under which sub-recommendations were also distributed. These preliminary recommendations were reviewed and refined by the expert working group and project steering committee to ensure they addressed the key issues identified during the readiness assessment. ATSE also deliberately aimed a roughly equal number of recommendations to government, industry and the research community.

This approach was broadly successful in the initial project (transport), but it was decided that the recommendations would benefit from more time spent on refining and stress testing. As such, a new step was added in the following two projects (health and waste and resource recovery) – testing the recommendations with stakeholders. Recommendations were subsequently tested with selected expert Fellows and sector stakeholders, then refined based on feedback provided.

This testing process proved very valuable, both to the project and to the stakeholders involved. It resulted in credible, impactful, achievable recommendations, delivered to stakeholders who felt a sense of ownership over them. Stakeholders were thus much more likely to drive change by acting on the recommendations and encourage similar support from their stakeholders. Reaching out to stakeholders early and often to test assumptions, analysis findings, the evidence-base and conclusions is critical to ensure the work is relevant, useful and to build stakeholder buy-in.

Alongside the recommendations are an accompanying set of research priorities. These priorities are identified as issues which often cannot be addressed by existing technological solutions and therefore lack a clear solution or recommendation. The research priorities are drawn from input from expert stakeholders and refined by secondary research and analysis. These research priorities, while usually targeted to the research sector, can also be addressed to industry or government to encourage collaboration between different parts of the sector to address key sectoral issues.

ATSE's recommendations and research priorities were all subject to Project Steering Committee approval, and a four-page summary report was created on each topic. This summary report enables key recommendations and research priorities to be clearly communicated in a short, stand-alone document which was much more widely read than the full report. The short, easily distributed document is key to accessing broader awareness, adoption, and implementation of report findings to drive impact.

Governance

The primary governance mechanisms (detailed in the appendix) guiding the project included a steering committee of expert Fellows who provided oversight and strategic direction to the whole project (all three sector analyses), as well as an ‘expert working group’ of expert ATSE Fellows and key sector stakeholders who provided sector-specific advice and guidance to the project team.

The project team, who undertook all aspects of the project including conducting research and consultations, analysing research results and data, and drafting the reports, were supported and guided by both the steering committee and expert working group, as well as by ATSE Fellows and external stakeholders who served to guide the research and shape the final recommendations.

Conclusion

This methodological approach produced technology readiness assessments that were robust, transparent, and reproducible, with the time taken for each analysis ranging from 12 to 14 months.

The methodology proved adaptable to different sectors and issues, and clearly showed accurate results in all three sectors assessed, as tested with expert stakeholders. It is a rigorous project methodology and framework which can be applied to any sector or issue internationally.

This methodology enabled ATSE to produce a body of evidence about the technology readiness issues and opportunities in the three sectors sector examined, which has been used by policy-makers and industry leaders to effect change. The reports are viewed as blueprints for technology uptake in each sector, with their key strength being objectivity – there is immense value in providing a neutral view with no commercial or political interest.

The reports have been used as a discussion point by the Council of Australian Governments, the ASEAN Academies of Technology and Engineering, and for a diverse range of workshops hosted by ATSE and external partners. They have been cited as evidence by Ministers, Parliamentary inquiries, the Productivity Commission, and the Australian Government’s National Manufacturing Roadmaps. Parts of the reports have been republished in articles, books and media.

Over the course of the three distinct projects, the methodology and approach was adapted and improved based on experience in each preceding project. ATSE will continue to apply this methodology, adapting and refining it through our work, and would welcome any feedback or experiences others have in applying it to their own.

Acknowledgments

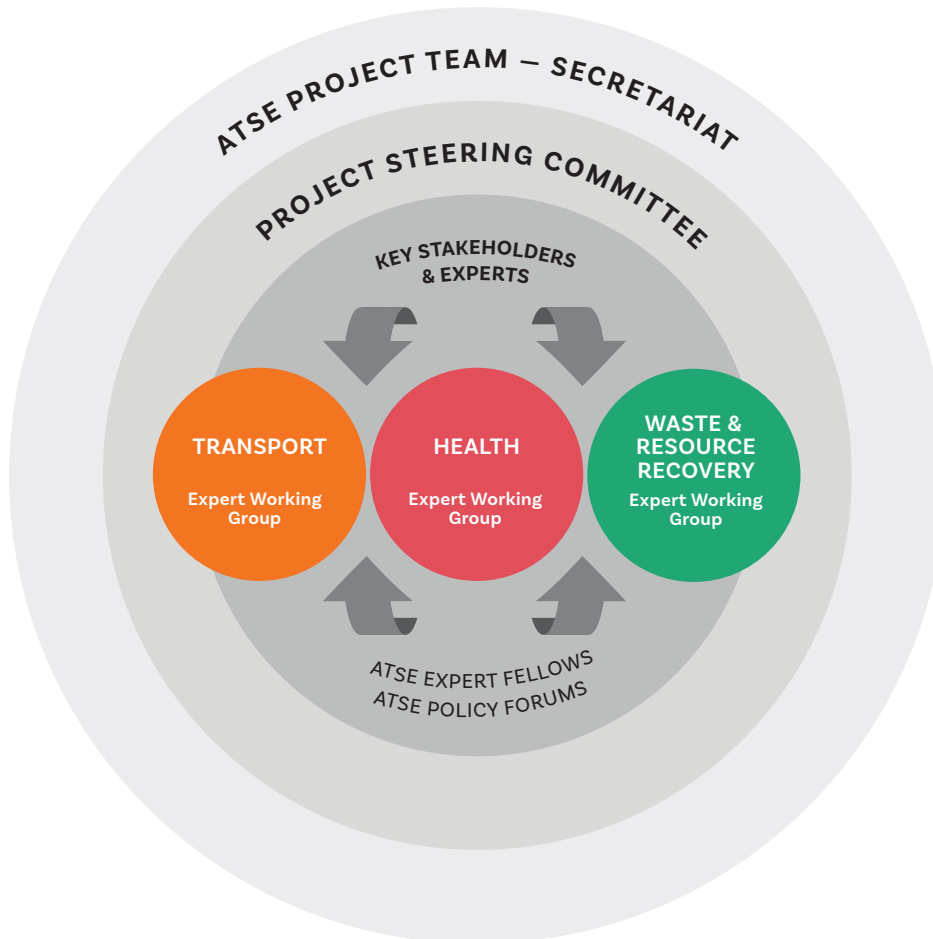
ATSE acknowledges the very generous contributions of our Fellows in undertaking this project. Without them, this project would not have been possible. In particular, we would like to acknowledge the extensive contributions of the project Steering Committee and Expert Working Groups, who provided substantial time and expertise to make the project a success.

ATSE would also like to sincerely acknowledge and thank the hundreds of stakeholders who gave their valuable time and expertise to contribute to this project.

Finally, we wish to acknowledge the generous financial support provided by the Australian Research Council through the Learned Academies Special Projects grant, which allowed us to undertake this work.

Appendix

FIGURE 4
Project
governance



Steering Committee

A steering committee of experts from industry, academia and government was formed to oversee this project, including Fellows of ATSE as well as other Learned Academies. The identification of likely future operating environments, research and skills needs necessitated the involvement of experts from the social sciences (specifically economics and behavioural sciences) to ensure that economic and social licence considerations were fully incorporated. The steering committee provided oversight and direction throughout the entire project.

Expert working groups

The project also engaged with expert ATSE Fellows and key sector stakeholders as specific industry sectors were examined. For the first project on transport, sector experts were invited to join the steering committee and provide expert input and advice as well as strategic oversight. Following that report, ATSE amended the governance structure to form expert working groups of topic experts to guide the day-to-day development of the specific sector research and reports, and the steering committee reverted to a more traditional oversight and strategic direction role. Fellows were invited to join the expert working groups based on their areas of expertise, experience, and a diverse range of perspectives from academia, industry and government.

ATSE Fellows

ATSE's Fellows were a key source of information and evidence for the project. Fellows were directly engaged through surveys, interviews and workshops, and facilitated connections between the project team and a wider network of sector experts, allowing ATSE's consultations to reach deeply and broadly into the specific sectors.

Key stakeholders and experts

The three projects received qualitative and quantitative data from external stakeholders and experts in a variety of formats, as well as guidance, feedback and support. We are exceptionally grateful to those experts who contributed time and information to ATSE's projects.

Initially, stakeholders were contacted via a survey, asking them to rate the relevant sector's technology readiness on particular parameters. Selected stakeholders were invited to follow up interviews, workshops, and larger Dialogue events, to test the results of the survey and gather case studies and further qualitative data. Finally, the project team met with key stakeholders to test conclusions and recommendations of each report, to ensure they were accurate and useful.

Project team

The project was supported by a professional team in the ATSE Secretariat, made up of Policy Analysts and Senior Policy Analysts in the Policy and Government Relations Team. Each project had a dedicated Policy Analyst as project manager, supported by the Director of Policy and Government Relations as project director. The project team conducted research, planned and executed consultations, analysed research results and data, drafted the reports and supported the expert working group and steering committee to draw conclusions and make recommendations.

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