Setting up Projects for Success

Research Report
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Over 50 CEOs, MDs, heads of department, principals and professionals from construction firms, government delivery agencies, central government agencies, engineering consultancies and associations have been generous with their time and spoken candidly in regard to changes required for improving and developing further the critical delivery of infrastructure in Australia and New Zealand.

Finally, the research team would like to acknowledge the engineering faculty and the business school of UTS for their support of research independence and academic rigour, essential for professional research practice.

Guy Templeton
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We are in the midst of an unprecedented infrastructure boom. Economic development and population growth are fuelling demand for the essential services all Australians and New Zealanders rely on – from transport networks to energy, water and telecommunications, as well as social infrastructure, including health, education, public administration, housing and justice facilities.

As the size, complexity and number of these projects grows, so too does the risk of failure. Widespread shortcomings, such as cost-overruns, delays, litigious threats, community opposition, and low success rates are now so pervasive that there is a clear mandate to rethink the way we plan, deliver and operate our infrastructure. Engineers, construction professionals, business advisers, researchers, financiers and government officials, need to find a better way to improve the lives of Australians and New Zealanders through quality, accessible, and cost-effective services that enhance opportunities for better quality of life.

We are delighted to have supported this independent UTS-led research to help industry proponents better understand critical steps required to realise necessary improvements in both our living standards and national productivity, and achieve it through better developing infrastructure. The research reported here has tapped into the wealth of experience of professionals involved in major public and private projects in Australia and New Zealand, to establish insights into good practice that can be widely adopted.

Use of these insights, borne out of real-life experience, is for improving awareness of risks and opportunities; gaining greater certainty in execution; ensuring added clarity about performance; and streamlining governance and management.

Executive summary

In Australia and New Zealand, we spend billions of dollars annually delivering mega-infrastructure projects, however, inadequate delivery means we still suffer delays, budget blowouts, and disappointed communities. Unfortunately, this is not news; it has long been thus.

Globally, the need for infrastructure investment is forecast to reach $94 trillion by 2040, and a further $3.5 trillion will be required to meet the United Nations' Sustainable Development Goals for electricity and water, according to the G20 Global Infrastructure hub.

With a project pipeline of work consisting of infrastructure amounting to billions of dollars, it would be wasteful not to consider ways of improving delivery. Working with leading industry practitioners, we conducted extensive desk research, in-depth preliminary interviews, a leader's workshop, stakeholder engagement and a research survey. People from all professional groups involved in delivering infrastructure contributed to this research: engineers, construction organisations, government delivery agencies, central government departments, business advisers, legal and finance agencies. All participants agreed that megaprojects could be delivered more effectively and exceed community expectations.

We identified three key themes participants agreed have the greatest impact on successful major project delivery:

- Improved integrated planning, business cases, and front-end engineering design
- Efficient use of contracts
- Strengthening government and political engagement.

The propositions with the highest degree of support concerned the early use of contractors to assess the environmental conditions of specific brownfield sites (before further tenders are pursued); constructing highly competent project teams imbued with a collaborative culture; implementing early inception reviews and sharing lessons learned.

Insights from the research survey were shared with key stakeholders, and we obtained further case studies to exemplify specific issues.

This report presents three focus areas for improvement, in conjunction with appropriate actions for implementation.

1. Skills and expertise

- Increase participation in major project leadership academies, such as Victoria's, and include private sector participants to encourage joint learning.
- Increase infrastructure agencies' resources and authority, without changing existing reporting lines.
- Implement standard contracts (with a consistent issues-resolution framework) and joint training, except on brownfield and other sites where infrastructure interfaces with other complex assets and where collaborative contracts can be more effective.
- Improve total asset reporting, and assess the need to build new infrastructure rather than upgrading or repairing existing assets.
- Increase delivery agencies' technical skills and expertise 'client-side', and combine tenure and experience with strong central infrastructure in coordination agencies.

2. Collaboration between partners

- Projects with a partnership approach are more likely to succeed combined with early project inception workshops that embed a collaborative culture and have consistent processes to handle variations and claims.
- Consistent and better-coordinated release of major infrastructure, to enable better long-term resource planning than boom-and-bust cycles or changes mandated as a result of changes in government.
- More consistent digital technology use among all parties, to help identify and resolve issues early and provide more integrated project designs.
- Improve post-opening project evaluation and share results more widely so others can act on lessons learned and reduce the likelihood of future mistakes.

3. Early Engagement

- Better-integrated planning and more robust business case processes, combined with thorough front-end engineering design and early community engagement. Fewer projects may come to market, but those that do will enjoy better scrutiny and preparation beforehand.
- Conduct early contractor investigations, to reduce environmental impacts and major concerns caused by non-contestable utilities. Embed a process to ensure non-contestable utilities are moved within appropriate time frames, and have a suitable claims process in place.
- Involve asset operators early to instil confidence in the asset's successful use.

1. Delivering major infrastructure has its challenges: can we do better?

"Setting up projects for success" was the focus of this research. What constitutes success is the first matter to consider.

First, we note that contractors delivering megaprojects have mixed results in delivering these at a profit. In research by Ryan and Dufield (2017), the Australian infrastructure sector was identified as experiencing a considerable boom in mega projects since 2000 (megaprojects being those greater than A$500m in value).

"In 1990, the largest single project tendered in Australia was worth A$50m. By 2000 this had grown to A$500m and in 2015 it was of the order of A$8bn. The financial outcomes of the 28 completed projects that were sampled ranged from a 1% profit to a 43% loss" (Ryan et al. 2017).

The potential downside of delivering megaprojects is evident. Evidence does not suggest they are outstanding economic successes, using conventional accounting measures of value. These measures are increasingly being criticised as too restricted in scope and time, with the argument being that value is delivered not immediately but over time, by more measures than merely economic (Clegg, Skyttermoen and Vaagaasar, 2020).

Projects' value should no longer be measured purely in terms of engineering success. Increasingly, success entails delivering both sustainable services and sustainable economic outcomes. As projects become larger, last longer and involve more complexity, endemically low success rates need better management to reverse present trends. As Dunn et al. (2015) identify, new approaches are needed to replace old models.

Over the last decade, we have seen substantial public and private investment in major infrastructure – significant investment in transport (rail, road, maritime and air), utilities, resources as well as major investments in social infrastructure, including hospitals, education and sports facilities. How many of these were delivered ahead of schedule, on budget, and achieved a positive social benefit?

"Globally, the need for infrastructure investment is forecast to reach $94 trillion by 2040, and a further $3.5 trillion will be required to meet the United Nations' Sustainable Development Goals for electricity and water." (Global Infrastructure Hub, 2017).

The Australian Industry Group/Australian Constructors Association Construction Outlook survey indicates that after lifting by 9.0% in 2017-18 (current prices), the total value of non-residential construction work was forecast to rise by 5.4% in 2018-19 and a further 3.8% in 2019-20. Thus, the forecast in terms of activity is good. Engineering construction will lift to a higher level, with expected growth of 8.0%.

"$600bn of spending needed over next 15 years, Infrastructure Australia says," as quoted by the Guardian,

12 August, 2019.

In New Zealand, total construction value in 2018 increased by 5% to $39bn, according to the 2019 national construction pipeline report. This year's forecast is for continued growth in the value of construction to $43b in 2021. After this peak, construction value is forecast to slightly tail off to $42b in 2024.

Major project delivery is not just an issue for Australia and New Zealand similar challenges can be seen in other parts of the world.

"Britain needs high performing infrastructure. Without it we have little hope of improving the productivity of our economy. Without an improvement in productivity we will not be able to secure the quality of life demanded by our growing population. Yet the model we use to deliver and operate much of our infrastructure is broken. Too often it produces assets and networks that are expensive, perform poorly and fail to exploit the advances in technology that are transforming other industries. Too often the supply chain that delivers our infrastructure seems locked into a cycle of low margins, low investment and dysfunctional relationships" (Institution of Civil Engineers, 2017).

With the search for new models firmly in mind, we planned and conducted the present research. Through a combination of in-depth interviews, survey research and structured workshops, we investigated options and canvassed improvements. The research question that we sought to answer was: would taking a different approach during projects' inception and establishment phases mitigate risks more effectively? Would it lead to greater economic value and societal benefit from future major infrastructure work?

The research added further value by investigating ways to set up major infrastructure projects for success.

Success depends on the initial stages of project inception, planning and design. Hence, we decided to:

1. Identify key themes with the greatest impact on project delivery
2. Test propositions that could lead to improvement
3. Recommend actions and illustrate through specific case studies.

2. UTS/WSP's approach to investigating major infrastructure delivery

2.1 Research process and respondent profile

The research team comprised members from both UTS and WSP.

The first steps involved grounded research. The first stage involved reviewing a range of recent evidence from both consulting and academic literature.

The second steps sought further insights from a leadership workshop and ten preliminary interviews with key stakeholders from a range of infrastructure perspectives. They stressed the importance of the inception and establishment phases of major project delivery.

In the third grounding exercise, we refined the brief to focus on those areas perceived to pose the greatest risk in terms of their impact on successful project delivery.

The fourth steps involved a workshop held in the WSP boardroom with senior executives from all WSP business units as well as the ANZ CEO. The main workshop objective was to obtain WSP leaders' input to improve the quality and robustness of the grounded research and hypothesis.

The fifth research stage processed the workshop output to inform design of a research survey. The survey was fielded via an online platform and through telephone interviews. The targeted respondents included people with expertise in all aspects of major project delivery. (See Tables 1–3 for data on their distribution in terms of location and experience). The research survey was conducted over a 5-month period 1 May–30 September 2019, with contributions from 180 respondents engaged in all aspects of major infrastructure delivery. Most survey respondents were located in NSW, Victoria, Queensland and NZ, and had more than 15 years' experience working for government delivery agencies, construction firms, or engineering consultancies.

The survey comprised three components:

1. Prioritised eight key themes with regards to their impact on major project delivery
2. Collected and assessed support for specific propositions related to each theme
3. Collated verbatim respondent comments concerning their top 2 or 3 recommendations.

In the sixth research stage, we shared the survey insights gained with key stakeholders through client forums held the WSP's offices.

In the seventh stage, we obtained further case studies to exemplify some of the specific issues identified.

This report represents the final research stage, and presents all the elements with a particular spotlight on three focal areas for improvement, with supportive recommendations for each area.

Table 1: Respondents' years working in Infrastructure

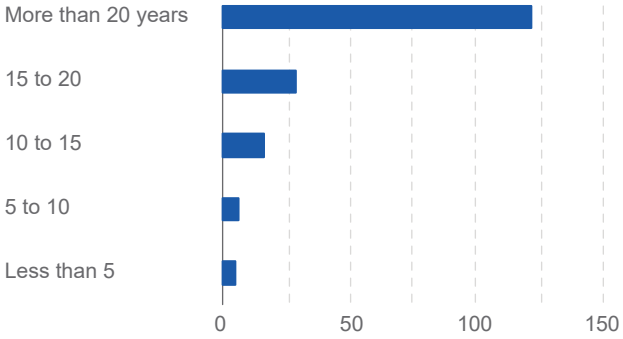


Table 2: Respondent location

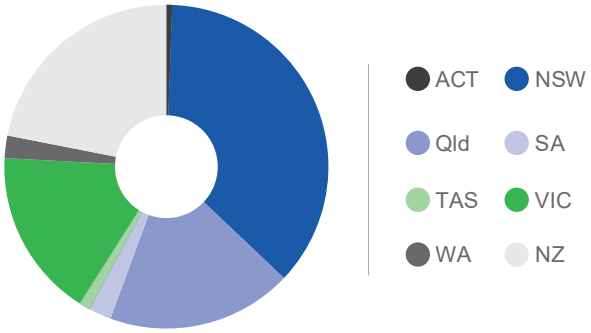
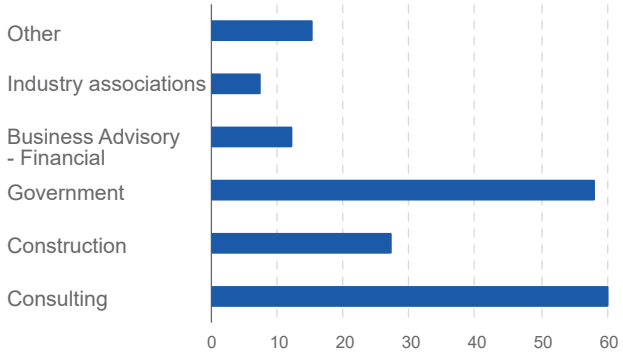


Table 3: Sectors



2.2 Theme definition and propositions for improvement

Each theme that arose during the field research, together with potential related propositions for improvement, are outlined below.

Theme 1 Strengthening effective government and political engagement	The first theme identified the need for increased expertise within government and its sharing across state agencies through enhanced statutory powers for state and federal infrastructure delivery agencies.
Propositions:	1. Successful project delivery requires improved in-house expertise within the government sector. 2. The work of dedicated governmental agencies that support the delivery of infrastructure projects results in greater collaboration across project proponent 3. Business cases for all projects above $500m should be coordinated through infrastructure agencies
Theme 2 Integrated planning and business cases	The second theme stressed the importance of bringing projects to market that are well planned and have a robust business case. To do this requires that there is the necessary in-house expertise within government, albeit with additional external advice. Many key stakeholders felt that client-side expertise could be improved through additional resourcing, training and remuneration (to attract talent). Risk allocation could be improved early in the project delivery cycle by increasing and encouraging positive community engagement from an early stage.
Propositions:	1. Integrated planning, a robust business case and early community engagement will improve the validity of project benefit estimates. 2. Lower overall costs for delivering the project can be attained by undertaking thorough front-end engineering design. 3. Early engagement inception workshops with contractors, consultants and delivery agencies will enable many risks to be identified and assessed at an earlier stage of the project life cycle
Theme 3 Efficient choice of contracts	The third theme stressed the value of using collaborative/alliancing contracts for complex Brownfield sites and using standard contracts, such as GC21 consistently, for traditional projects.
Propositions:	1. For most projects, standard contracts are sufficient but need to be implemented consistently across agencies. 2. Joint training should be implemented for both commercial and legal staff in Government agencies and delivery partners in the consistent use of standard contracts 3. Complex Brownfield megaprojects require alliance style delivery models. 4. Infrastructure PPPs are most effective when risks can be appropriately allocated between parties. 5. The propensity of government agencies to add additional risk to the contract at the preferred bidder stage should be limited. 6. All risks should be identifiable from the tender documents and no additional risks added at the preferred bidder stage
Theme 4 Improved confidence in project pipeline delivery	The fourth theme stressed that, once a project has gone through the various planning and business case phases and engineering design, construction firms need to be confident that the project will go ahead and not be cancelled. As a corollary, many stakeholders felt that too many projects had been rushed through, based on the political cycle.
Propositions:	1. Short-term political cycles result in poorly conceived projects that have not been adequately prepared or prioritised 2. Increasing the remit and resources of Government Infrastructure bodies to improve coordination and timing in bringing megaprojects to market, will lead to increased project success. 3. All major infrastructure projects should be reviewed and endorsed by relevant Infrastructure Agencies and an audit done post completion to validate if the estimated benefits were achieved 4. Government Infrastructure bodies should report directly into a Parliamentary Committee.

Theme 5 Increase emphasis on project assets' life-time costs	The fifth theme that emerged stressed that operation and maintenance of an asset will be managed more effectively if demand risks are borne by the private sector. The increased use of Design-Build Finance Operate Transfer (DBFOT) contracts were seen as ensuring that the private sector designed for the maintenance and operation phases of the asset that they will transfer only after operation for a stipulated time.
Propositions:	1. A Design-Build Finance Operate Transfer contract that stipulates a set period of operation, will enable the private sector to design for the maintenance and operation phases of the asset. 2. Design Build Finance Operate Transfer PPP model for major infrastructure projects should be used more frequently. 3. Operation and maintenance of an asset will be managed more effectively if demand risks are shared with the private sector 4. Increasing government accountability and visibility of the capital tied up in the operations of existing assets will lead to improved management and performance. 5. On an annual basis governments' should produce a lifecycle cost report, including capital versus operations data for each of their major assets.
Theme 6 Reduce unknown contaminants and utilities risk	Theme six stressed that a major impact on the success or failure of a project concerned the degree of uncertainty concerning conditions of in ground contaminants, such as asbestos and other toxic elements, as well as the precise location of utilities. Front end engineering design based on transparent use of data in bid preparation could reduce many of these risks that occur within projects.
Propositions:	1. Unknown environmental conditions and utilities are the greatest threat to project success. 2. To identify latent conditions and utilities, Early Contractor Investigations (ECI) on complex brownfield sites should be undertaken and relevant information to all bidding parties pre-contract. 3. An agreed approach across agencies and contractors should be implemented for addressing non-contestable utility works. 4. Government should warrant the factual accuracy of data on in ground conditions and utilities. 5. Project disputes will be improved by developing an agreed claims process to manage variations resulting from unknown environmental risks.
Theme 7 Improved industry ecosystem	Theme seven stressed that significant value could be attained by designing a culture for working collaboratively between clients (state agencies) and delivery partners (construction firms and service delivery). Although Alliance contracting, Early Contractor Involvement Contracts (ECI Contracts) etc., were cited as two delivery options, benefits may result from other organisational strategies, such as, for example, encouraging increased movement of staff between the private and government sectors through using secondments and placements to encourage increased awareness of the challenges faced by each party.
Propositions:	1. Selecting experienced and highly competent team members able to instil a collaborative culture between partners will improve project delivery. 2. Project delivery team inception workshops to establish strong alignment between parties to deliver successful project outcomes should be staged. 3. All projects awarded should contain a simplified claims process and implement a standard approach to dispute avoidance, variations and claims resolution. 4. Consideration for large firms for major infrastructure increases if a collaborative relationship with government delivery agencies is evident. 5. All major projects should contain a senior level dispute avoidance forum to identify potential areas of dispute before they arise.
Theme 8 Effective use of technology and data	The eighth theme addressed digital engineering (BIM, GIS etc) use across all partners undertaking infrastructure delivery and the importance of sharing across the sectors the lessons learned and innovation obtained from the project.
Propositions:	1. Improved use of integrated technology across all infrastructure delivery partners will potentially improve the likelihood of a successful project. 2. In delivering major infrastructure, lessons learned and best practices need to be more adequately captured and used across the sector.

3. Survey results

The research survey results are outlined in Graph 1, focussing on:

- Ranking the eight themes that have an impact on delivering a successful project
- The support gained for propositions for improvement
- Cross tabular assessment to evaluate differences by segment
- General insights from key stakeholder interviews.

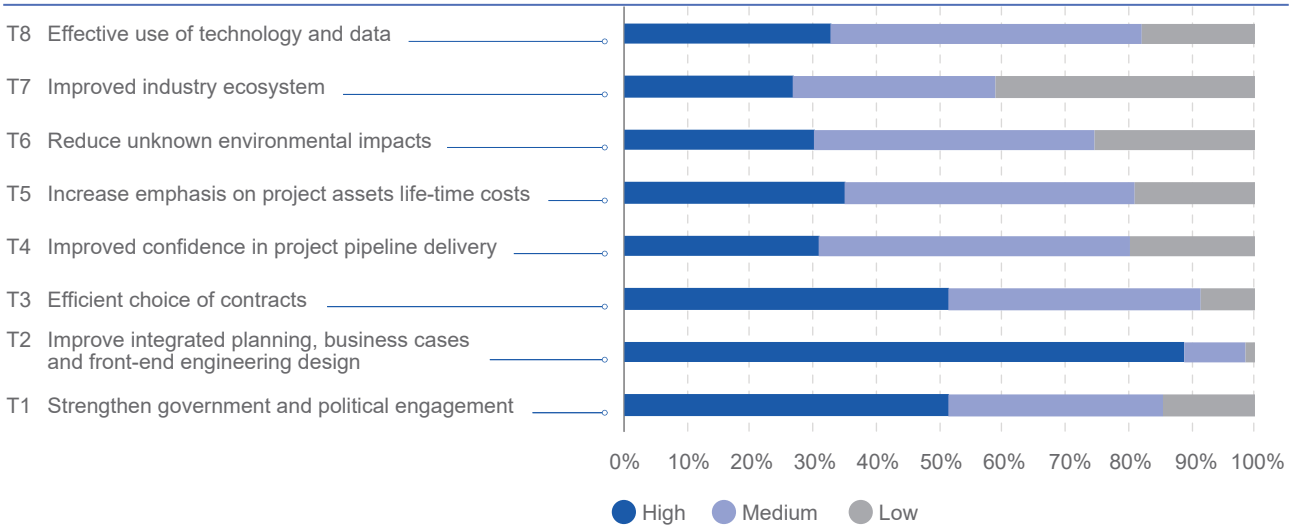
3.1 Eight key themes assessed for their impact on project success

Respondents were asked to assess each theme according to its impact on a project's successful delivery. Graph 1 outlines the percentage of responses within each category – high, medium or low support for options. Graph 2 outlines the mean score rating.

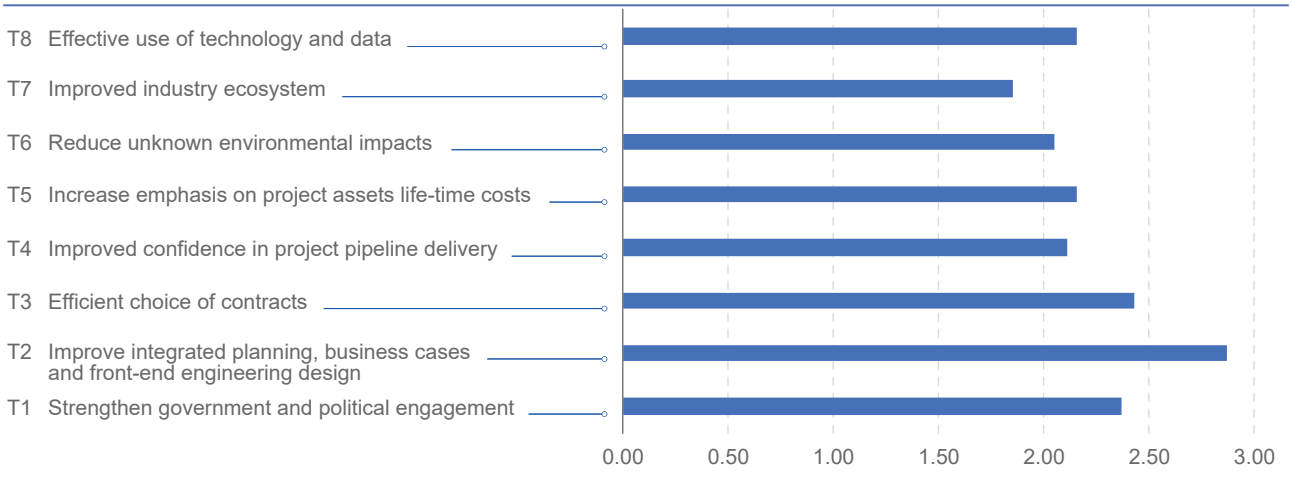
From the research survey output, we can see that the themes ranked highest, mean score, were:

- Theme 2: "Improved integrated planning, business cases and front-end engineering design"
- Theme 3: "Efficient choice of contract"
- Theme 1: "Strengthening effective government and political engagement".

Graph 1 Percentage of responses signifying significance per category



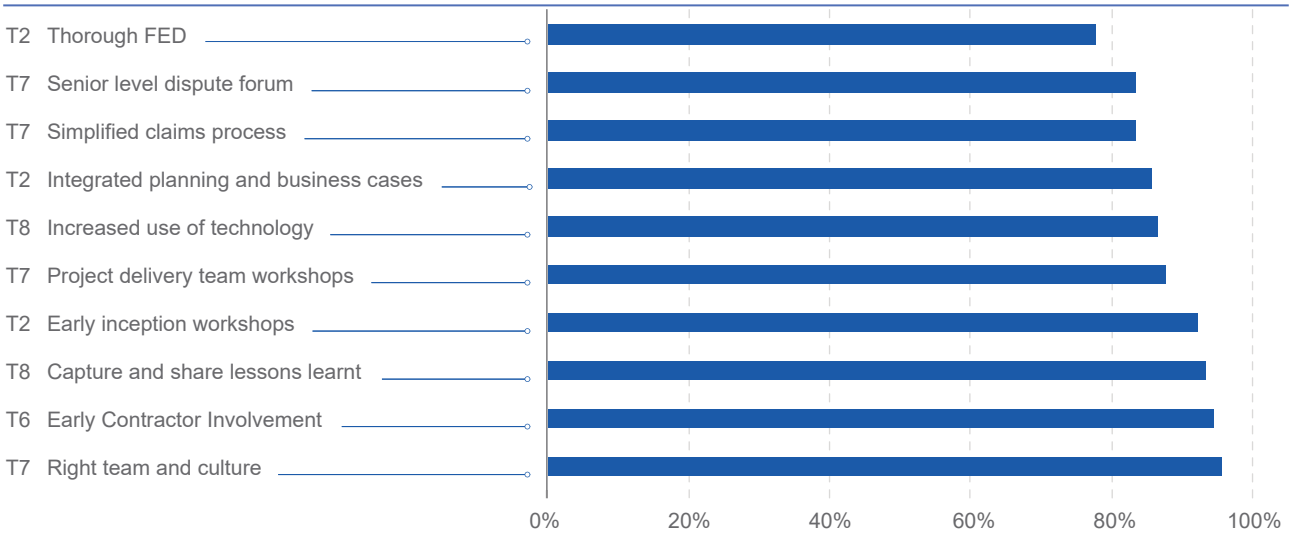
Graph 2 Mean score rating (out of 3)



3.2 Propositions for improvement with the highest and lowest degree of support.

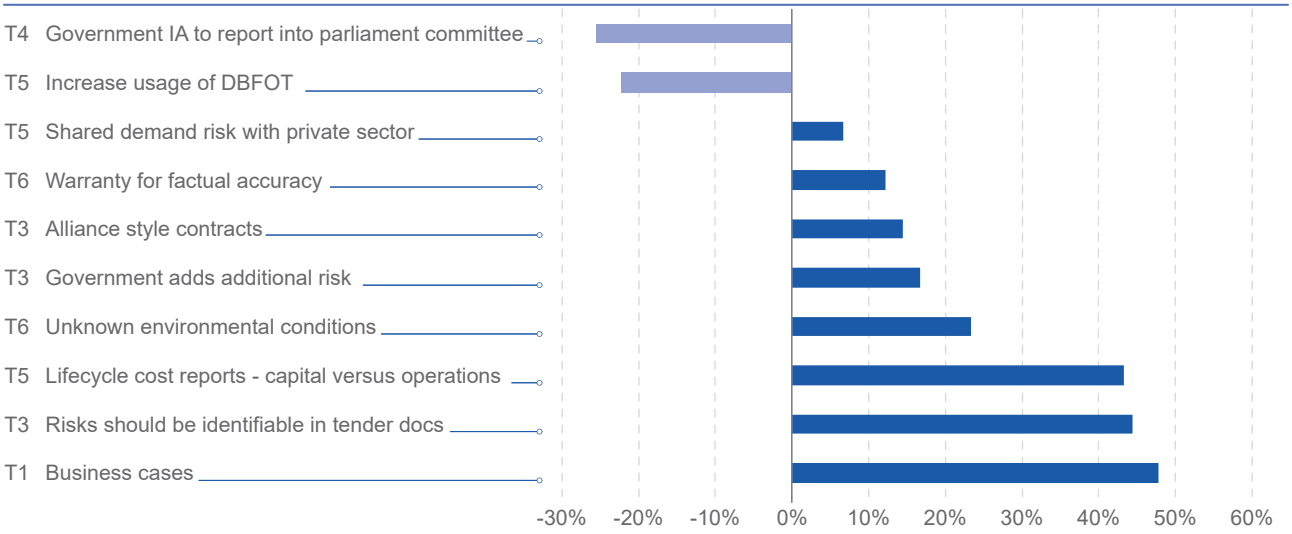
The research survey contained 33 statements pertaining to project impacts and potential areas of improvement. Respondents could score each proposition using the following response categories: Strongly disagree (1), somewhat disagree (2), neither agree or disagree (3), somewhat agree (4) strongly agree (5). Each proposition was assessed against mean score, standard deviation, and variance of means and net support,i.e. number of respondents who agreed or strongly agreed as a percentage of total respondents.

Graph 3 Top 10 propositions ranked



The propositions with the highest degree of support concerned the early use of contractors to assess the environmental conditions of specific Brownfield sites (before further tenders are pursued), constructing a highly competent project team with a collaborative culture, implementing early inception reviews and sharing lessons learned.

Graph 4 Least supported propositions



The research also sought to test the degree of support for increased independence for Infrastructure delivery agencies (through a reporting line into a parliamentary committee) and increased usage of Design-Build Finance Operate Transfer (DBFOT) contracts; these were both rejected.

3.3 Cross tabulation analysis

We used IBM SPSS software to further analyse themes and propositions with a view to identifying whether there were any significant differences between specific sub-groups in cases where enough (over 30) responses had been received.

Themes

The highest-ranked (theme2) and lowest-ranked (theme 7) remained the same between Australian and New Zealand responses; however, strengthening government engagement, and using technology and data were marginally higher in New Zealand.

With both countries, the notable factor was:

- Theme 2: Integrated planning, robust business case and Front End engineering Design ranked highest (Australia 2.89 mean and New Zealand 2.87), with the lowest variance between responses (0.37 and 0.35 respectively)
- Theme 7: Industry ecosystem ranked lowest (Australia 1.88 and New Zealand 1.77). However, it had the highest variance between responses.

ANOVA of Themes by Country

The data was tested to meet the assumptions of ANOVA(analysis of variance – alpha = 0.05), given that the sample was representative of the population; each survey was completed independently; and each sample group had variance equality. We assumed that the Likert scale could be treated as an interval data measurement scale.

We conducted an ANOVA comparing difference in means between Australia and New Zealand for each of the eight themes. The only significant difference is Theme 3: Efficient Choice of Contracts, with an F Statistic 25.46>6.806 F Critical (a=0.01), which is significant at alpha < 0.01. This indicates that the New Zealand mean is significantly less than the Australian mean for this theme.

For all other themes evidence could not establish a difference in means between the two countries.

ANOVA of Themes by Industry

We conducted an ANOVA to compare difference in means for industry segments for each of the eight themes on the basis of stated assumptions. Theme 1 is significantly different at alpha = 0.05; Theme 5 is significantly different at alpha = 0.10.

Theme 1: ‘Strengthen effective government and political engagement’ had an F Statistic 2.73>2.28 F Critical (a= 0.05) with P Value = 0.022. The two industry segments’ mean responses, ‘Government Central Agency’ and Government Delivery Agency’ were both significantly lower than the other four industry segments. This indicates that these government agencies do not see government and political engagement as having the same potential impact on project success as the other industry segments – an interesting finding that requires further investigation.

Theme 5: ‘Increase emphasis on project assets life-time costs’ had a significant difference in mean, with an F Statistic 2.021>1.88 F Critical (alpha = 0.10) with an P Value = 0.079. The industry segment ‘Construction Organisation’ has a significantly lower mean than all other industry segments. It may be that Construction Organisations focus less on project life-time costs as an indicator of project success, but the finding requires further research. For all other themes, there is not enough evidence to find a difference of means between the industry segments.

All other ANOVA analyses by sector show no evidence of significant difference in means.

Propositions

In relation to the 33 propositions, we can observe:

- Australia’s highest-scored (means) propositions were:
  - early contractor involvement for assessing unknown environmental impacts
  - early project concept inception workshops
  - integrated planning and business cases.
- New Zealand had a higher score for improved in-house expertise within government (e.g. more in-house skilled technical experts).
- Both countries had similar lowest-ranked propositions, i.e.:
  - increase use of DBFOT
  - infrastructure delivery agencies to report to an independent parliamentary committee
  - increased demand risk to be shared with the private sector.

ANOVA of Potential Actions by Country

The data was tested to meet the assumptions of ANOVA (alpha = 0.05) as before, on the same assumptions. Of the 33 potential action statements provided in the survey instrument, the following potential actions had significantly different means at an alpha of 0.05:

- For most projects, standard contracts suffice but need to be implemented consistently across agencies.
- Increase the use of a Design-Build Finance Operate Transfer PPP model for major infrastructure projects.
- Unknown environmental conditions and utilities are the greatest threats to project success.
- Undertake early contractor work on complex brownfield sites to identify latent conditions and utilities, and provide derived information to all bidding parties.
- Improve project delivery by selecting experienced, highly competent team members and instilling a collaborative culture between partners.
- When delivering major infrastructure, adequately capture lessons learned and best practices, and use across the sector.

ANOVA of Potential Actions by Industry Segment

We conducted an ANOVA comparing difference in means for industry segments for each of the eight themes, with the assumptions previously indicated.

Of the 33 statements of potential actions in the survey instrument, the following potential actions have significantly different means at an alpha of 0.05:

- Integrated planning, a robust business case and early community engagement will improve the validity of project benefit estimates.
- Government agencies have a propensity to add additional risk to the contract at the preferred bidder stage.
- All risks should be identifiable from the tender documents and no additional risks added at the preferred bidder stage.
- Short-term political cycles result in poorly conceived projects that have not been adequately prepared or prioritised.
- Increasing the remit and resources of government infrastructure bodies to improve coordination and timing in bringing megaprojects to market, will lead to project success increased.
- Increase the usage of a Design-Build Finance Operate Transfer PPP model for major infrastructure projects.
- Governments should produce a lifecycle cost report, including capital versus operations data for each of their major assets on an annual basis.
- Unknown environmental conditions and utilities are the greatest threat to project success.
- Implement an agreed approach across agencies and contractors for addressing non-contestable utility works.
- All major projects should contain a senior level dispute avoidance forum to identify potential areas of dispute before they arise.

More detailed cross tabulation analysis can be found in Appendix1.

3.4 Key stakeholder engagement

Research insights, exemplars of programs and initiatives and recommendations are outlined in section 4. However, there are some general observations from key stakeholders interviewed during the research.

During the research study,online survey received 140 responses and we conducted 40 interviews (as well as the initial 10 interviews to refine the research brief).

All participants interviewed acknowledged the salience of diverse issues involved in delivering major infrastructure in Australia and New Zealand, and that greater value could be delivered to society at large.

There was a positive willingness to work across both the private and public sectors, and across components of the delivery chain to improve performance.

It was recognised that there are challenges, but none that collaboration could not overcome.

4. Insights and exemplars

The research results (desk research, initial in-depth interviews and survey responses) produced a wealth of quantitative data as well as verbatim qualitative data (in italics).

Findings from the 180 respondents are addressed under each of the eight identified themes.

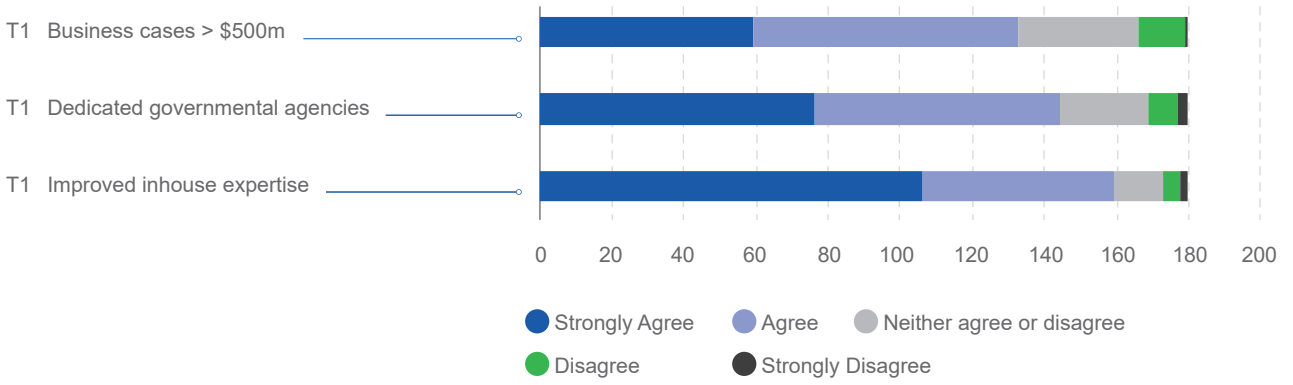
- Each theme rank had a score allocated of low (1), medium (2) and high (3). Mean score ranking, standard deviation and variance of means was analysed for all respondents and where sufficient data on subgroups was received (at least 30 responses).
- Each of the 33 propositions was similarly allocated a score: Strongly disagree (1), somewhat disagree (2), neither agrees nor disagree (3), somewhat agree (4) strongly agree (5).
- Each proposition was assessed against the mean score, standard deviation, variance of means and net support (the number of respondents who agreed or strongly agreed as a percentage of total respondents).
- For each theme, we also drew upon individual interviews and the literature review to showcase specific areas of best practice, or to exemplify a specific item.

4.1 Strengthen government and political engagement

Increase technical expertise within the government sector; how skills can be shared across agencies; enhance statutory powers for infrastructure delivery agencies with increased independence.

Although this theme is not directly applicable to one individual project, qualitative and quantitative data suggests improved project delivery can be attained by increasing skills within the government sector and achieving improvements in the timing and certainty of projects coming to market. This theme was the third highest-ranked item within our research findings.

Strengthen government and political engagement



Respondents' comments include:

- *State entities need to have the expertise to quickly and appropriately assess in order to maintain delivery programs.*
- *We need skilled government staff who manage contracts, not skilled government staff that micromanage contractors.*
- *More openness at the Ministerial level to forecast cost and time to completion, with more willingness by senior executives within government agencies to reveal true forecasts is required.*

Exemplar programs and initiatives

Victorian Major Projects Leadership Academy

OPV (Office of Projects Victoria) is working with the University of Oxford's Saïd Business School and Ernst & Young (EY) to deliver state-of-the-art training in project leadership. Each year, more than 50 Victorian project leaders take part in the program. Future cohorts will also include more participants from state governments around Australia. The course is designed to boost infrastructure leadership and capability across the entire Victorian public sector. The program content is based on primary research and case studies that have been proven to deliver significant positive impact. In addition to delivering structured theoretical content, the Academy provides experiential learning with opportunities to apply learning in day-to-day work and resolve the issues of greatest impact for major projects. The Academy is intended for Executive Officers with responsibility for large or strategically important projects, programs or portfolios. Admission to the VMPLA is by CEO/Agency head nomination. Program intake is overseen by the Construction Leadership Group of OPV.

Engineers Australia – being an informed buyer

Engineering expertise is an essential component of the expertise an agency needs to procure engineering intensive products and services. Engineers Australia drew attention to this in the first edition of its 2000 report, Government as an Informed Buyer. It identified that risks included: (i) the inability to manage engineering contracts because contracting staff lacked the necessary technical expertise, and (ii) the inability of contract staff to adequately assess the engineering competencies of contractors and subcontractors. The procurement consequence from losing engineering expertise was highlighted in several submissions in 2011 and 2012 to a Senate inquiry into the shortage of engineering skills. Consult Australia's submission identified that, when government agencies lose their engineering workforce, they lose their ability to be a well-informed purchaser. Value for money should not be based solely on determining the costs and benefits that procurement accrues to an agency. Achieving a holistic concept of value for money requires agencies to have an effective procurement system underpinned by a range of expertise.

Research conclusions: Increased technical skills and expertise required within the delivery agency"client side", combined with the coordination agency's tenure, experience and strong central infrastructure.

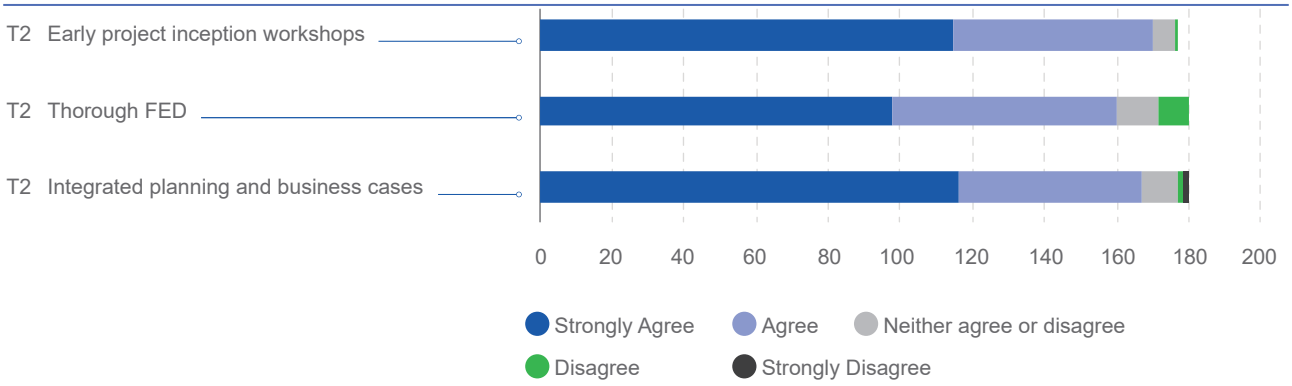
4.2 Integrated planning, robust business case, frontend engineering design and early community engagement

Bringing projects to market that are well planned and have a robust business case requires necessary in-house expertise within government with additional external advisers. Risk allocation could be improved, early in the project delivery cycle by bringing projects to market that communities needed through increased community engagement.

Considerable feedback shows we need to improve the way we identify and prioritise projects to proceed.

This theme focussed on integrated planning, robust/ transparent business cases; overall value to society; and thorough (peer-reviewed) front-end engineering design. It received over whelming support, with the highest mean score and lowest variance amongst respondents.

Integrated planning, robust business case and early community engagement



Respondent comments include:

- *An increased, transparent and consistently applied level of business case detail applied across all types of infrastructure business case.*
- *We need to publish long term plans and strategies that are agreed on. Governments then broadly need to stick to them.*
- *Mandate a public project business case approvals process that separates political announcements from a GO decision.*

Exemplar programs and initiatives

Parkes will be NSW's First Special Activation Precinct

The NSW Government is establishing Special Activation Precincts (SAPs) as part of its 20-Year Economic Vision for Regional NSW. SAPs are a new way of planning and delivering infrastructure projects in certain NSW regional locations, to attract and grow businesses, stimulate the local economy, and provide more local employment opportunities. Each location will be chosen for its unique local offering, services, and competitive advantage. Key elements include faster and easier planning processes; government-led development in some locations; investment in infrastructure; coordinated land-use and infrastructure planning. Business concierge services will help businesses start up in SAP areas, including grants and interest-free loans for eligible businesses under the Regional Investment Attraction Package.

SAPs are unique in regional NSW as they bring planning and investment support services together. Businesses will be able to establish and grow with certainty and confidence knowing that the right planning framework is in place.

A deliberative democracy approach

A deliberative democracy approach for engaging communities in infrastructure projects and getting their support and agreement. The OECD Open Government unit is currently undertaking a global study under Claudia Chwalisz that will be completed in the middle of 2020. The study is focusing on the successful criteria used in deliberative processes by citizen juries engaged in local issues, including infrastructure. Preliminary findings indicate that there are literally hundreds of cases where this process has been very successful, including scores of examples of citizen juries for infrastructure matters. Such juries have been established in many countries, including Canada and South Korea. Examples in Australia include Infrastructure Victoria Citizens Juries'30-year infrastructure plan, the Community Panel for South East Drainage (South Australia), and many others.

"As part of Infrastructure Victoria's consultation program, we convened two citizen juries of around 40 people each – in Melbourne and regional Victoria between May and August 2016," said Infrastructure Victoria's CEO Michel Masson. "We wanted our 30-year strategy to reflect a broad community view of what is important, and infrastructure affects everybody, everyday, so it's only right that people have a say in the decisions that will impact them over the next 30 years.

"Jury members were sought through a random selection process to ensure a representative, cross section of people were involved. We asked these juries to consider the question: What should we do to meet Victoria's infrastructure needs?" added Mr. Masson. Each jury met for six full-day sessions over several months in order to build their subject understanding. In total, jurors spent around 50 hours together.

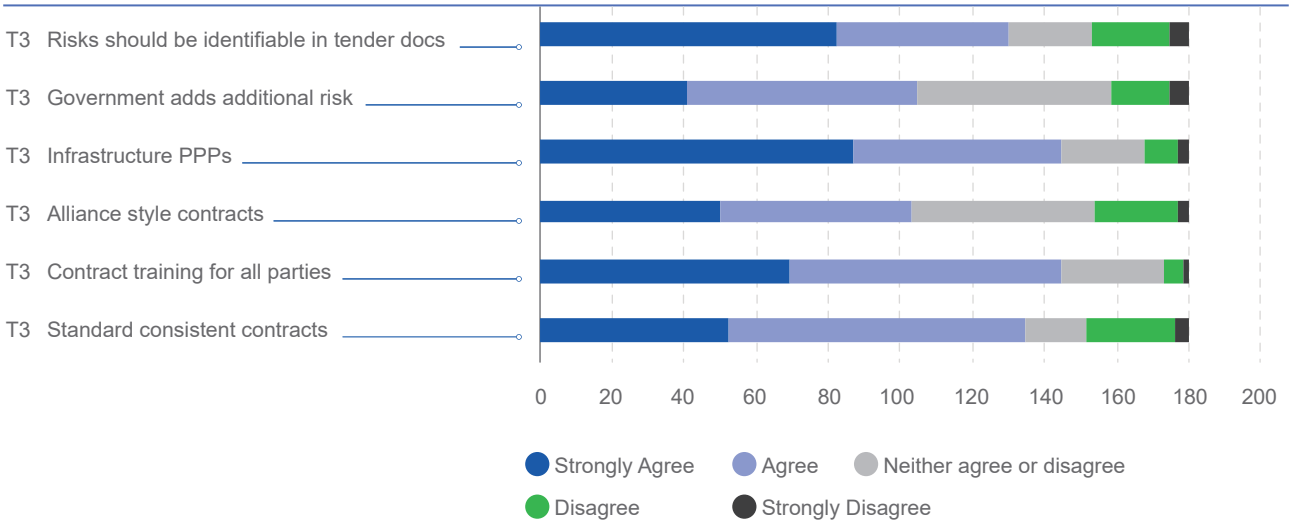
Research conclusions: Major infrastructure requires a more integrated planning and robust business case process, combined with thorough front-end engineering design and community engagement; this may mean fewer projects coming to market but with increased scrutiny.

4.3 Efficient choice of contract

Use of collaborative/alliancing contracts for complex Brownfield sites, and consistent use of standard contracts,e.g. GC21, for traditional projects.

For its impact on project delivery, more than 90% of respondents supported efficient choice of contracts focussed on having the right contract that is consistently used across delivery agencies as well as construction firms. For example, respondents proposed the use of collaborative alliancing contracts for complex Brownfield sites and consistent use of standard contracts such as GC21 for traditional projects.

Efficient choice of contracts



Respondents' comments include:

- *Contracts should be standardised as much as possible, no bespoke authoring/negotiation/disputing; clear accountability between parties critical.*
- *Choose the right contract, allocate risk to the best party and recognise the value of Alliances in value beyond the $$'s in VFM (value for money).*
- *Adopting a consistent form of contract, reduce the commercially driven/legal emphasis on running a project where an adversarial behavioural culture promulgates. Could use the NEC or FIDC contract?*

Exemplar programs and initiatives

Sydney Water to use New Engineering Contracts (NEC) contracts to deliver new works

Sydney Water is the first major infrastructure company in Australia to use the contract approach used by NEC to deliver new works. The contract will help simplify their supply chain and deliver significant benefits to Sydney Water, its customers and its partners through increased efficiency, work continuity, resource availability, and partner capability. NEC produces a diverse range of definitive end-to-end project management contracts that, in principle, enable users to deliver projects on time, on budget and to the highest standards. Its NEC3 contract was credited as “the unsung hero of the Olympic games” in London in 2012, and its suite has been used to deliver major water projects around the world. These include Thames Tideway in London, Happy Valley Underground Stormwater Storage scheme in Hong Kong, and Watercare Services’ Hunua 4 Water scheme in New Zealand.

Mark Simister, Head of Delivery Management at Sydney Water, said: “Through our Partnering for Success program, we’re looking to use the NEC4 suit of contracts to benefit Sydney Water, our partners and ultimately our customers by incentivising high performance and increasing productivity. By doing this, we’ll give our partners more certainty, and drive better decision making across the whole lifecycle of our assets, improving our productivity and delivering value for our customers. The NEC3C pain share/gain share could be said to shift the parties focus from the deliverable to the avoidance of disallowed costs and efficient mechanisms are required to expedite decision making and assure contractors that proactive behaviour will not be penalised under disallowed costs.”

Waikato roading alliance

The alliance is NZ’s largest roading alliance, set up by Waikato District Council in conjunction with Downer NZ, and was created to deliver and improve asset management, renewal and management services to the community. The alliance allows a much quicker response than is possible from a traditional council-contractor relationship, highlighted by the response to the 2016 collapse of a culvert on Otonga Valley Road early one November morning. The culvert suffered catastrophic failure and left 28 residents on the no-exit road without access. Through the alliance, an engineer visited the site that day and escalated the response. Resources available to the alliance provided transportation to school students sitting national exams; a bridge deck and crane were taken to the site, and the road was returned to service within 20 hours of the collapse.

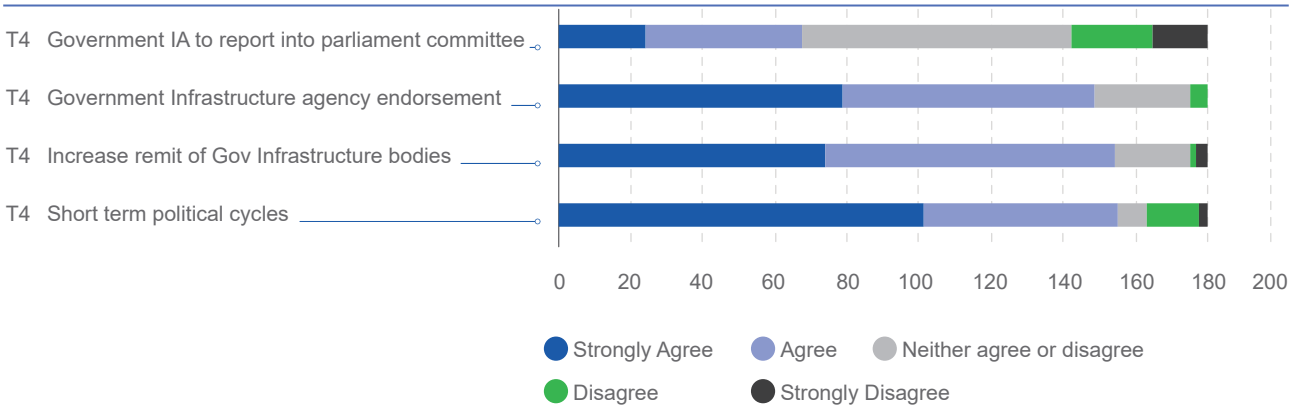
Research conclusions: Standard contracts when used consistently after joint training in their use, are more than adequate for a large number of projects. However, for Brownfield sites, and when interfacing with other complex assets, a collaborative contract is more effective. There was minimal support for increased use of Design-Build Finance Operate Transfer (DBFOT) models. True partnerships involving multiple parties to the contract, arguably achieve higher collaboration levels by fundamentally reallocating risk among multiple parties, with collaboration leading to a level of joint liability and shared gain.

4.4 Increased confidence in project pipeline

Once a project has gone through the various planning and business case phases and engineering design, construction firms need to be confident that the project will go ahead and not be cancelled, based on the political cycles.

Although there was general agreement that the scope and remit of infrastructure agencies should be enhanced, there was minimal support for agencies to have increased independence beyond the current position. Short-term political cycles, husting-led project announcements, and the impact of multiple megaprojects coming to the market at the same time, all impacted confidence in project pipeline delivery.

Increased confidence in project pipeline



Respondents' comments include:

- *Reduce the effect that short-term political cycles have on major projects.*
- *Increase collaboration at early stages of planning, agreement on outcomes, practical timings and bi-partisan political involvement.*
- *Start to spread the delivery of major projects instead of the boom/bust cycles tied with government terms.*
- *Remove the commoditization and political weight behind transport projects that lead to business and/or political decision being made that take the focus away from what is good system design.*
- *Develop a long-term plan and stick to it, avoid bleeding edge technology projects and adopt a strict delivery model based on a whole of systems thinking approach.*

Exemplar programs and initiatives

NZ Infrastructure Commission

A key benefit of the NZ Infrastructure Commission is the greater certainty it will provide around pipeline projects, boosting the previous Infrastructure Transactions Unit's remit of:

- Infrastructure market and procurement pipeline: acting as a 'shop front' for the market and publishing a pipeline of infrastructure projects.
- Best practice guidance: providing best practice guidance on infrastructure procurement and delivery, including standardised procurement processes and documentation for major infrastructure projects.
- Procurement and delivery support: involving supporting agencies in the preparation of business cases for major infrastructure projects and project delivery, including by providing embedded commercial and procurement expertise.

Surrey County Council (SCC) Roads Renewal Programme

On a smaller scale, SCC as the road network owner, aimed to save £20m on a roads renewal programme using the Alliancing Code of Best Practice to create an Enterprise. This was achieved via a collaborative model that included both tier 1 and 2 of the supply chain. The original cost of the works was £120m over five years. By introducing the Infrastructure Alliancing principles, SCC managed to reduce the price by around 15% while maintaining the whole-life value. Total savings from the first two years totalled £7m enabling the council to resurface an additional 30 miles of road. By the programme's end it had achieved 15% savings. Extending procurement cycles from annual to five years was a key ingredient for success. Although not a megaproject it provided pipeline certainty; enabled the market to focus on innovation, waste reduction and quality; co-located the team and fostered interpersonal relationships between team members; and involved specialist suppliers early. As the program neared completion, SCC expanded the scope beyond road maintenance to the whole capital maintenance portfolio. SCC also extended their supplier engagement to build a supply chain alliance.

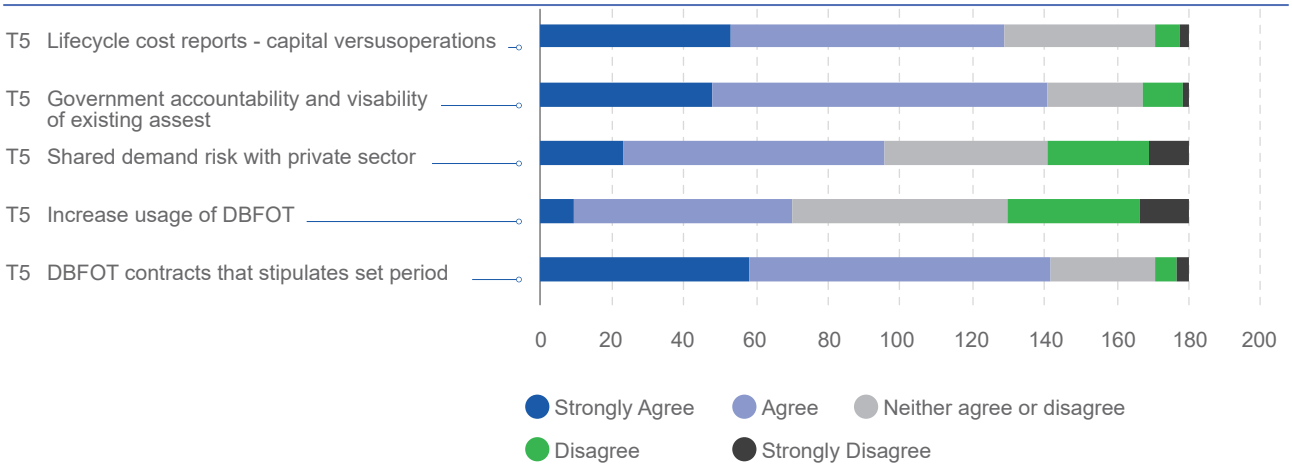
Research conclusions: Respondents outlined that a consistent more coordinated release of major infrastructure will be more effective and enable better resource planning, rather than boom–bust cycles and changes in projects with changes of government. Although increased resources and authority were expressed for infrastructure agencies, there was minimal support for any changes to existing reporting lines.

4.5 Increase emphasis on project assets life-time costs

Operation and maintenance of an asset are managed more effectively if demand risks are borne by the private sector; and increased use of Design-Build Finance Operate Transfer (DBFOT) contracts enable the private sector to design for the maintenance and operation phases of the project, as they have to transfer the asset only after operation for a stipulated time.

This theme looked at a whole-of-life-cycle cost perspective on whether or not to build infrastructure – how reporting improvements in capital versus operational costs would impact on the need to build new infrastructure, and including operational delivery partners at an earlier stage of project scoping. Asset operation and maintenance are arguably more effectively managed if demand risks are borne by the private sector. Increased use of Design-Build Finance Operate Transfer (DBFOT) contracts enable the private sector to design for the project's maintenance and operation phases, as they must transfer the asset only after operating it for a stipulated time.

Increased emphasis on project assets life time costs



Respondents' comments include:

- *We do not do asset management very well. Instead, there is a tendency to look for a quick fix with new infrastructure, that can be showcased and have a ribbon cutting photo event. Instead we should look at the whole project life cycle use and when a project is being scoped out, we need to get the operators more involved.*
- *Share risk appropriately including in PPP's. This does not happen at present.*
- *Whole of environment and life cycle cost-benefit analysis and comparison with alternatives prior to commitment to proceed.*
- *Integrated Planning with whole of life analysis, early contractor engagement.*

Exemplar programs and initiatives

Digital Asset Information Management (DAIM): A Guide and Manual.

The Sustainable Built Environment National Research Centre (SBEnrc) is the successor to the CRC for Construction Innovation. Asset management in the built environment has been the subject of changing practice and research for years and is often complicated by inconsistency in measuring and monitoring the condition and performance of assets across the industry. This project recommends the use of digital information modelling, such as BIM and DE, beyond design and construction to encompass asset management practices. It provides an asset information model framework and delivery manual with supporting cross-sector case studies. It will enable access to asset information and identify opportunities for adding value to assets by enhancing the quality and use of digital asset data. The outcomes will serve as a foundation for future development of a digital asset information model to aid management over asset lifecycles, identifying ways of decreasing the cost of operation and maintenance and of improving the return on investment of asset management, whilst concurrently improving sustainability, resilience and safety.

New Zealand Investment Management and Asset Performance in the State Services

The New Zealand government (Cabinet Office) introduced a circular that outlined Cabinet's expectation for managing investments as well as both physical and intangible assets, across all investment life cycle stages. The investment life cycle comprises four recognisable phases: thinking, planning, doing and reviewing. Each phase has different implications for agencies and decision-makers.

- The thinking phase:The purpose is fully to understand and define the underlying causes and effects of problems or opportunities, the potential benefits of addressing these, and to identify a broad range of potential responses. Decision-makers want to understand why the issues need resolving and the array of potential investments available.
- The planning phase: The purpose is to choose investments that create the best value investment portfolio. Given financial or other constraints, this phase involves making difficult trade-offs between options and investments with different merits and costs. This phase may result in divestment and/or investment decisions that target resources to their best effect.
- The doing phase: The purpose is to give investments the greatest chance of success while maintaining control to avoid loss of value. Decision-makers want assurance that the investments are delivering the expected value, as well as advice on further actions required to secure the expected value.
- The reviewing phase: The purpose is to review investments' actual performance against expectations –review benefits, and the assets' and investment portfolio's performance in relation to current and emerging needs. The aim is to ascertain what else needs to be done to optimise customer service levels and asset performance levels over time.

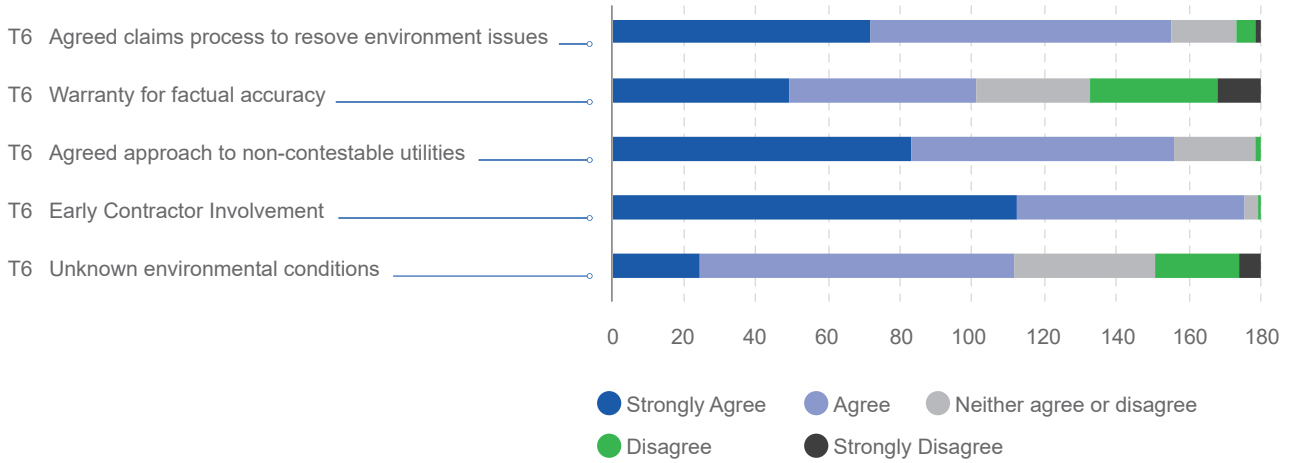
Research conclusions: Total asset reporting to evaluate accurately whether to build new infrastructure instead of upgrading/repairing existing would be good but the operators of the asset would need to be involved earlier in the process to enable great confidence in the asset being used successfully.

4.6 Reduce unknown contaminants & utilities risk

Reducing uncertainty around the unknown condition of in-ground contaminants, such as asbestos and other toxic elements, as well as the location of utilities, was seen to have a major impact on the success or failure of a project. Many of the risks that occurred within the projects cited could have been reduced if front-end engineering design had been undertaken more thoroughly. Transparent use of data is needed in bid preparation.

Reducing uncertainty around the unknown status of in-ground contaminants, such as asbestos and other toxic elements, as well as the location of utilities, was seen to have a major impact on a project's success or failure. Many of the risks that occurred within the cited projects could have been reduced if front-end engineering design and Early Contractor Involvement (ECI) had been undertaken more thoroughly, with data shared transparently in bid preparation. The proposition with the highest support concerned early contractor involvement to reduce uncertainty around environmental conditions.

Reduce unknown environmental impacts



Respondent comments include:

- *Latent conditions risk should sit with the government, not contractors.*
- *Risk allocation has not materially changed over time; however, with the large increase in scale, value and complexity of the major projects, the consequences of the risks have grown exponentially. There needs to be some reconsideration of sharing critical risks with limited information and control (e.g. non-contestable utilities, contamination, latent conditions and ground conditions). An element of these risks should be shared by the government as the ultimate owner of the assets.*
- *Better management of utilities and contamination risks via early works packages and Govt adopting a partnering solution-oriented approach.*

Exemplar programs and initiatives

Barangaroo site remediation

Barangaroo was once home to the Millers Point Gasworks, which operated from the mid-1800s through to 1918 and lit the way for Sydney to become a modern city. After the gasworks was decommissioned, its above ground structures were removed but contaminated soil and tanks containing coal tar were left underground.

Giselle Howard, Regional Director Metropolitan Branch, NSW EPA, said the remediation works had been complex and required the management of significant risks. “The premises included highly contaminated groundwater as well as asbestos. There were significant risks that offensive odours could be generated by remediation activities due to the close proximity of tourist, commercial and residential precincts around Barangaroo. “I am proud of the work our teams did, working in conjunction with NSW Health, the Planning Assessment Group within DPIE and the Contaminated Land, Air and Water Technical groups, to ensure the potential for any environmental and health impacts were minimised and appropriately communicated”

“The work at Barangaroo showcases our effective regulation of a complex remediation project in a highly populated area which included residential and commercial occupants as well as a childcare centre. “It is also a textbook example of effective collaboration between agencies. Through the application of best practice technology, demanding regulatory requirements, as well as extensive stakeholder engagement by Infrastructure NSW and its contractors, there have been minimal complaints and impact on the community and that is something we can be proud of.”

Melbourne Metro

The Arcadis Arup WSP (AAW) design joint venture, provided advice to Cross Yarra Partnership (JHG, Lendlease, Bouygues JV) in the tender phase. They recognised the likely categorisation of soils based on the client-provided data (Rail Projects Victoria, RPV)as well as soil sampling approaches to manage the risks and minimise the costs associated with soil disposal. AAW initially produced a sampling, analysis and quality plan (SAQP), which was reviewed by several third parties, including EPA, RPV’s Technical Advisor, the Independent Reviewer, and the Independent Environmental Auditor. The SAQP was ultimately included in a project-wide Spoil Management Plan and approved for use by RPV.

To date, the works have included drilling soil sampling of approximately 750 soil bores in logistically difficult locations such as rail corridors, the CBD, on major roads/interchanges (e.g. Domain interchange), and in sensitive (heritage) areas. As predicted during the tendering phase, additional contaminated soils sampling (over and above the guideline requirements) has reduced the ultimate hazard categorisation for contaminated soils. The additional samples obtained for analysis resulted in a better statistical output and the ability to lower the hazard. Also, where there were hot spot areas of highly contaminated soil, the higher density sampling allowed for better segregation of the highly contaminated soil and minimised the waste disposal costs. When the tendering phase prediction of the hazard categorisation for the different stations was compared with the actual hazard categorisation of these areas, it showed that significant savings were gained.

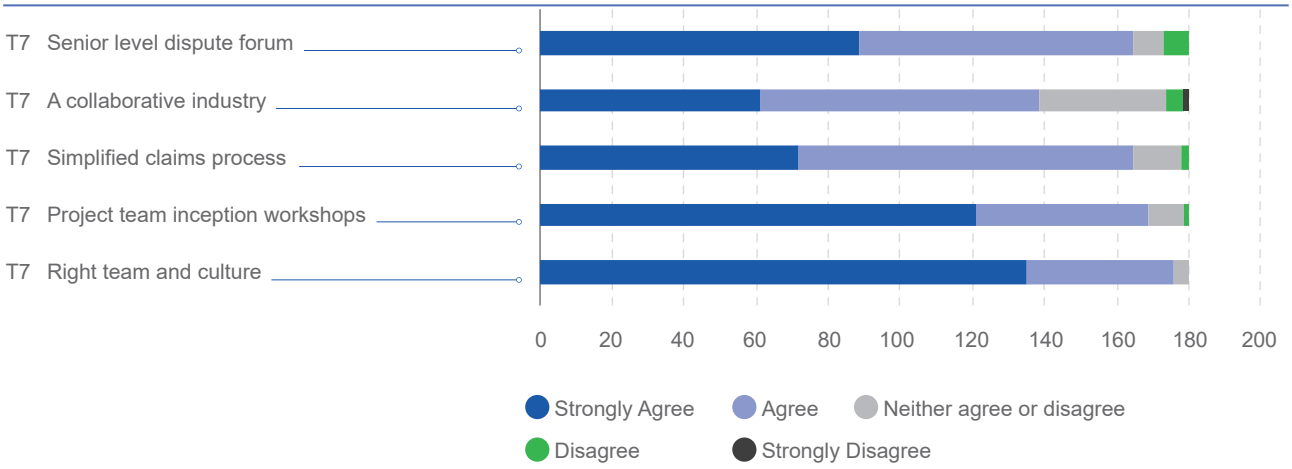
Research conclusions: Environmental impacts and non-contestable utilities cause major concerns and can be reduced through early contractor investigations with data obtained transparently and shared with all parties, with a process to ensure non-contestable utilities are moved within an appropriate time frame and that a suitable claims process is instituted.

4.7 A more collaborative industry ecosystem

Irrespective of delivery model or what contract is in place, significant value could be attained in working through a culture of collaboration between Clients (State Agencies) and delivery partners (Construction firms and Service delivery).

Although Alliance contracting, ECI Contracts etc., were cited as two delivery options, other organisational strategies may offer some other benefits; for example, encouraging increased staff movement between the private and government sectors and using secondments and placements to improve awareness of the challenges each party faces. Collaborative teamwork and sharing lessons learned is also significant. Although "Improved Industry ecosystem" did not rank as high compared to other themes, the propositions concerning a highly competent team, working in a collaborative manner, with an early inception workshop and a continuous improvement orientation, were widely recognised as increasing the probability of a successful project (both quantitative and qualitative data).

Improved industry ecosystem



Respondent comments include:

- *High-quality project management and professionals working for both the client and the contractor focussed upon collaboration.*
- *All tenderers submit a reasonable tender with appropriate profit margin rather than undercutting each other and trying to recoup losses through poor design, construction or claims.*
- *Design Construct Maintain PPPs need more accountability on PPP Co to manage design for maintainability rather than utilising two independent sub-contractors with little oversight.*
- *Collaborative contracting partnerships with aligned objectives. Well-developed concept design, including extensive site investigations, where required. Clear alignment of risk allocation and pricing/contingencies to manage risks.*
- *Earlier identification of project risks through a collaborative approach with industry.*

Exemplar programs and initiatives

W2B delivery partner model

Woolgoolga to Ballina is the final Pacific Highwaylink (Hexham—Queensland border)being upgraded to four lanes. Upgrading the Pacific Highway and carrying out safety improvements to the existing highway have greatly improved road conditions. These improvements support regional development and provide safer travel, reduced travel times,improved transport efficiency, made travel more consistent and reliable, and improved amenity for local communities.

The project includes upgrading the highway to motorway (Class M) or arterial (Class A) standard over its 155-kilometre length, nine interchanges, more than 170 bridges and more than 350 connectivity structures. It will bypass South Grafton, Ulmarra, Woodburn, Broadwater and Wardell. This project was established using a Delivery Partner contract that Laing O'Rourke had used on the London 2012 Olympics (a combination of program management, project management and EPCM contracts). The delivery partners (RMS/ Laing O'Rourke and WSP) initially undertook ECI engagements to reduce the uncertainty and 'de-risk" the project. They also implemented a whole-of-materials procurement program with industry consultation to ensure all materials were available for the project with cost certainty. Individual packages were delivered under various contracts, e.g., D&C where appropriate, or construct only. Where sub-contractors performed well (especially tier 3 contractors), these organisations were rewarded with more work. At the start of the project, a good collaborative culture was embedded and all partners and contractors were expected to abide by the shared values.

Northside Storage Tunnel

The Northside Storage Tunnel was a major component of Sydney Water's strategy to clean up the harbours, bays, rivers, and beaches in its jurisdiction. As the project involved concurrent engineering, much of the design was unspecified. Specified in detail were agreed principles that the partners committed to as the means for resolving issues within the alliance. These differed markedly from traditional detailed construction contracts with the prospect of arbitration when agreement broke down. Management consultants with experience in large-scale construction projects helped design a project culture. They recommended that cohesiveness could be fostered by creating a project culture that was explicitly designed and crafted to encourage shared behaviours, decision-making, and values. They produced a list of value statements with two core values: striving to produce 'best-for-project' solutions, and having a 'no-blame' culture. These were buttressed by a risk/reward calculation. Specialist consultants regularly assessed and reported performance against KPI criteria. Success against the non-cost/schedule criteria was critical for commercial and overall project success. As such, this area represented significant risks.

Research conclusions: Projects are more likely to succeed if a partnership approach is evident, involving all parties; combined early project inception workshops to embed collaborative culture and with a consistent process to handle variations and claims.

4.8 Using technology and data more effectively

Digital engineering (BIM, GIS etc) used across all partners undertaking the infrastructure delivery, identifying lessons learnt and innovation obtained from the project, is shared across the sector.

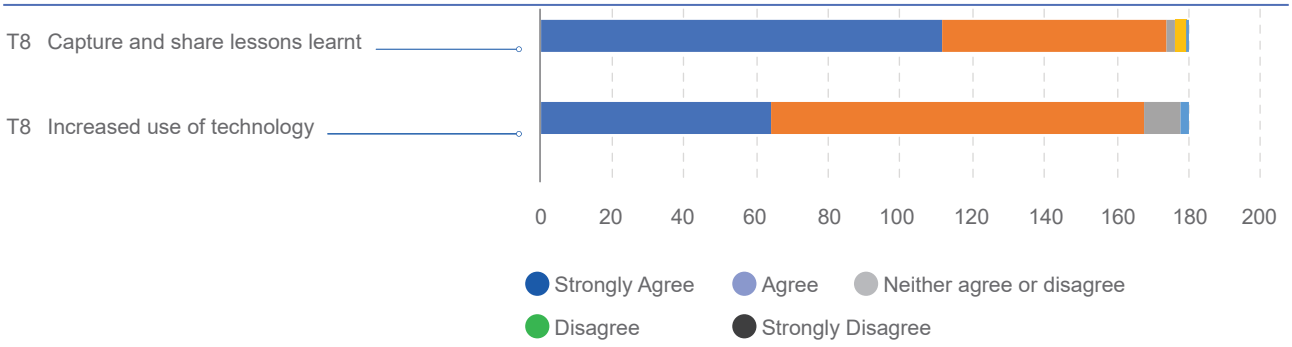
More than 90% of respondents either strongly agreed or agreed with the two propositions put forward under:

a. Improved use of integrated technology across all infrastructure delivery partners has the potential to improve the likelihood of a successful project

b. When delivering major infrastructure, lessons learned and best practices are not adequately captured and used across the sector.

The use of digital engineering – especially in initial project phases, with all delivery partners working across consistent digital platforms for ease of data transfer – was specifically highlighted. Similarly, lessons learnt and post-opening project evaluations are not undertaken effectively. Participants felt that significant improvements could be made by learning from the past, not making the same mistakes on future projects.

Effective use of technology and data



Respondents' comments include:

- *Sharing of standardised data across all infrastructure delivery partners during project delivery and commissioning.*
- *Improved quality of feedback from Agencies on successful and unsuccessful tenders.*
- *Sharing of lessons learnt and best practice across the sector, improved monitoring of benefits being sought by projects, improved monitoring of threats to project completion.*
- *Ensure strong governance and accountability for project delivery based on measurement of performance. There needs to be a clearly defined project delivery system that is followed with appropriate hold points so that if performance does not meet expectations then the system can be improved using lessons learned etc.*
- *Have integrated information management systems across all facets of and parties to the contract.*

Exemplar programs and initiatives

Darlington Upgrade project – digital engineering

The Darlington Upgrade Project is another important stage in the delivery of Adelaide's North-South Corridor and will deliver an upgrade of approximately 3.3 kilometres of the existing Main South Road. On behalf of the Australian and South Australian Governments, Gateway South, a Joint Venture between Laing O'Rourke and Fulton Hogan, is improving the connectivity between Flinders University and Tonsley, and one of the key components of the project is the Darlington bridge.

"The joint venture has come up with a very innovative way to construct and install the bridge. We're building it in a paddock adjacent to the road; we're going to move it in a fully assembled manner using SBMts. We literally drive it down the road and drop it in the final position. It's 180 metres long, its 3000 tonnes, it's the first and only bridge structure to be moved, of the scale and size in Australia" Stuart Croft, Regional Director.

"We're using digital engineering on the move, really to de-risk the whole task. We understand physically where the bridge will move during the transport from the yard up to its final install base and how it will land on its' bearings", James Glastonbury, HUB Engineering Director.

The project is a very good example of the use of digital engineering across all partners and its impact on delivering a complex project ahead of time on budget.

UK Transport Infrastructure Efficiency Strategy

The Transport Infrastructure Efficiency Strategy is a joint strategy developed by Crossrail, Highways England, High Speed Two (HS2 Ltd), Network Rail, Transport for London and the Department for Transport. The organisations will collaborate to maximise the opportunities to drive efficiency across the wave of new transport projects being delivered or in the pipeline. They will seek to learn from each other's experiences and collaborate with their shared supply chain. The strategy will target key stages in the asset investment lifecycle where there is greatest opportunity to deliver efficiencies It will focus around 7 challenges: Judge strategic choice and trade-offs based on whole-life cost and wider benefits; Improve the way we set up our projects to maximise value and prevent delivery inefficiency; Create a transport infrastructure benchmarking forum to share best practice and innovation; Establish a common approach to estimating cost management to improve cost confidence and assurance;Promote long-term, collaborative industry relationships to reduce procurement transaction costs and maximise innovation; Challenge standards to enable innovation and drive efficiencies; Exploit digital technologies and standardise our assets towards adopting best practice from the manufacturing sector, such as off-site construction.

Research conclusions: Using digital technology consistently across all parties helps identify and resolve issues early and provides a more integrated design for the project. Improvements in post opening project evaluation (POPE) and sharing of results more widely will enable lessons learnt to be acted upon, with a decreased frequency of similar mistakes occurring in the future.

5. The way ahead

With an infrastructure work pipeline worth billions of dollars, there is plenty of room for improvement within the infrastructure ecosystem cohort to improve delivery. All the separate components of the infrastructure system that we consulted, expressed a positive collaborative willingness and observed that things can be improved to help more effectively deliver projects and megaprojects, in ways that exceed expectations.

This research proposes recommendations around three focus areas: skills and expertise, collaboration between partners, and early engagement.

Skills and expertise

- Increase participation in major project leadership academies, such as Victoria's, and include private sector participants to encourage joint learning.
- Increase infrastructure agencies' resources and authority, without changing existing reporting lines.
- Implement standard contracts (with a consistent issues-resolution framework) and joint training, except on brownfield and other sites where infrastructure interfaces with other complex assets and where collaborative contracts can be more effective.
- Improve total asset reporting and assess the need to build new infrastructure rather than upgrading or repairing existing assets.
- Increase delivery agencies' technical skills and expertise 'client-side', and combine tenure and experience with strong central infrastructure in coordination agencies.

Collaboration between partners

- Projects with a partnership approach are more likely to succeed combined with early project inception workshops that embed a collaborative culture and have consistent processes to handle variations and claims.
- Consistent and better-coordinated release of major infrastructure, to enable better long-term resource planning than boom-and-bust cycles or changes mandated as a result of changes in government.
- More consistent digital technology use among all parties,to help identify and resolve issues early and provide more integrated project designs.
- Improve post-opening project evaluation and share results more widely so others can act on lessons learned and reduce the likelihood of future mistakes.

Early Engagement

- Better-integrated planning and more robust business case processes, combined with thorough front-end engineering design and early community engagement. Fewer projects may come to market, but those that do will enjoy better scrutiny and preparation beforehand.
- Conduct early contractor investigations,to reduce environmental impacts and major concerns caused by non-contestable utilities. Embed a process to ensure non-contestable utilities are moved within appropriate time frames, and have a suitable claims process in place.
- Involve asset operators early to instil confidence in the asset's successful use.

6. Next steps

After the research and client discussion forums held in WSP offices, a recurrent perspective centred around one question: “What next?– this is good research but how can we make a difference? What must we do?”

All participants shared a genuine collaborative spirit and recognised the need to improve the existing delivery process if we are to successfully deliver future large infrastructure projects.

Potential next steps will depend on appropriate funding. They could include some/all of the following elements:

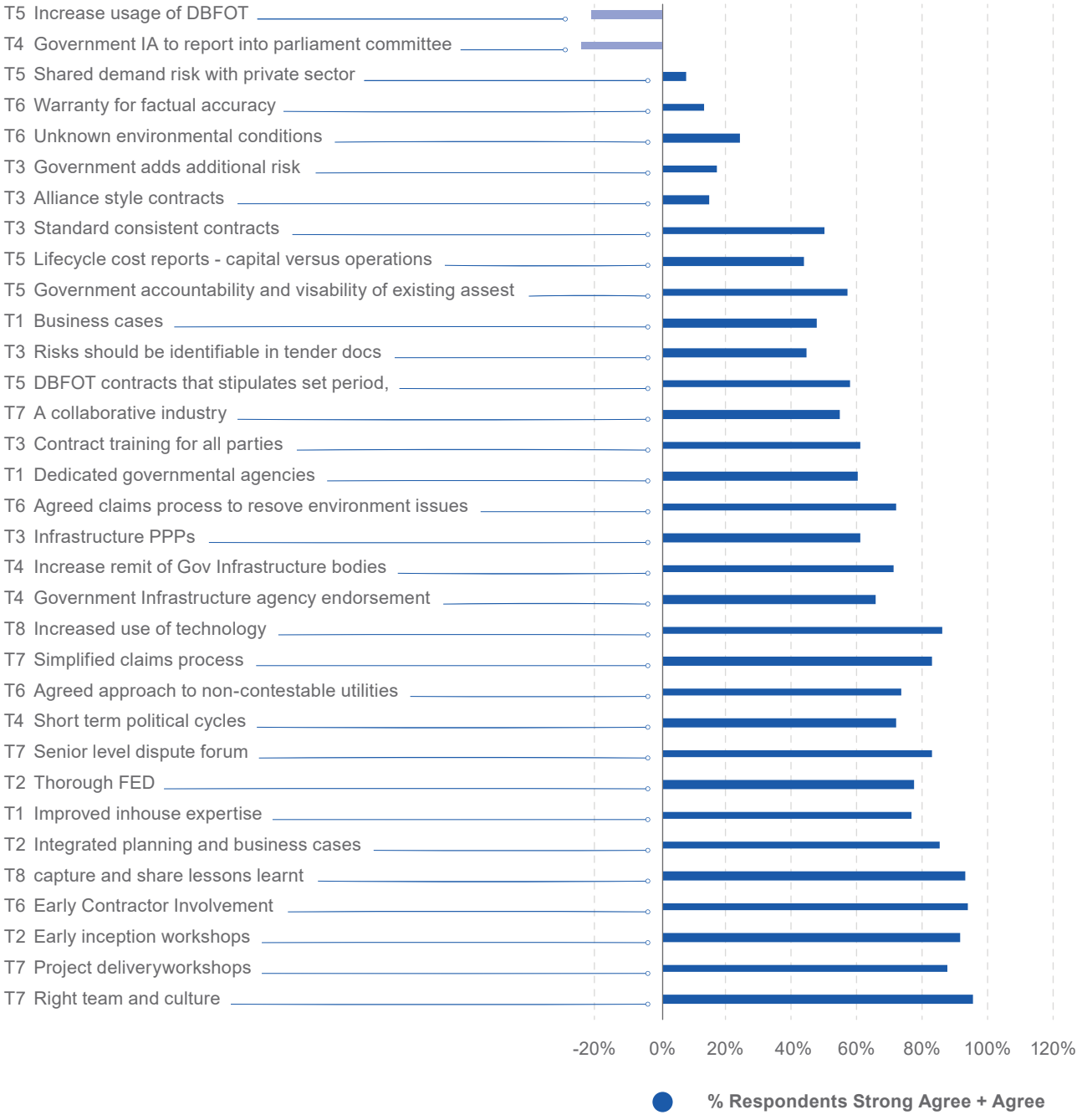
- As an academic body, UTS can provide independent input into industry forums drawing on engineering, project management, and business insights. UTS would be supportive in hosting joint industry and government sector industry conferences focussed on relevant topics.
- UTS would be happy to present more detailed research findings at specific department, company or industry-wide levels.
- For the three focus areas,UTS could institute a process of mapping out potential actions with key stakeholders, and review potential improvements.
- Arguably, the choice of contract creates a framework for addressing other themes, such as: to what extent does the choice of contract drive behaviours, and willingness to invest or take risks that might address issues other themes raise? Investigating this area could be a future research focus that encompasses partnering in contracts; ECI; implementation of standard contracts; use of technology in contracts; and post-opening evaluation compliance.

7. Research team profiles

Professor Steve Burdon AM, FAICD, FIEA, FIML	Academic research interests are Innovation, Disruptive Technology, Infrastructure and Government Policy. He has more than 50 journal articles, conference papers and book chapters published in these areas. He was recently appointed a member of the Order of Australia (AM) and has been an Advisor to a number of leading Australian organisations including Telstra, Westpac and Transfield. He has also worked on government policy as an advisor to the Minister of Communications in Australia and the UK. Steve has held over a dozen Chair and Director positions. He previously held a number of senior executive positions in the telecommunications sector including Managing Director, OTC, Group Managing Director of Telstra, and Managing Director of British Telecom Asia Pacific.
Distinguished Professor Stewart Clegg BSc (Hons); PhD; D. Litt; D. Phil.	Stewart Clegg is a leading international researcher recognised in a number of fields in the social sciences for his work in organisation studies and on power. His enormous impact on research and teaching as well as management practice is undisputable, as he is recognised, by a multi-method ranking, as one of the world's top-200 Management Gurus (and the only Australian) in What's the Big Idea? Creating and Capitalizing on the Best New Management Thinking by Thomas H. Davenport, Laurence Prusak, and H. James Wilson (2003), Harvard: Harvard Business Review Press. From the first edition of Power, Rule and Domination in 1975 to the latest editions of Managing and Organizations and Strategy: Theory & Practice (in 2019 & 2020 respectively), Stewart has continued to provide a critical eye on organisational practices.
John Clay BA Hons, MBA, GAICD, CPM, Fellow AMI	After 25 years in the professional services, telecommunications and IT industries, John moved into a portfolio career consisting of lecturing, board and advisory work. John has a comprehensive understanding of the key drivers within delivering major infrastructure gained through his experience as a regional board member for Arup Australasia, Global Marketing and Communications skills practice leader for Arup, and previously Regional M&C leader for URS. Prior to moving into the engineering sector John held senior roles in Telstra and BT.
James Smithers BEng, MBA	A results-oriented professional with extensive experience as a management consultant and project manager assisting organisations make the right infrastructure decisions and delivering business services to improve organisations. James is a Principal and NSW Advisory Lead for global engineering consultancy WSP who has a history of achievement and consistent record of success to develop and implement strategies, organisational changes and cost-effective solutions to enhance market competitiveness. James has excellent analytical and communication skills, with a proven ability to lead cross-functional teams and manage long-term client relationships. Strong stakeholder engagement skills to ensure changes are adopted and objectives achieved.
Dr Johan Ninan Phd.	Dr. Johan Ninan is currently a postdoctoral fellow at University College London (UCL). He has had hands-on experience in the planning and construction of multiple infrastructure megaprojects before delving into researching the project management complexities surrounding such projects in Australia, the UK, and India. His research interests are in the areas of stakeholder engagement, innovation, project organizing, and project governance, with a particular emphasis on the role of social media in stakeholder engagement and management.
Dr Andy West B.Comm, MBA, DBA, Fellow IML	Associate Professor Dr Andy West is currently the Director of the Centre For Entrepreneurship at UBSS, lecturer at New York University – Sydney Campus and sessional lecturer at UTS in Business Statistics. His research and consultancy interests are in consumer behaviour (Reckitt Benckiser), sport management (Athletics Australia and Athletics NSW), higher education (IHEA and HEPP-QN) and not-for-profit organisations including Amnesty International and Special Olympics. Dr West's has presented numerous conference papers and reports into the higher education industry and is currently involved in various benchmarking projects.

Appendix 1. Survey results

33 proposed actions ranked by mean score for support with % respondents in agreement



A1.2 Cross tabulation analysis

We further analysed themes and propositions to examine whether there are any significant differences between specific subgroups that received sufficient response numbers (over 30). This followed an analysis of data from the 180 respondents obtained using IBM SPSS software based on the following parameters:

- Each theme rank had a score allocated: Low (1), medium (2) and high (3). Mean score ranking, standard deviation and variance of means was undertaken for all respondents and where enough subgroups received at least 30 responses.
- Each of the 33 propositions was similarly allocated a score: Strongly disagree (1), somewhat disagree (2), neither agree or disagree (3), somewhat agree (4) strongly agree (5). Each proposition was assessed against mean score, standard deviation, variance of means, and net support, i.e. numbers of respondents who agreed or strongly agreed as a percentage of total respondents.
- Statistical analysis – ANOVA is the most appropriate. It establishes if there are significant differences between the means, then a Tukey Multiple Comparison establishes which means are different for monomials, as the variables are either nominal (Country, state, Industry Segment) or ordinal (years as 5 year category including 20+).

Responses per location

	Aus	NZ	Other	Total responses
Themes	121	30	1	152
Propositions	143	36	1	180

Responses per sector

	Consulting	Construction	Government	Business Advisory	Industry Association	Other	Total responses
Themes	52	22	45	10	6	17	152
Propositions	59	25	56	11	7	20	180

The highest-placed (theme2) and lowest-placed (theme 7) remained the same between Australia and New Zealand responses. However, strengthening government engagement and use of technology and data were marginally higher in NZ.

With both countries, the notable factor was:

- Theme 2: Integrated planning, robust business case and Front End engineering design ranked highest (Australia 2.89 mean and New Zealand 2.87), with the lowest variance between responses (0.37 and 0.35 respectively)
- Theme 7:Industry ecosystem ranked lowest (Australia 1.88 and New Zealand1.77). However, it had the highest variance between responses.

In relation to the 33 propositions, we can observe:

- Australia's highest-scored (means) propositions were:
  - early contractor involvement for assessing unknown environmental impacts
  - early project concept inception workshops
  - integrated planning and business cases.
- New Zealand had a higher score for improved in-house expertise within government (e.g. more in-house skilled technical experts).
- Both countries had similar lowest-ranked propositions, i.e.:
  - increase use of DBFOT
  - infrastructure delivery agencies to report to an independent parliamentary committee
  - increased demand risk to be shared with the private sector.

A1.2.1 Highest and lowest rated theme per sector.

The following table highlights the mean score for each sector, including scores with the highest and lowest values.

	T1	T2	T3	T4	T5	T6	T7	T8
Consulting	2.52	2.85	2.42	2.08	2.13	2.04	1.83	2.21
Construction	2.36	2.86	2.68	2.09	1.86	2.23	1.68	2.18
Government	2.07	2.93	2.31	2.09	2.13	2.02	1.84	1.96
Business Advisory	2.40	3.00	2.10	2.30	2.70	1.70	1.80	2.30
Industry association	2.67	3.00	2.83	2.33	2.17	1.67	2.00	2.50
Other	2.59	2.76	2.53	2.06	2.31	2.53	2.18	2.25

ANOVA of Themes by Country

For each of the eight themes, we conducted an ANOVA comparing difference of means between Australia and New Zealand. Theme 3: Efficient Choice of Contracts is the only significantly different theme, with an F Statistic 25.46>6.806 F Critical (a=0.01), which is significant at alpha < 0.01.

This indicates that the New Zealand mean is significantly less than the Australian mean for this theme

Anova:3. Efficient choice of contracts

Groups	Count	Sum	Average	Variance
AUS	141	405.3776	2.875018	0.122321
NZ	39	94.55204	2.424411	0.370016

All other ANOVA analysis by country shows no evidence of significant difference in means.

ANOVA of Themes by Industry

Theme 1 is significantly different at alpha = 0.05; Theme 5is significantly different at alpha = 0.10.

Theme 1: ‘Strengthen government and political engagement’ has an F Statistic 2.73>2.28 F Critical (a= 0.05) with P Value = 0.022. Further observation points to the two industry segments, – ‘Government Central Agency’ and Government Delivery Agency’– whose mean responses are both significantly lower than the other four industry segments. This suggests that government agencies do not see government and political engagement as potentially impacting projects’ success as much as the other industry segments. This is curious and requires further investigation.

There is a significant difference in means for Theme 5: ‘Increase emphasis on project assets life-time costs’ with an F Statistic 2.021>1.88 F Critical (alpha = 0.10)with an P Value = 0.079. Further observation shows the industry segment ‘Construction Organisation’ has a significantly lower mean than all other industry segments. It may be that Construction Organisations are less focussed on project life-time costs as an indicator of project success, but requires further research.

For all other themes there is not enough evidence to declare a difference of means between the industry segments

Anova: 1. Strengthen government and political engagement

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	14	34	2.428571	0.571429
Construction organisation	22	52	2.363636	0.4329
Engineering consulting	50	127	2.54	0.375918
Government central agency	12	24	2	0.545455
Government delivery agency	33	69	2.090909	0.710227
Other (please specify)	22	57	2.590909	0.443723

Anova: 5. Increase emphasis on project assets life-time costs

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	14	36	2.571429	0.571429
Construction organisation	22	41	1.863636	0.504329
Engineering consulting	50	106	2.12	0.515918
Government central agency	12	26	2.166667	0.151515
Government delivery agency	33	70	2.121212	0.547348
Other (please specify)	21	49	2.333333	0.533333

All other ANOVA analysis by sector shows no evidence of significant difference in means.

A1.2.2 Highest and lowest rated propositions per sector

The top three and bottom three (least) supported propositions per sector have been illustrated below.

	Top 3 ranked propositions			Least supported propositions		
	1	2	3	1	2	3
Consulting	Right team, right culture 4.81	Integrated planning 4.66	Inception workshops 4.61	Increase usage of 2.97	Gov IA's to report to committee 3.29	Demand risk shared with private sector 3.32
Construction	Agreed approach to non-contestable utilities 4.73	Early contractor involvement 4.65	Risks identified from tender docs 4.65	Gov IA's to report to committee 3..0	Increase usage of dbfot 2.97	Demand risk shared with private sector 3.04
Government	Right team, right culture 4.77	Capture & share lessons 4.61	Inception workshops 4.57	Increase usage of dbfot 2.88	Government adds addition risk 3.21	Gov IA's to report to com. 3.21

For illustration only due to lack of responses

	Top 3 ranked propositions			Least supported propositions		
	1	2	3	1	2	3
Business Advisory (11 responses)	Capture and share lessons learnt 4.64	Project initiation workshops 4.45	Project team inception workshops 4.45	Unknown environmental conditions 2.45	Gov IA's to report to committee 3.00	Warranty for factual accuracy 3.18
Industry association (7 resps)	Right team right culture 4.71	Improved in house expert 4.71	Short term pol cycles 4.71	Unknown environmental 3.0	Gov IA's to report to comm 3.29	Alliance style contracts 3.43

ANOVA of Potential Actions by Country

The data was tested to meet the assumptions of ANOVA (alpha = 0.05). We assumed the Likert scale is an interval data measurement scale. Of the 33 potential actions statements provided in the survey instrument, the following are the potential actions with significantly different means at an alpha of 0.05:

- For most projects, standard contracts are sufficient but need to be implemented consistently across agencies
- Increase the use of a Design-Build Finance Operate Transfer PPP model for major infrastructure projects
- Unknown environmental conditions and utilities are the greatest threat to project success
- Undertake early contractor work on complex brownfield sites to identify latent conditions and utilities, with derived information provided to all bidding parties
- Improved project delivery will be achieved by selecting experienced highly competent team members and instilling a collaborative culture between partners
- When delivering major infrastructure, lessons learned and best practices are not adequately captured and used across the sector.

3a) For most projects, standard contracts are sufficient but need to be implemented consistently across agencies, has a P Value of 0.0076 < 0.01 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	141	529	3.751773	1.116515
NZ	39	166	4.25641	0.879892

5b) Increase the usage of a Design Build Finance Operate Transfer PPP model for major infrastructure projects, has a P Value of 0.0029< 0.01 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	141	453	3.212766	0.968693
NZ	39	104	2.666667	1.122807

6a) Unknown environmental conditions and utilities are the greatest threat to project success, has a P Value of 0.0366< 0.05 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	141	512	3.631206	1.020162
NZ	39	127	3.25641	0.774629

6b) Undertake early contractor work on complex brownfield sites to identify latent conditions and utilities, with derived information provided to all bidding parties, has a P Value of 0.0107< 0.05 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	141	655	4.64539	0.273354
NZ	39	171	4.384615	0.453441

7a) Improved project delivery will be achieved by selecting experienced highly competent team members and instilling a collaborative culture between partners, has a P Value of 0.0393< 0.05 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	141	661	4.687943	0.273354
NZ	39	190	4.871795	0.11471

8b) When delivering major infrastructure, lessons learnt and best practices are not adequately captured and used across the sector, has a P Value of 0.0133< 0.05 Alpha, indicating a significant difference in means.

Groups	Count	Sum	Average	Variance
AUS	140	599	4.278571	0.490185
NZ	39	179	4.589744	0.406208

ANOVA of Potential Actions by Industry Segment

An ANOVA comparing difference of means for industry segments was conducted for each of the eight themes. We tested the data to meet the assumptions of ANOVA, that is, the sample group is normally distributed, each survey was completed independently and the equality of variance for each sample group. We assumed the Likert scale is an interval data measurement scale.

Due to the small sample size of Architectural Firm (n=4) and Finance Organisation (n = 4), these groups were combined with Business Advisory Firm (n =6) to create a group Architectural, Finance, Business Firms (n = 14). The rationale for combining these being they are all private firms. Industry Associations are also a small sample group (n = 5). This group was combined with Other (n=16).

Of the 33 potential actions statements provided in the survey instrument, the following are the potential actions that have significantly different means at an alpha of 0.05.

- Integrated planning, a robust business case and early community engagement will improve the validity of project benefit estimates
- Government agencies have a propensity to add additional risk to the contract at the preferred bidder stage
- All risks should be identifiable from the tender documents and no additional risks added at the preferred bidder stage
- Short-term political cycles result in poorly conceived projects that have not been adequately prepared or prioritized
- Increasing the remit and resources of Government Infrastructure bodies to improve coordination and timing in bringing megaprojects to market, will lead to increased project success
- Increase the usage of a Design Build Finance Operate Transfer PPP model for major infrastructure projects
- Governments should produce a lifecycle cost report, including capital versus operations data for each of their major assets on an annual basis
- Unknown environmental conditions and utilities are the greatest threat to project success
- Implement an agreed approach across agencies and contractors for addressing non-contestable utility works
- All major projects should contain a senior level dispute avoidance forum to identify potential areas of dispute before they arise

2a) Integrated planning, a robust business case and early community engagement will improve the validity of project benefit estimates has a P value of 0.01839 < alpha 0.05 indicating significantly different means. Constructions Organisations have a significantly lower mean of 4.19, while Other category have a significantly higher mean of 4.77 than the other industry segments.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	71	4.4375	0.395833
Construction organisation	26	109	4.192308	0.641538
Engineering consulting	56	260	4.642857	0.415584
Government central agency	14	60	4.285714	1.296703
Government delivery agency	42	195	4.642857	0.381533
Other (please specify)	26	124	4.769231	0.184615

3e) Government agencies have a propensity to add additional risk to the contract at the preferred bidder stage has a P Value of 0.000384< alpha 0.01indicating significantly different means. Government Central Agency (mean 3.12) and Government Delivery Agency (mean 3.24) have significant lower means than the other industry segments, not surprisingly reporting that the government agencies do not add risk at the preferred bidder stage. Construction Organisations on the hand, do believe government agencies add risk with a significantly higher mean of 4.23than the other industry segments.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	59	3.6875	1.295833
Construction organisation	26	110	4.230769	1.144615
Engineering consulting	56	217	3.875	0.911364
Government central agency	14	44	3.142857	1.516484
Government delivery agency	42	136	3.238095	0.771196
Other (please specify)	26	94	3.615385	0.486154

3f) All risks should be identifiable from the tender documents and no additional risks added at the preferred bidder stage has a P Value of 0.004852 < alpha 0.01 indicating significantly different means. This is a similar result to statement 3e) with Government Delivery Agency resulting in a significant lower mean of 3.55 and the Construction Organisations believing all risks should be identifiable with a significantly higher mean of 4.65 than the other industry segments.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	64	4	1.466667
Construction organisation	26	121	4.653846	0.315385
Engineering consulting	56	232	4.142857	1.215584
Government central agency	14	54	3.857143	1.516484
Government delivery agency	42	149	3.547619	1.668409
Other (please specify)	26	100	3.846154	1.255385

4a) Short-term political cycles result in poorly conceived projects that have not been adequately prepared or prioritized has a P Value of 0.025 < Alpha 0.05indicating significantly different means. Government Central Agencies have a significantly higher mean than the other industry segments of 4.85. However, all categories did mean of 4 or over agreeing with the statement.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	64	4	1.866667
Construction organisation	26	108	4.153846	0.855385
Engineering consulting	56	248	4.428571	0.685714
Government central agency	14	68	4.857143	0.131868
Government delivery agency	42	170	4.047619	1.31475
Other (please specify)	26	119	4.576923	0.573846

4b) Increasing the remit and resources of Government Infrastructure bodies to improve coordination and timing in bringing megaprojects to market, will lead to increased project success has a P Value of 0.0017 < Alpha 0.01 indicating significantly different means. Architectural, Business and Finance Firms have a significantly lower mean of 3.625, while Government Central Agencies have a significantly higher mean than the other industry segments of 4.64.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	58	3.625	1.183333
Construction organisation	26	102	3.923077	0.953846
Engineering consulting	56	242	4.321429	0.367532
Government central agency	14	65	4.642857	0.401099
Government delivery agency	42	185	4.404762	0.734611
Other (please specify)	26	108	4.153846	0.455385

5b) Increase the usage of a Design Build Finance Operate Transfer PPP model for major infrastructure projects has a P Value of 0.0227 < Alpha 0.05 indicating significantly different means. All industry segments have a relatively low mean range of 2,86 to 3.65. Both government industry segments have a significant lower mean than the other industry segments, with means of Government Central Agencies 2.86 and Government Delivery Agencies 2.88.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	55	3.4375	1.0625
Construction organisation	26	78	3	1.44
Engineering consulting	56	168	3	0.981818
Government central agency	14	40	2.857143	1.054945
Government delivery agency	42	121	2.880952	0.79036
Other (please specify)	26	95	3.653846	0.875385

5e) Governments should produce a lifecycle cost report, including capital versus operations data for each of their major assets on an annual basis, has a P Value of 0.0431< Alpha 0.05 indicating significantly different means. Both Construction Organisations (mean = 3.54) and Government Central Agency (mean = 3.57) have significantly lower means than the other industry segments.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	67	4.1875	1.229167
Construction organisation	26	92	3.538462	0.578462
Engineering consulting	56	225	4.017857	0.599675
Government central agency	14	50	3.571429	1.648352
Government delivery agency	42	169	4.02381	0.804297
Other (please specify)	26	108	4.153846	0.455385

6a) Unknown environmental conditions and utilities are the greatest threat to project success, has a P Value of 0.0011< Alpha 0.01 indicating significantly different means. This potential action is where Architectural, Business and Finance Firms means vary the greatest from the Construction Organisations. Architectural, Business and Finance Firms have a significantly lower mean of 2.88 than the other industry segments, while Construction Organisations have a significantly higher mean of 4.12 than the other industry segments.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	46	2.875	1.183333
Construction organisation	26	107	4.115385	0.586154
Engineering consulting	56	203	3.625	0.784091
Government central agency	14	52	3.714286	0.989011
Government delivery agency	42	138	3.285714	1.135889
Other (please specify)	26	93	3.576923	0.893846

6c) Implement an agreed approach across agencies and contractors for addressing non-contestable utility works has a P Value of 0.0065< Alpha 0.01 indicating significantly different means. The Construction Organisations once again have a significantly higher mean than the other industry segments of 4.73.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	63	3.9375	0.729167
Construction organisation	26	123	4.730769	0.284615
Engineering consulting	56	244	4.357143	0.488312
Government central agency	14	62	4.428571	0.417582
Government delivery agency	42	178	4.238095	0.478513
Other (please specify)	26	107	4.115385	0.666154

6d) Government should provide a warranty of the factual accuracy of data on in ground conditions and utilities has the lowest P Value of 2.63 x 10-9< Alpha 0.01, which is the lowest P Value, indicating the most significant difference in means. Of great interest is the Government Delivery Agencies have a significant lowest mean than the other industry segments of 2.64, with Construction Organisations having a significantly higher mean than the other industry segments of 4.62.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	54	3.375	1.583333
Construction organisation	26	120	4.615385	0.886154
Engineering consulting	56	212	3.785714	1.18961
Government central agency	14	48	3.428571	1.802198
Government delivery agency	42	111	2.642857	1.357143
Other (please specify)	26	85	3.269231	1.084615

6e) Project disputes will be improved by developing an agreed claims process to manage variations resulting from unknown environmental risks has a P Value of 0.0131 < Alpha 0.05. Construction Organisations has a significantly higher mean than the other industry segments of 4.58.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	62	3.875	0.65
Construction organisation	26	119	4.576923	0.413846
Engineering consulting	56	241	4.303571	0.469805
Government central agency	14	61	4.357143	0.401099
Government delivery agency	42	165	3.928571	1.141115
Other (please specify)	26	109	4.192308	0.481538

7e) All major projects should contain a senior level dispute avoidance forum to identify potential areas of dispute before they arise has a P Value of 0.0390 < Alpha 0.05, indicating significant difference in means between the industry segments. Government Delivery Agencies have a significantly lower mean than the other industry segments of 4.09. However, all industry segments have a mean in the strong to very strong response.

Groups	Count	Sum	Average	Variance
Architectural, Business, Finance Firm	16	72	4.5	0.4
Construction organisation	26	118	4.538462	0.498462
Engineering consulting	56	253	4.517857	0.399675
Government central agency	14	63	4.5	0.730769
Government delivery agency	42	172	4.095238	0.771196
Other (please specify)	26	109	4.192308	0.481538

Appendix 2 Participating organisations

Consulting	AECOM Arup Atkins Beca	BVN Sense Strategy Tonkin and Taylor Turner and Townsend
Construction	Acciona John Holland Laing O'Rourke Lend Lease Indra	CIMIC CPB Contractors Fulton Hogan Roberts Pizzarotti
Government	Australia Rail Track corporation ACT Government Infrastructure NSW Salisbury Council Barossa Council Department for the Environment Department of Economic Development Department of Premier and Cabinet Department of Transport and main Roads Logan Water Moorebank Intermodal South East Water Tasmania Water Transport for NSW Unity Water	Level Crossings Removal Authority NZ Infrastructure Commission NZ Transport Authority Office of Projects Victoria Hunter and Central Coast Development Authority Public Transport Victoria Queensland rail Gold Coast Council Yarra Trams
Business advisory / Financial / Other	KPMG Macquarie bank Charter hall GPT	Pendal Group Plenary Group Transurban Faraday Associates Yancoal
Industry associations / education	Building Industry Federation NZ Consult Australia NZ Infrastructure Roads Australia Infrastructure Queensland	Engineers Australia Infrastructure Partnerships Australia Institute of Public Works Engineering (NZ) University of NSW

Appendix 3 Respondents' job titles

Acting Alliance Manager

Assistant Director

BD Director

Board member

Business Development Manager

CEO

Chief Operations

Commercial Manager

Consultant- major projects

Contract Engineer

Coordinator Business Strategy

Delivery Director

Deputy General Counsel

Deputy Head of Legal

Design Manager

Director - Environmental Planning

Director / CEO telecommunications

Director Engineering

Director- Major Projects

Director of Transport

Director Program Management

Director Project Support

Director Technical Services

Director Water

Director, Strategy

Director, Transformation

Director, Works and Engineering

EGM Major Project Support

Engineering Leader

Executive Coordinator Strategic Asset and Data Management

Executive Director (Program Management and Delivery)

Executive Director Urban Mobility

Gateway Review team leader and member

General Counsel

General Manager - Operations

General Manager Customer Service

GM Asset Delivery

GM Project Finance and investment

Group Manager Strategy

Group Operations

Head of Business Development

Head of Commercial and Major Project Governance

Head of Development

Head of Investment

Head of Origination

Head of Projects

Head of Transport Planning and Advisory

Integration Director

Interface Manager

Investment Analyst

Lead Advisor Structures

Legal consultant

Legal Counsel

Major projects Director

Manager Corridor Works

Manager Engineering Support

Manager Infrastructure

Manager Maintenance

Manager Service Sustainability

Managing Director

Manger Risk Services

Market lead

Mechanical Engineering Superintendent

National building Services design and delivery project manager

Partner

Planning Leader

Policy Director

Principal Advisor, Network Planning

Principal Engineer

Principal Project Director

Principal Road Development Engineer

Program Director

Program Director Major Projects

Project Delivery Manager

Project Development Director

Project Manager

Project Manager, Expansion Projects

Regional Leader - Operations

Regional Managing Director

Regional Transport Planning

Risk Manager

Section Executive

Senior Delivery Director

Senior Engineer

Senior Manager Gov and Assurance

Senior Policy Officer

Senior Portfolio Manager

Senior Project Manager

Senior Service Manager

Senior Specialist Road and Civil

Team Leader Planning

Technical Director

Technical Director - Civil Infrastructure, Transportation

Technical director - Transport

Technical Director-sustainability

Technical Executive

Technical Principal

Technical Principal - Project Delivery

Technical Principal, Transportation Engineering

Transport Planner

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