Introduction
Innovation in the delivery and operation of infrastructure projects has been identified as one of the ways to alleviate the constraints of rising construction costs, shortages in industry resource and project delivery expertise. The concept of innovation diffusion can be broken down further into how new products are adopted into construction organisations and projects.

In 2010, Queensland University of Technology, Queensland Transport and Main Roads, the Construction Industry Institute Australia, and the University of New South Wales commenced a research project co-funded by the Australian Research Council (ARC) to investigate barriers to the adoption of new products in road and bridge projects. The Innovative Products research project aims to facilitate project innovation by exploring means to improve the diffusion of innovative products in road and bridge projects across Australia.

This article presents phase two of the project which is the industry survey phase of a three phase project. Phase one, the investigative phase, was reported earlier this year (1) with the final phase three being a focus group study, in 2012.

Conceptual framework
The development of a conceptual framework was required to guide the survey analysis and interpret its findings. This framework, shown in Figure 1, outlines the relationships that influence product innovation in a construction project-based context, focusing on the impact of two key organisational capacities – ‘learning capacity’ and ‘relationship capacity’ – on product innovation outcomes. These causal variables were expected to impact innovation outcomes.

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The term ‘learning capacity’ refers to the fundamental learning process of a firm and its ability to acquire, assimilate, transform and exploit knowledge from its environment. Learning capacity is thought to increase the ‘speed, frequency and magnitude’ of innovation, producing knowledge that further increases an organisation’s learning capacity. The conceptual framework shows the four phases of learning capacity are: acquisition, assimilation, transformation and exploitation. Each phase can be aggregated to examine both potential (acquisition and assimilation) and realised learning capacity (transformation and exploitation) (4). Empirically tested items were applied to measure learning capacity. Test comparisons demonstrated successful replication of results compared to previous studies.

Relationship capacity was the other innovation capacity examined in the survey. This causal variable measures an organisation’s experience with relationship contracts and hence its capacity to positively contribute to a collaborative inter-organisational relationship.

Efficient inter-organisational relationships are argued to have a significant positive impact on the uptake of innovation in construction projects. An organisation’s relationship capacity is indicated by its experience in relationship-based contracts. Thus, the research design assumed that organisations with experience in relationship-based contracts would have a higher capacity than organisations without such experience to positively contribute to a collaborative project relationship and thus improved innovation outcomes.

The conceptual framework also highlights three innovation outcomes that were explored in the survey: innovation activity, innovation difficulty and innovation obstacles. The relationships between innovation capacities and innovation outcomes were examined in detail; however, the study was not set up to examine the relationships between different innovation capacities or between different innovation outcomes.

Findings
This report presents the results of the 2011 Australian road and bridge product innovation survey, believed to be the largest survey of its kind ever undertaken in Australia. The research employed the OECD’s definition of an ‘innovative product’ as a ‘new product that differs significantly compared with previous products in the industry, in its intended use, performance characteristics, attributes, design properties or use of materials and components’.

The survey sample was defined as key organisations involved in the Australian road and bridge construction industry. The survey focused on four sectors across the road and bridge product supply chain:

- Suppliers - comprising manufacturers and distributors
- Consultants - primarily engineering consultant firms
- Contractors - comprising head and trade contractors and subcontractors
- Clients - state government road agencies.

The term ‘learning capacity’ in this report is known by the term ‘absorptive capacity’ in the literature and refers to an organisation’s external learning capacity. We have changed the name to make it more accessible to a general audience.
The survey only covered Queensland, New South Wales and Victoria as resources did not permit covering the remaining Australian states and territories. Of the 865 questionnaires distributed to industry, 212 responses were received providing a response rate of approximately 25%.

The survey collected information about respondents' perceptions in relation to two key innovation areas of outcomes and capacities:

- Innovation outcomes were measured through three variables relating to product innovation - activity, difficulty and obstacles

- Innovation capacities were measured through two variables - learning capacity and relationship capacity. Both these innovation capacities have been shown to support the innovation efforts of organisations (9,10).

Cross-tabulations were undertaken to identify the extent and nature of relationships between innovation outcomes and innovation capacities.

Survey results have been split into two sections. The first section is the raw survey statistics and the second part represents the analysis of those statistical results.

**Survey statistics**

The main results for the industry as a whole and for the four sectors are presented. These results relate to new products and cover the areas of - innovation activity, innovation difficulty, innovation obstacles and innovation capacity.

**Innovation activity** - on average two-thirds of survey respondents have introduced or facilitated the introduction of new products over the last three years (2009-2011). The sector results did not deviate much from this overall average: 73% of the supplier respondents, 63% of the consultant respondents, 62% of the contractor respondents and 71% of the client respondents introduced, or facilitated the introduction of, new products over the last three years. Suppliers had the highest rate of innovation and contractors had the lowest. Given the roles played by the different sectors, this result was expected.

As innovation is a group effort in a construction team environment, the survey question about innovation activity combined those who had directly introduced a new product and those who had facilitated a new product introduction. The latest Australian Bureau of Statistics data shows a construction product innovation rate of only 13.5% (11). Our result shows a higher rate of innovation because it includes innovation facilitators. The extent to which our innovation rate exceeds the ABS rate is a reflection of the extent to which innovation in the construction industry is a team effort. However the two rates are strictly not directly comparable due to slightly different time periods and industry definitions.

**Innovation difficulty** - Overall, 77% of survey respondents found the introduction of new products 'somewhat hard', 'hard' or 'very hard'. The result for each sector showed very little variation in perception of difficulty: suppliers 78%, consultants 72%, contractors 79% and clients 79%. These figures suggest it is generally challenging to introduce new products to projects despite high levels of product innovation activity, supporting the need for ongoing process improvement to ease the adoption of new products, including addressing obstacles to product uptake. Product innovation 'difficulty' indicates inefficiency in current processes, providing the opportunity for productivity gains.

**Innovation obstacles** - The survey explored 22 key product innovation obstacles, identified in the pilot study, by asking respondents to rate the importance of each obstacle. The objective was to rank the obstacles and identify the most important to be addressed by the industry to improve product adoption rates. The five most important obstacles common to all four groups were:

- Restrictive tender assessments which focused on price-only criteria, resulting in less flexibility for the contractor and consultant to experiment with new products

- There is disagreement between industry participants over who carries the risk of new product failure. This arises from risk aversion of both the client road agency and the party proposing the new product and concern over liability should the product fail
As adversarial contracts do not support relationships they have been found to inhibit the adoption of new products and negatively impact on how new products are assessed and approved.

Time pressures inhibit a contractor's ability to consider new product ideas from the consultants, subcontractors and suppliers, predominantly during the tender submission stage. This leads to conservative product selection, particularly when risks are not easily quantifiable.

Client road agency time pressures inhibit their ability to effectively assess and approve new products for use, resulting in a more risk-averse stance. Another inhibitor is when product performance cannot be easily quantified within the time constraints.

The most important innovation obstacles identified by each of the four sectors were as follows:

- Suppliers were most concerned about restrictive price-only tender assessment. Although suppliers are not directly involved in the project tender process, this result implies that they have close relationships with contractors and understand the extent to which their new product placement is disadvantaged by price-only contracting.

- Consultants were most concerned about clients preferring new product ideas that save direct project cost over ideas that offer greater savings over the life of the asset. This emphasis on short-term gain can reduce long-run efficiency.

- Contractors were most concerned about price-only tender assessment and selection. As expected, addressing this obstacle is of the highest importance to contractors in comparison with other sectors because of the contractor's key role in the tender process. This obstacle can cause the contractor to pursue a defensive self-interest position, potentially leading to adversarial relationships.

- Client road agencies were most concerned about the difficulty in getting suppliers to conduct sufficient testing prior to presenting a new product for consideration. The submission of poorly tested product ideas ties up client resources, leaving less time for the consideration of robust ideas.

Innovative capacities - The survey investigated the organisation's capacity for innovation by reviewing two key drivers of this capacity: learning capacity (2,3) and relationship capacity (6,7).

Learning capacity refers to the external learning process of an organisation in its ability to acquire, assimilate, transform and exploit knowledge from its environment. The survey analysis classified 18% of organisations in the industry as having low learning capacity, 65% as having medium learning capacity and 17% as having high learning capacity. The data showed that nearly one in five construction organisations had low learning capacity and thus poor learning processes. Contractors did slightly better than this (16% low), while suppliers did a lot better (11% low), and clients (22% low) and consultants (26% low) did worse. Suppliers were the most effective adopters of ideas from outside the organisation and consultants were the least effective.

Relationship capacity is important because effective, collaborative inter-organisational relationships have a significant positive impact on innovation in construction projects. As an indicator of an organisation's capacity to positively contribute to a collaborative relationship, the survey asked respondents to indicate how experienced they were across two types of relationship contracts- alliance contracts and early contractor involvement (ECI) type contracts.

More than half the respondents (57%) had experience with at least one relationship contract. Client respondents had the most experience with relationship contracts (78%), followed by contractors (60%) and suppliers (54%), while the consultant respondents had the least experience (40%).

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Analytical results
The two innovation capacity variables (learning capacity and relationship capacity) were correlated with the three innovation outcome variables (innovation activity, innovation difficulty and innovation obstacles).

Innovation activity - A positive correlation with the two types of innovation capacities was expected by other researchers (9):

- Learning capacity had no significant relationship to innovation activity. An organisation was not significantly more likely to be innovative if it had strong learning capacities. This unusual finding can be explained by the way in which the survey measured innovation activity. An organisation was counted as an ‘innovator’ if it merely facilitated the introduction of innovation. This was because we wanted to capture the team-based nature of innovation on construction projects. Comparison with the ABS construction innovation rate indicated that our ‘innovation activity’ measure was dominated by ‘facilitators’. Thus, the result suggests that innovation facilitators need much lower learning capacity than innovation initiators to be successful. This makes sense given the leading role that initiators play.

- Relationship capacity. It was not possible to design a test of statistical significance for the relationship capacity variables; however, a strong positive trend was observed. Respondents with high relationship capacity were more likely to be innovative. This is to be expected, as innovation facilitators are likely to be active on relationship contracts. Thus, the countervailing impact of facilitators was less pronounced, and the expected strong correlation between relationship capacity and innovation was confirmed.

Innovation difficulty - A negative correlation with each of the two types of innovation capacities was expected. This relationship was supported in relation to relationship capacity. A strong negative relationship was found between innovation difficulty and relationship capacity. An organisation with a high level of relationship contracting experience was significantly more likely than an organisation with lower levels of experience to have low innovation difficulty. This is firm evidence that relationship contracts make innovation on road projects easier. On the other hand, the correlation of innovation difficulty with learning capacity yielded no relationship. Again, the inclusion of innovation facilitators among the innovators that completed this question cancelled out the expected relationship. The different results suggest that relationship capacity may be more important to innovation success than learning capacity.

Innovation obstacles - It was expected that organisations with greater innovation capacities would rank the resolution of innovation obstacles as more important. Highly innovative organisations were expected to encounter the obstacles more frequently and be more inconvenienced by them, compared with less innovative organisations. Highly innovative organisations would think it was more important that such obstacles were addressed. The strongest results obtained in this study supported this relationship. Organisations with higher learning capacity were significantly more likely than organisations with lower learning capacity to rank the resolution of obstacles as very important. Organisations with greater relationship contract experience were also significantly more likely than organisations with less relationship contracting experience to rank the resolution of obstacles as very important. This suggests that the obstacles identified in the study are central to unlocking the industry’s innovation capacity.

The potentially different needs of innovation initiators versus innovation facilitators were not relevant to this correlation, so did not weaken the results.
Conclusion
The survey results provide valuable evidence of, firstly, the link between relationship contracts and innovation and, secondly, the type of obstacles to product innovation on road and bridge construction projects. They provide a strong base for future research to be carried out in 2012 to further define the critical relationships and actions required to promote product innovation on projects. This work will involve the development of action plans to address highly ranked product adoption obstacles identified in this survey. These obstacles are clearly of concern to stakeholders involved in new product adoption on Australian road and bridge projects.

Recommendations to improve innovation performance will be made in the next project report, following the national workshops scheduled for 2012, which are aimed at building consensus between sectors on the ideal path forward. These workshops will focus on the two key obstacles identified by this study:

* Too much focus on direct project costs during tender and idea assessment
* Disagreement over who carries the risk of new product failure. This includes issues of insufficient testing, trialling and/or lack of warranty.

References
6. Dubois A, Gadde L. The construction industry as a loosely coupled system: Implications for productivity and innovation, Construction Management and Economics. 2002
8. Frascati manual - the measurement of scientific and technological activities: Standard practice for surveys of research and experimental development, OECD. 1993
10. Manley K. The innovation competence of repeat public sector clients in the Australian construction industry, Construction Management & Economics. 2006
11. Summary of IT use and innovation in Australian business 2009-10, ABS. 2011