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ICT IN THE AUSTRALIAN CONSTRUCTION INDUSTRY: STATUS, TRAINING AND PERSPECTIVES

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ABSTRACT

This paper outlines the results of a survey conducted as a part of the CRC Construction Innovation research project '2001-008-C Project Team Integration: Communication, Coordination and Decision Support'. The survey conducted through this research aimed at investigating the Australian construction industry's current performance in ICT related issues including the current status of ICT, training trends associated with ICT and the perceptions surrounding enablers/drivers and barriers/limitations to the introduction and use of ICT. The survey was implemented on a national (Australia) basis within the construction industry and targeted the non-building, building (commercial/industrial), and residential sub-sectors. The most significant observations from the survey results were:

- *'Annual turnover' has an effect on the uptake of ICT and training performance in ICT for an organisation.*
- *Interoperability issues (incompatibility of ICT systems) and not having an ICT professional on site (or within ready access) were found to be strong influential barriers to the uptake of ICT on projects.*
- *The overriding driver for ICT uptake for respondents was to improve operational performance through improved productivity - at both personal and organisational / team levels.*

Keywords: construction, ICT, information and communication technology, training

1. INTRODUCTION

This paper outlines the results of a survey conducted in November 2003 aimed at investigating the Australian construction industry's current performance in ICT related issues. The survey targeted three broad areas:
- Current ICT status including annual ICT investment, access to and use of ICT devices according to annual turnover;
- ICT training including training participation by individuals, training support within respondent organisations with regards to workload and time flexibility for employees, preferred mode of training for individuals, and level of ICT competence expectations of the various construction project participants of their colleagues; and
- ICT trends and opinions on the Benefits/Drivers and Barrier/limitation to the implementation and use of ICT on construction projects.

The survey was implemented on a National (Australia) basis within the construction industry - including non-building, building (commercial/industrial), and residential sub-sectors - with a view to informing the decision makers within the construction industry on ICT policy relating to:
- The types of ICT being used across the construction industry sub sectors and for various project sizes to enable them to identify possible improvements through ICT uptake;
- The preferred mode of training amongst construction industry employees allowing them to implement suitable ICT training regimes for employees; and
- The Benefits/Drivers and Barrier/limitation to the uptake of ICT on construction projects to enable them to identify suitable ICT implementation strategies within their organisations.

2. SURVEY METHODOLOGY

The survey reported here was carried out using web based survey methodology. An email was sent to potential respondents with a web link embedded enabling respondents to hotlink to the survey web server. Respondents were asked to complete each of the four sections and submit the responses - which were stored in the web server. After the nominated survey closing date, the responses were forwarded for analysis by the project team. Further details on the methodology including the survey development, pilot study, response rates, and general principles are outlined in Kajewski, et. al. (2004).

2.1 SURVEY RESPONDENT PROFILE

Respondents where asked to answer specific questions to enable detailed comparative analysis of the responses. In terms of a general profile, the analysis revealed that:
- 92% of respondents were from the East Coast of Australia;
- 78% of respondents have some form of Tertiary Qualification;
- 71% of respondents were in some form of managerial role within their organisation;
- All respondents had greater than 1 year and 54% had at least 10 years service in their present position;

- 63% of respondents were from a contracting organisation and 29% were from a consultant/specialist organisation with the remaining 12% being spread between Supplier and Client organisations;
- The majority (74% of those who knew the organisation's annual turnover) of respondents organisations had annual turnover's of less than $5M and 10% of respondents organisations had annual turnover's of $100M+ or greater; and
- At least 80% of respondents were from the Vertical/Building construction sub-sector.

3. CURRENT ICT STATUS

This section investigates the respondents, and respondent's organisations where appropriate, current ICT status including:

- ICT organisational investment: including further analysis of ICT investment according to sub-sector and annual turnover; and
- ICT device access and use: including use and access for various devices, access and use of emerging/innovative technologies by annual turnover.

3.1 ORGANISATIONAL INVESTMENT

Respondents were asked to specify how much their company currently invests in ICT annually. The amount spent varied considerably from $500 to $1,000,000 with the most frequent amount specified being $2000. The factors expected to be influential on ICT investment included annual turnover and the industry sector. Figure 1 displays the distribution of the respondents' organisations annual ICT investment commitment by turnover category. The categories were arbitrarily set at greater than $10M, between $10M and $1M and less than $1M. A further category (Don't Know) is provided to cover respondents that did not know their organisations annual turnover.
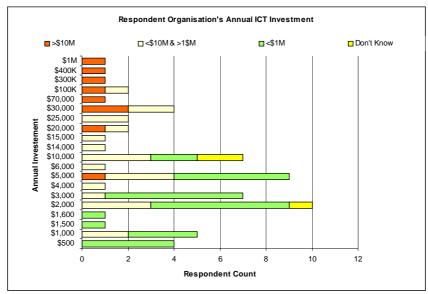

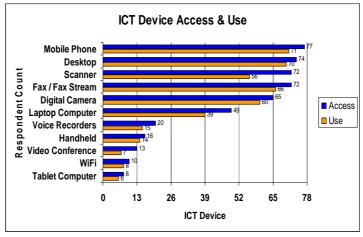**Figure 1 Distribution of ICT Investment Amount by Annual Turnover**

To test whether a relationship existed between the annual investment in ICT and annual turnover ranges, a correlation test was performed. The annual turnover responses were coded from 1 to 9 with 1 being the lowest turnover category and 9
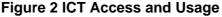
being the highest. The correlation statistic used for this test was the Spearman's Rho. The analysis between annual turnover (coded) and ICT investment indicated a positive relationship exists (Spearman's rho 0.51, Correlation is significant at the 0.01 level). It is worth remembering that a proportionally higher number of respondents from the non-building sector were also represented in the higher turnover ranges, which could be confounding the results.

3.2 ICT DEVICE ACCESS AND USE

Respondents were asked to identify which ICT devices, from a specified range, they have access to within their company and subsequent to this, which of these devices they used on a range of project sizes. Details of project size the respondent participates in was not readily obtained, thus the data were pooled and analysed for any project size. Responses for both of these questions are illustrated in

Figure 2.

Figure 2 ICT Access and Usage

The list provides a range of ICT technologies. Some ICT technologies such as Desktop computer, Mobile phone, Scanner, Fax and Digital camera are established technologies and according to the responses are accessible by most respondents. Based on the responses, these technologies are widely used on construction projects. When considering emerging technologies such as Wi-Fi, Handheld and Tablet computers, and Video Conference equipment, the analysis revealed that the amount of annual ICT investment of the companies apparently impacts on accessibility. Organisations with higher investment budgets have a higher proportion of these emerging technologies. This is illustrated in Figure 3 which displays the distribution of access to handheld computers according to the ICT investment category. This chart shows that 83% of the respondents with an annual ICT investment budget greater than $50,000 have access to handheld computers

compared with only 4% of those with an ICT budget of less than $10,000. A similar pattern emerges when analysing technology usage for other emerging technologies.
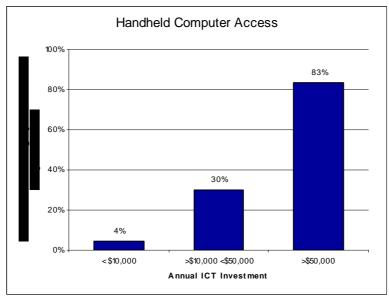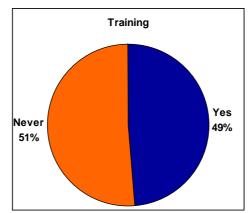

Figure 3 Distribution of Handheld Computer Access
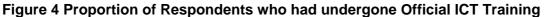
4. ICT TRAINING

This section investigates the ICT training characteristics of the respondents and respondent's organisations including:

- Official ICT training participation – including overall participation, participation considering annual turnover, and participation variability in the sub-sector groups;
- ICT training company support – including whether the respondents were allowed time or workload flexibility to undergo ICT training, sub-sector analysis was also completed;
- ICT training mode preference – including analysis dependent on annual turnover ranges;
- ICT competence expectations – including respondent's expectations dependent on sub-sector group.

4.1 OFFICIAL ICT TRAINING PARTICIPATION

Respondents were asked to indicate whether they had undergone any official ICT training. Almost half (49%, Figure 4) of the respondents indicated they had undergone official training. When comparing responses by the company classification, sub-contractors were more likely to have never undergone official training. Larger ($100M+ turnover) organisations had a higher proportion of respondents indicating they had undergone official training, as did respondents who indicated their core sector was non-building construction (both 5 out of 7). While worthy of note, these were not statistically significant findings.

Figure 4 Proportion of Respondents who had undergone Official ICT Training

4.2   ICT TRAINING AND COMPANY SUPPORT

Respondents were asked to indicate whether their company allowed them sufficient time during office hours to undergo ICT training with over half indicating that such time was made available (Figure 5). Although respondents from the residential construction sector were less likely to be provided adequate time for training (13 out of 21), this was not a statistically significant finding. Respondents were also asked whether their company adjusted/reduced their workload to undergo ICT training – with only 10 respondents indicating that such an adjustment had been made. Interestingly, six of those were from companies with a turnover range between $1M - $5M.

Figure 5 Organisational Training Support

Overall, only two had undergone official ICT training and had been allowed sufficient time and had their workload adjusted to undergo training. Conversely, 18 respondents indicated they had not undergone any official ICT training or received any adjusted workload or time. The residential building sector was heavily represented in this group. Based on the responses, 59 respondents indicated they either, have had either official training or have had their workload reduced, or been allowed sufficient time during work hours to undergo training, implying at least 76% have undergone some kind of training.

4.3   ICT TRAINING MODE PREFERENCE

The respondents were asked to nominate their preferred mode of training from a selected list. As is evident in Figure 6, the preferred training mode was with professional consultants, with 46% of respondents nominating this method.
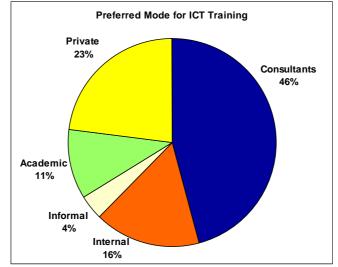
Preferred Mode for ICT Training

Figure 6 Preferred Mode of Training

The respondents who had undergone official ICT training and had been allowed sufficient time and had their workload adjusted to undergo training, both indicated a preference for training with professional consultants. This preference was supported by the 18 respondents who indicated they had not undergone any official ICT training or received any adjusted workload or time to undergo ICT training.

Figure 7 shows the response trend for preferred mode of training dependent on the respondent's turnover classification. The chart shows an increasing preference for professional consultants as the annual turnover category increased. 86% of respondents from the higher turnover categories indicated a preference for training mode with professional consultants compared with the lower turnover categories, where 52% indicated a preference for private training.
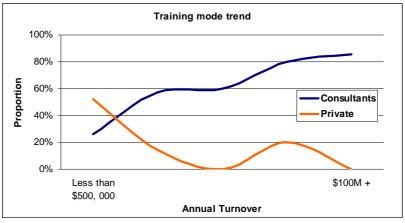
Figure 7 Training Mode Preference Trend

4.4 ICT COMPETENCE EXPECTATIONS

Respondents were asked to indicate what overall level of ICT competence (capabilities, skills, etc) they believed specific team members should have on a project. Overall respondents expect the consultant to have a greater level of ICT competency than all other team members. This result was statistically significant. Contractors and Suppliers were rated next with Clients and Sub-contractors rated lowest however, still expected to have at least average competence.
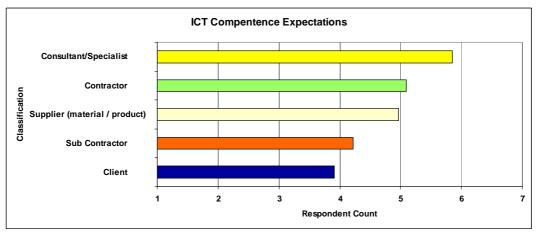

Figure 8 Average Responses for Overall Level of ICT Competence

When comparing the responses dependent on the role of the respondent it was apparent that those in managerial roles tended to expect a higher competency from all team members than did other groups. This was not a statistically significant finding. When comparing responses based on the respondent class, sub-contractors tended to expect a greater level of competency from sub-contractors in general than did other groups. They also expected a higher level of competency from contractors than other groups.

5. ICT PERSPECTIVES

5.1 BENEFITS AND DRIVERS FOR ICT ON PROJECTS

Respondents were asked to indicate what influence a specified range of benefits and drivers has on their decision to implement or use ICT on projects. The issues presented included:

- Benefit 1.   To help improve overall team/company efficiency (productivity).
- Benefit 2.   To help enable electronic banking etc (eCommerce).
- Benefit 3.   To help enable electronic tendering (eTender).
- Benefit 4.   To help enable electronic archiving of documentation (eArchive)
- Benefit 5.   To help set up a dependable ICT infrastructure within your company.
- Benefit 6.   To help become Industry leaders in ICT adoption.
- Benefit 7.   To help downsize or become a leaner company/team.
- Benefit 8.   To help increase business opportunities.
- Benefit 9.   To help gain increased efficiency (improved productivity).
- Benefit 10.   To help support industry Research and Development.
- Benefit 11.   To help receive tangible rewards (pay/job advancement).
- Benefit 12.   To help receive intangible rewards (respect, self-fulfilment).

The response options ranged from no influence at all to highly influential with a total of seven rating options.

The mean response rating for most issues was above average suggesting that most issues were influential in their decision to implement or use ICT on projects. The only issue with a below average mean response was '*to help become industry leaders in ICT adoption*'. The mean response for the issues is displayed in Figure 9.
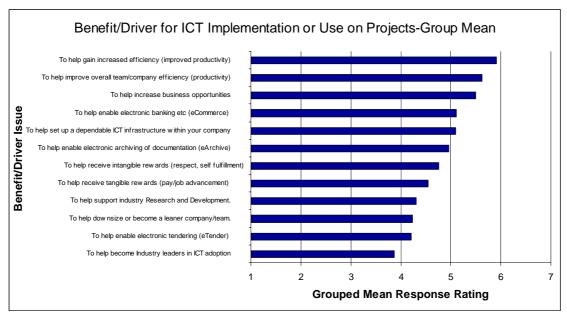

Figure 9 Mean Response for Benefits/Drivers Influencing ICT Implementation
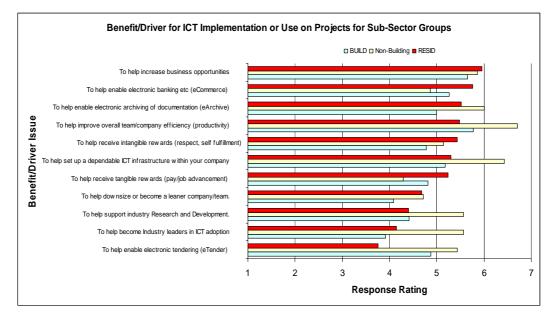
Figure 9 shows the issue with the highest mean rating was '*to help gain increased efficiency (improved productivity)*' followed by '*to help improve overall team/company efficiency (productivity)*' and '*to help increase business opportunities*'.

Based on the sample error the results showed a statistically significant difference in the mean response between issues, with the top three issues being significantly different to the bottom six issues. This result suggests that the top three issues are likely to be the most influential for the population in general.

The issues found to be of least influence, in order of influence include *'to help become industry leaders in ICT adoption'; 'to help enable electronic tendering (eTender)';* and *'to help downsize or become a leaner company/team'.*

Essentially, respondents perceive ICT to provide productivity benefits to their project operations, both at the individual and team/company level. They also perceive some strategic benefits in the way of improved business opportunities that the ICT may provide.

When comparing the responses dependent on the analysis factors, there was considerable variability between the core sectors (Figure 10), in particular the responses for the non-building sub-sector. Due to the small number of respondents in this category the differences, in general, were not statistically significant. Figure 10 below displays the results of the core sub-sector analysis. The non-building sub-sector respondents perceived '*to help improve overall team/company efficiency (productivity)*' and '*to help gain increased efficiency (improved productivity)*' as the most influential benefits/drivers respectively to ICT implementation or use on projects. Other issues, which have a strong influence for the non-building sub-sector respondents, in order of influence are *'to help set up a dependable ICT infrastructure within your company'; 'to help enable electronic archiving of documentation (eArchive)';* and *'to help increase business opportunities'.*

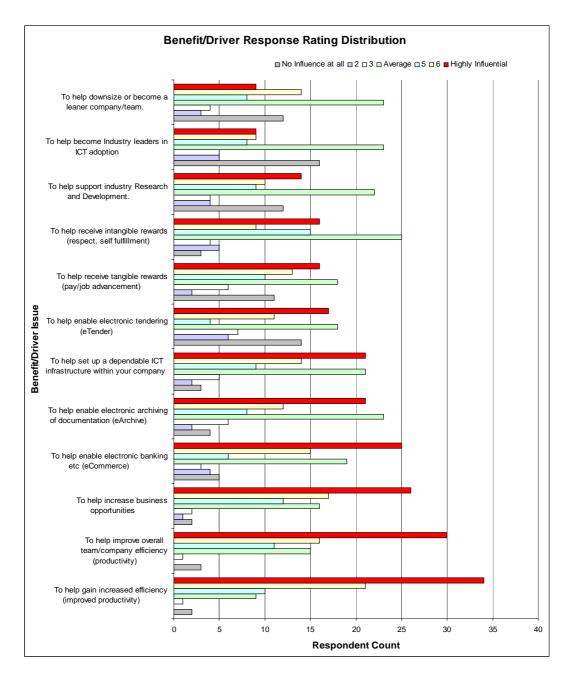**Figure 10 Mean Response for Benefits/Drivers by Core Sector**

It is worthy of note that those in the non-building sub-sector indicated that "*to help set up dependable ICT infrastructure'* was more influential than "*to help increase*

business opportunities" where the overall mean response showed a different result. This sub-sector also rated (4th highest) eArchive capability more influential than did the group mean, which gained a ranking of 6th highest overall. In addition, worthy of note was that all issues raised had higher than average influence response for the non-building sub-sector.

Building construction (commercial/industrial) respondents perceived '*to help gain increased efficiency (improved productivity)*' and '*to help improve overall team/company efficiency (productivity)*' as being the most influential benefits/drivers respectively to implementing or using ICT on projects. Other issues, which have a strong influence for building construction sub-sector, in order of influence are '*to help increase business opportunities*'; '*to enable electronic banking etc (eCommerce)*'; and '*to help set up a dependable ICT infrastructure within your company*'. These results are in line with the grouped mean response for all sub-sectors where the top 5 issues match in order of influence.

The residential sub-sector respondents perceived '*to help gain increased efficiency (improved productivity)*' and '*to help increase business opportunities*' as their most influential benefits/drivers respectively to ICT use and implementation on projects. Other issues, which have a strong influence for the residential sub-sector, in order of influence are '*to enable electronic banking etc (eCommerce)*'; '*to help enable electronic archiving of documentation (eArchive)*'; and '*to help receive intangible rewards (respect, self fulfilment)*'.

It is interesting to note that the residential sub-sector rated the increase in business opportunity benefit/driver as more influential than the other sub-sectors. Another interesting result for residential sub-sector is the relatively high influence rating, compared to the group mean, for the issue '*to help receive tangible rewards (pay/job advancement)*'. It is also interesting to note that the issue '*to help enable electronic tendering (eTender)*' had less influence for those in the residential construction sub-sector than the other two.

Figure 11 displays the rating response distribution for the influence the specific benefits/drivers had on their decision to implement or use ICT on projects.

Figure 11 Response Distribution for Benefits/Drivers Influencing ICT Implementation

5.2   BARRIERS AND LIMITATIONS FOR ICT ON PROJECTS

Respondents were asked to indicate what influence a specified range of Barrier/limitation has on their decision to implement or use ICT on projects. The issues presented included:

- Barrier 1.   Not having an ICT implementation "Champion" on a project.
- Barrier 2.   Existing use of traditional/paper-based documentation.
- Barrier 3.   The dispersed nature of the industry/projects & participants.
- Barrier 4.   Having limited or no ICT Infrastructure in place.
- Barrier 5.   Having limited or no ICT technical support readily available.
- Barrier 6.   ICT investment restrictions due to budget constraints.

- Barrier 7.   Not being aware of the cost benefits of investing in ICT.
- Barrier 8.   The continuous & quick succession of ICT upgrades/advancement.
- Barrier 9.   Having to use incompatible ICT hardware/software/systems.
- Barrier 10.   Security issues (re project data, access etc).
- Barrier 11.   Confidentiality issues (re shared project data).
- Barrier 12.   Legislative issues (re contracts, electronic signatures).
- Barrier 13.   Having no ICT Strategy Plan (re ICT use).
- Barrier 14.   Your company's perception that ICT is not part of its core business.
- Barrier 15.   Inconsistent employee requirements on projects.
- Barrier 16.   Lack of ICT training & experienced (knowledge, awareness & skills).
- Barrier 17.   Demanding & inflexible workload.
- Barrier 18.   Having limited or no ICT training opportunities within your company/team.

The response options ranged from no influence at all to highly influential with a total of seven rating options. The mean response for these issues is displayed in Figure 12. The chart shows that all issues are grouped between slightly below to slightly above average influence and that '*ICT investment restrictions due to budget constraints*' was most influential. This result confirms results in previous sections, where in general annual turnover, hence project/organisational budget, has had a great influence on both ICT status and ICT training outcomes.
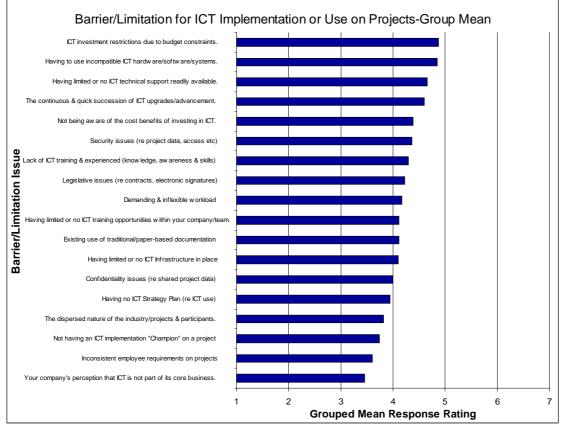

Figure 12 Mean Response for Barrier/limitation Influencing ICT Implementation

Technical issues such as '*having to use incompatible ICT hardware/software/systems*', '*having limited or no ICT hardware/software support readily available*' and *'the continuous & quick succession of ICT upgrade/advancement'* were the next most influential barrier/limitation issues when considering to implement or use ICT on projects. The issues found to be of least influence, in order of influence include *'your company's perception that ICT is not part of its core business'; 'inconsistent employee requirements on projects'; and 'not having an ICT implementation "champion" on a project'.*

Another technology which is allowing interoperability amongst collaborative project members is the Internet, which through networking technologies such as Virtual Private Networks (VPN) and Application Service Providers (ASP), is allowing clients to provide services with minimal technological requirements, only requiring a Web Browser to access the project web site and sophisticated software applications. This leads to another influential (6th highest mean response) issue amongst respondents, the issue '*security issues (re project data, access etc.)*' In an electronic collaborative environment such as construction project websites, data security becomes a major consideration in the implementation and use of ICT for project participants.

Sub-sector groups were analysed to find results of any significance with regard to the barrier/limitation influencing ICT implementation or use on projects (Figure 13). Non-building construction respondents perceived *'having limited or no ICT technical support readily available'* and '*demanding and inflexible workload'* to be equally the greatest barrier/limitation influencing their decision to implement or use ICT on projects. Other issues, which have a strong influence for this sub-sector, in order of influence were *'having limited or no ICT training opportunities within your company/team'; 'having to use incompatible ICT hardware/software/systems';* and *'having limited or no ICT infrastructure in place'.*
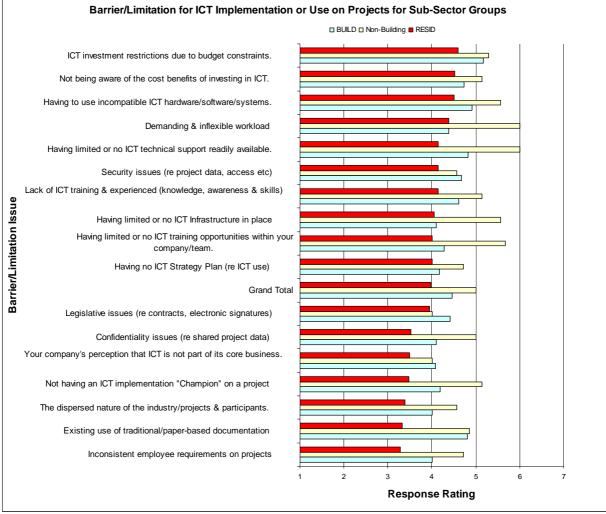
Figure 13 Mean Response for Barrier/limitation by Core Sector

It is interesting to note that '*ICT investment restrictions due to budget constraints*' was not as highly influential for this sub-sector than for the other two. This may be as a result of the relationship between ICT investment and annual turnover, where results indicate that a large percentage (86%) of the non-building sub-sector respondent organisations were in the high (greater than $5M) annual turnover ranges. It would appear they typically have more money to invest, hence their lower perceived restriction on budgets for ICT, and their tendency to be more innovative. All of the issues presented were perceived by the non-building sub-sector to be at least an average influential barrier/limitation to ICT implementation or use on projects.

The relatively high influence of '*having limited or no ICT training opportunities within your company/team*' is an interesting result due to the fact that all respondents in this sub-sector indicated that they are allowed sufficient time during office hours to undergo official ICT training. However, only one respondent indicated that they are able to adjust or reduce their workload to undergo ICT training, indicating that workload may be a significant determining factor when it comes to ICT training for the non-building sub-sector.

Building construction (commercial/industrial) respondents perceived '*ICT investment restrictions due to budget constraints*' and '*having to use incompatible ICT hardware/software/systems*' as being the most influential barrier/limitation respectively to implementing or using ICT on projects. Other issues, which have a strong influence for this sub-sector, in order of influence were '*having limited or no ICT technical support readily available'; 'existing use of traditional/paper based documentation';* and '*the continuous & quick succession of ICT upgrades/advancement'.*

The residential sub-sector respondents perceived '*the continuous & quick succession of ICT upgrades/advancement'* and '*ICT investment restrictions due to budget constraints* ' as their most influential barrier/limitation respectively to ICT use and implementation on projects. Other issues, which have a strong influence for this sub-sector, in order of influence were '*not being aware of the benefits of investing in ICT'; 'having to use incompatible ICT hardware/software/systems';* and '*demanding and inflexible workload'.*

Figure 14 displays the distribution of responses indicating what influence the range of barrier/limitation had on their decision to implement or use ICT on projects. As is clear many respondents indicated the issues had an average influence on their decision to implement or use ICT on projects.
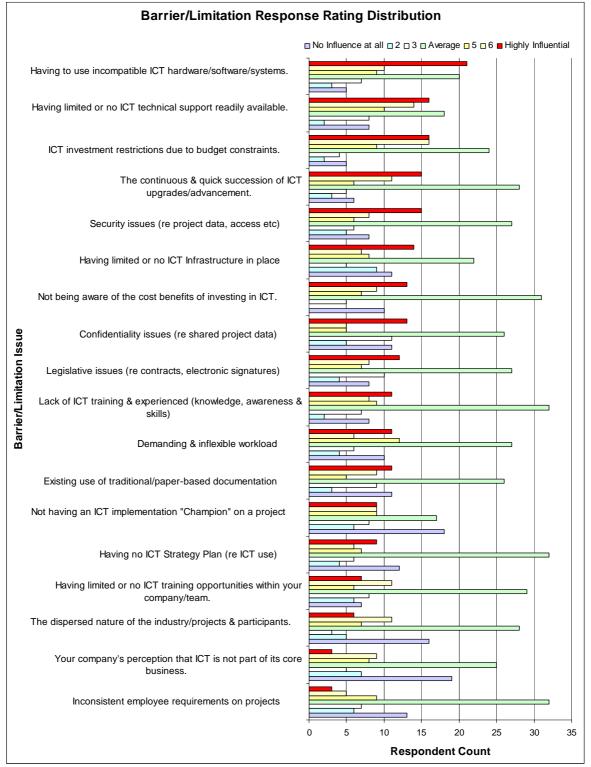
Figure 14 Distribution for Barrier/Limitation Influencing ICT Implementation

5.3 SUMMARY OF ICT PERSPECTIVES

Table 1 summarises the results of the most influential Benefit/Driver issues for respondents.

Table 1 Benefit/Driver Issue Ranking According to Respondent Group

Group	Benefit/Driver Influence Ranking				
	1	2	3	4	5
Total Mean	To help gain increased efficiency (improved productivity)	To help improve over all team/company efficiency (productivity)	To help increase business opportunities	To help enable electronic banking etc (eCommerce)	To help set up a dependable ICT infrastructure within your company
Non-building	To help improve overall team/company efficiency (productivity)	*To help gain increased efficiency (improved productivity); and *To help set up a dependable ICT infrastructure within your company		To help enable electronic archiving of documentation (eArchive)	To help increase business opportunities.
Building	To help gain increased efficiency (improved productivity)	To help improve overall team/company efficiency (productivity)	To help increase business opportunities	To help enable electronic banking etc (eCommerce)	To help set up a dependable ICT infrastructure within your company
Residential	To help gain increased efficiency (improved productivity)	To help increase business opportunities	To enable electronic banking etc (eCommerce)	To help enable electronic archiving of documentation (eArchive)	To help receive intangible rewards (respect, self fulfilment)

* Both had same influence and tied for second.

Table 2 summarises the results of the most influential barrier/limitation issues for respondents.

Table 2 Barrier/Limitation Issue Ranking According to Respondent Group

Sub-sector	Barrier/Limitation Influence Ranking				
	1	2	3	4	5
Total Mean	ICT investment restrictions due to budget constraints	Having to use incompatible ICT hardware/software/systems	Having limited or no ICT technical support readily available	The continuous & quick succession of ICT upgrades/advancement	Not being aware of the cost benefits of investing in ICT
Non-building	*Having limited or no ICT technical support readily available; and *Demanding and inflexible workload		Having limited or no ICT training opportunities within your company/team	Having to use incompatible ICT hardware/software/systems	Having limited or no ICT infrastructure in place
Building	ICT investment restrictions due to budget constraints	Having to use incompatible ICT hardware/software/systems	Having limited or no ICT technical support readily available	Existing use of traditional/paper based documentation	The continuous & quick succession of ICT upgrades/advancement

Residential	The continuous & quick succession of ICT upgrades/advancement	ICT investment restrictions due to budget constraints	Not being aware of the cost benefits of investing in ICT	Having to use incompatible ICT hardware/software/systems	Demanding and inflexible workload

* Both had same influence and tied for first.

6.   CONCLUSION

The most significant observations from the survey results were that annual turnover has an effect on the uptake of ICT and training performance in ICT for an organisation.

Identified effects of budget on uptake and/or current ICT status include:
- In general, higher ICT investment was observed for higher annual turnover organisations;
- In general, higher ICT investment, hence annual turnover organisations, had a higher rate of use and access to emerging or innovative ICTs such as Handheld and Tablet computers, Video Conferencing and Wi-Fi devices; and
- The most significant barrier/limitation to the implementation or use of ICT on projects was budget constraints.

Identified effects of budget on ICT training include:
- Lower turnover construction organisation respondents were less likely to have undergone ICT training;
- Lower turnover construction organisations were less supportive of ICT training through flexible workload and time allocation; and
- Higher turnover organisations had a greater preference for the professional consultants mode of training and conversely, lower turnover organisations had a greater preference for self-learning.

Technical issues such as interoperability (incompatibility) and not having an ICT professional on site or within ready access were found to be strong influential barriers to the uptake of ICT on projects for most respondents. When investigating results according to sub-sector, several of the groups were found to rank highly issues that were not in the top five as a sample group. For example, the non-building and residential groups ranked their demanding and inflexible workloads as being in their top five barriers to uptake of ICT for projects.

The overriding driver for ICT uptake for respondents was to improve their operational performance through improved productivity at both the personal level and the organisational /team level. Improved business opportunity was also highly influential for respondents. Similar results to these were found on investigation of results according industry sub-sectors. Interestingly the residential sub-sector rated the driver of improved business opportunities higher than the other two sub-sector groups.

7.   REFERENCES

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8. ACKNOWLEDGEMENTS