Process Complexity and Cultural Baggage – Barriers to Change

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ABSTRACT: Recent research at Deakin University in Australia has focused on developing a highly detailed understanding of current organisational interactions and information flows in the construction industry. This is leading to the development of a detailed process model which is being tested against a field study construction project. The field study reveals highly complex information flows and interdependencies between stakeholders such as designers, project managers, clients, contractors, subcontractors and suppliers. This, combined with the results from a recent project identifying inhibitors to the take up of IT in the construction industry undertaken by the IAI-Australasian Chapter allow conclusions to be drawn as to whether the current construction industry structure lends itself to increased levels of ICT or whether fundamental cultural changes are required before further beneficial ICT implementation is able to be achieved.

1 INTRODUCTION

The construction industry has come under considerable criticism both from outside and from stakeholders within the industry. Observations from outside the building industry see the use of IT as an enabler for addressing criticism and leading to greater productivity, higher quality and better cost control all leading to a better outcome for the client and society in general (Dept. Industry Science and Resources 1999). This has led to considerable effort being put into the key technology initiatives such as increasing the levels of interoperability in the building industry. The Industry Foundation Classes developed by the IAI are the most notable of these. At least one of the rationales for interoperability is that the seamless transfer and reuse of information will reduce or eliminate the preparation of duplicate information. In addition interoperability opens up the potential for new methods of carrying out what are currently manual operations such as automated code checking. Much of the new ICTs suggested for use in the building industry rely on the development of 3D building models. Certainly three major CAD system developers, Autodesk, Graphisoft and Bentley Systems see the future in 3D building models which contain both geometric and component attribute data.

Technologies, including the use of 3D building models and the application of interoperability, are currently struggling for broad acceptance in the building industry. Uptake has been slow and patchy by all but those most committed to the long term vision of a virtual building model supporting design, construction and facilities management.

Two key pieces of research have recently been undertaken which assist in explaining the reason for the slow uptake of what appears to be compelling new and productive technologies.

One of the authors (Pham) is undertaking a field study which is investigating detailed process modelling within the design and construction of a building project. The other (Dawson) has recently coordinated a series of workshop sessions and industry consultation seminars conducted by the IAI - Australasian Chapter which has investigated the reasons for the slow uptake of ICT in Australia.

These research programs have revealed the level of operational complexity which characterise the building industry today.

2 METHODOLOGY

2.1 *Field Study*

The field study has tracked the formal and informal information generation and communication processes used in a building project in Victoria, Australia. The investigation commenced in the initial briefing stages of the project and tracked the participation of all stakeholders through the design, documentation, letting of contracts and on to the completion of construction. It is therefore a comprehensive snapshot of the processes each participant used at all stages in the project.

The data was collected by the following methods:
1 Observation of project meetings,
2 Semi structured interviews with project participants from client to sub-contractors,
3 Observation of the design and construction process,
4 Analysis of the project documentation and records including those from the client, architect, design engineers and suppliers.

From this a detailed process model of the design and construction program is being developed.

2.2 *IAI workshop Sessions and Industry Consultation*

The IAI-AC during 2004/5 carried out a project to develop a Technology Roadmap for the building industry in Australia (Dept. Industry Science and Resources 2001, Phaal et al 2004, Barker & Smith 1995). This was undertaken in two broad stages.

Stage 1 - Workshop Program: This was designed to obtain views as to the current nature and the future of the construction industry in Australia. The aim of these groups was to identify key issues of concern to the industry related to four themes:
1 Characteristics of the industry in 2030,
2 Nature of the industry in 2004,
3 Medium term changes needed in the industry,
4 Immediate changes required now.

Each of these themes was discussed in a facilitated group discussion session with the key issues being identified and recorded for further discussion. The participants in the groups were selected based on representation from key stakeholders in the construction process. They were not selected to represent their industry groups but to provide an insight into their industry sector based on their extensive experience in the construction industry over many years. This was a key element in what they could contribute to the discussion.

The stakeholders participating included clients, architects, design engineers, construction managers, subcontractors and suppliers.

Stage 2 - Industry Feedback and Industry Consultation: Draft results were developed from the workshops and together with a series of ICT Demonstration Projects were presented to a series of industry workshops. The workshops were held in Brisbane, Sydney and Melbourne. The Technology Roadmap has been prepared from the initial group discussions and feedback from the draft report (Dawson, in press).

3 PROCESS COMPLEXITY

The field study project has revealed a highly complex set of relationships between the project participants. One section of the building investigated in the field study appears to be relatively trivial in terms of both its complexity and potential interactions between project participants. However, the investigation of the design, documentation and construction of a simple kitchenette (Figure 1) demonstrates the level of interaction between participants in the design process and the degree to which errors and resultant rework can creep into the construction process.

Neither the design nor the construction process is fully described below however, they serve to demonstrate the nature of the current interactions between project participants and some of the difficulties which arise in the process.

3.1 *The Design Process*

The design process is described below using the method discussed in Pham & Dawson (2004) in which the information distributed, the communication links required and the tasks to be undertaken may be described using various modes of reviewing the project interactivity structure.

The interactions between the participants (Table 1) in the design process are described in Figures 2-4. The commencement of the task is in the centre with the task being completed at the outer surface of the sphere. Subtasks to be undertaken are identified by nodes.

3.2 *The Construction Process*

The construction process may be described in a similar manner to that of design with the aggregate and time dependant views (Figures 5-6) of the process including the construction participants. The processes described in the stakeholder views (Figure 7) are similar for all subcontractors. It is evident that the level of the complexity of the interaction between the individual participants during the construction phase is less than that of the project participants during design.

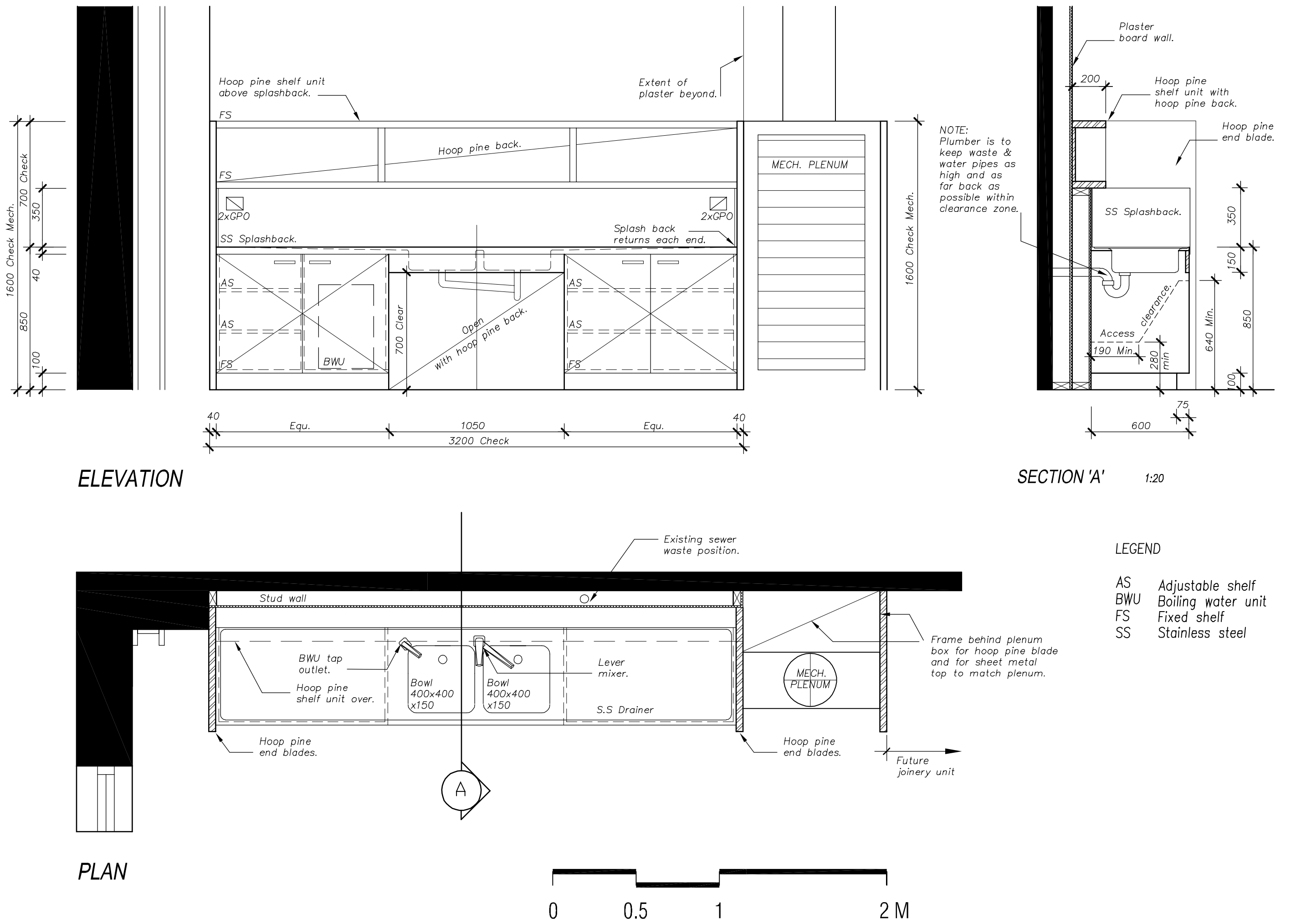

Figure 1. Architects' Documentation of Kitchenette

This may be explained by the greater fragmentation which is experienced in the industry at the construction phase of the project.

Table 1. Project Participants

AR	Architect
QS	Quantity Surveyor
SB-WA	Statutory Body-Water Authority
CL	Client
CM	Construction Management
PM	Project Management
SM	Site Manager
PC	Plumbing Contractor
BS	Building Surveyor
SU	Supplier
SC	Subcontractors: JN Joiner PC Plumbing Contractor CA Carpenter PA Painter PL Plasterer

While the architect, the project or site manager, coordinate aspects of the project at a broad level each subcontractor focuses on their own segment of construction at the detailed implementation level. As a consequence of this, the subcontractors are required to deal with any difficulties which arise during construction.

The views of the joiner are of particular relevance to the construction of the kitchenette and point to a set of problems which he was required to deal with during the project.

Several key points arose during the interview:

1 There was a slope on the floor which had to be resolved on site. This was known due to a site visit at which the stud wall behind the unit was measured. The fall meant that on site cutting was required.
2 Plywood for the joinery was ordered but the incorrect panels were delivered. This caused delays in the fabrication.
3 The sink as delivered was 166mm too short.
4 The joinery was made off site to the 3200mm dimension as per the documentation (Figure 1) but had to be rebuilt on site due to the incorrect sink length.

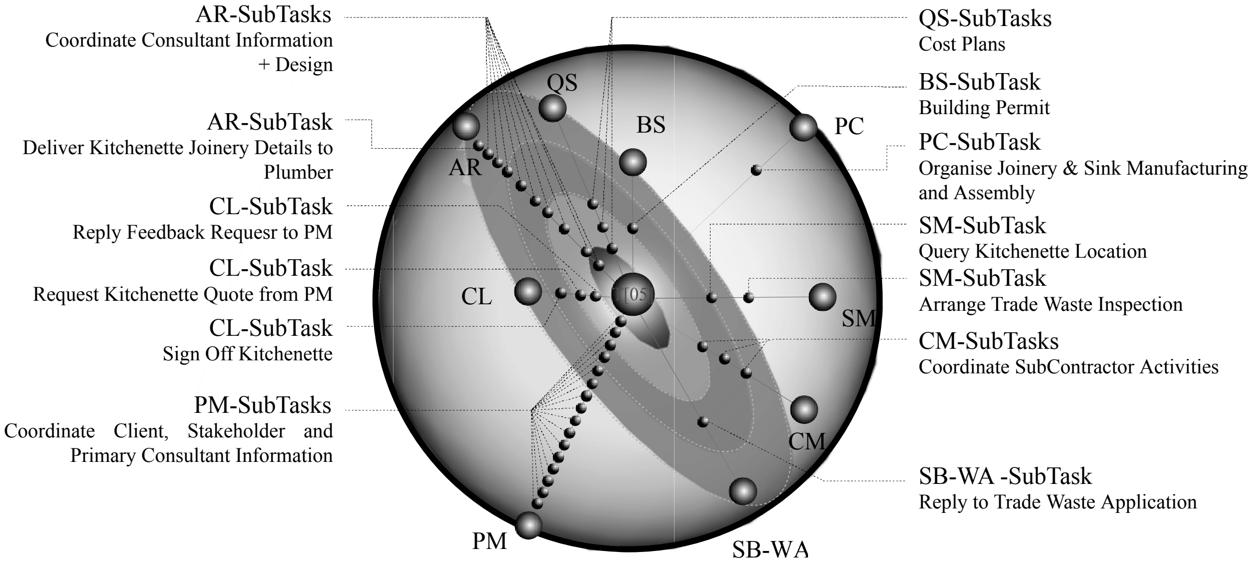

Figure 2. Aggregate View – Kitchenette Design

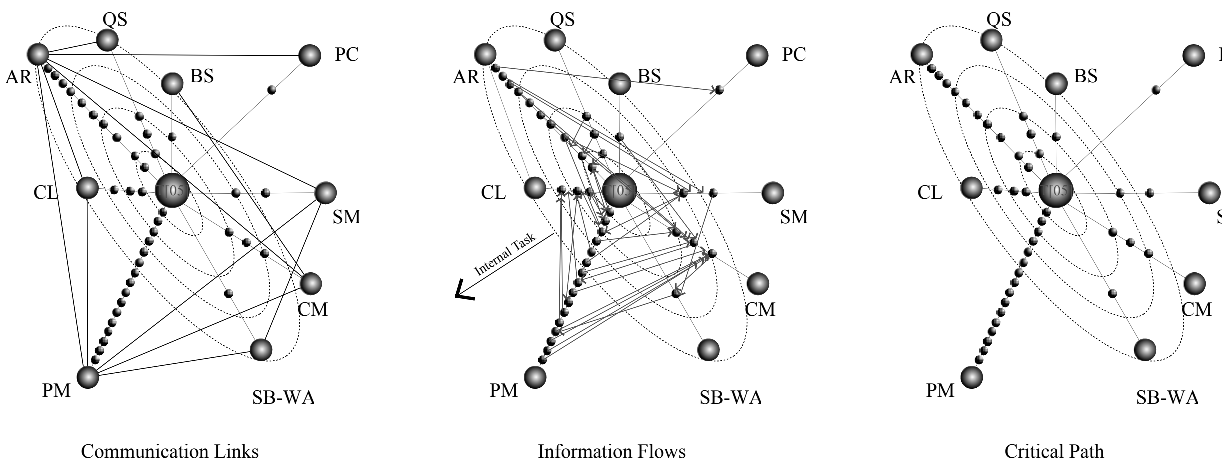

Figure 3. Design Phase - Time Dependant View

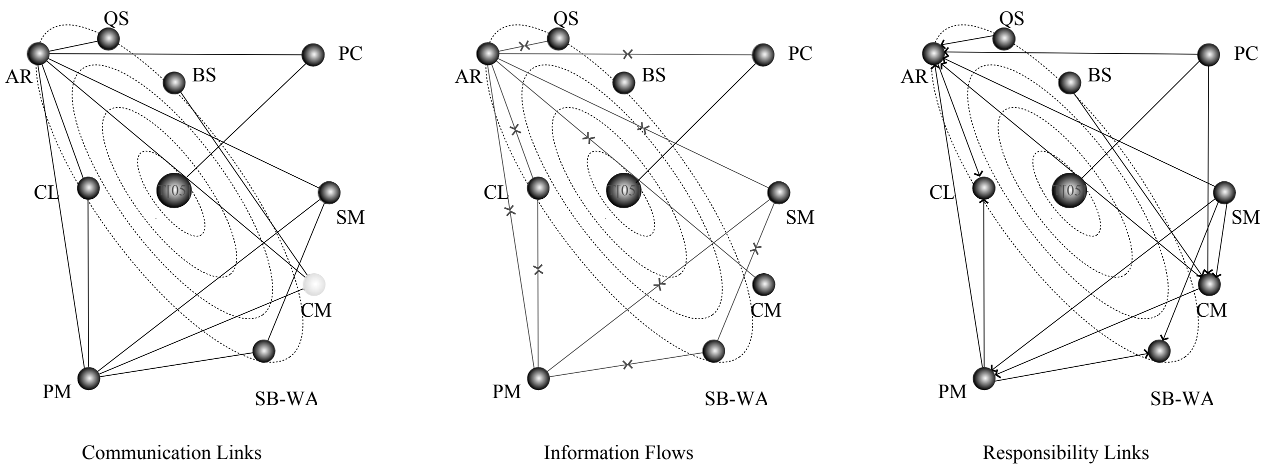

Figure 4. Design Phase - Stakeholder View

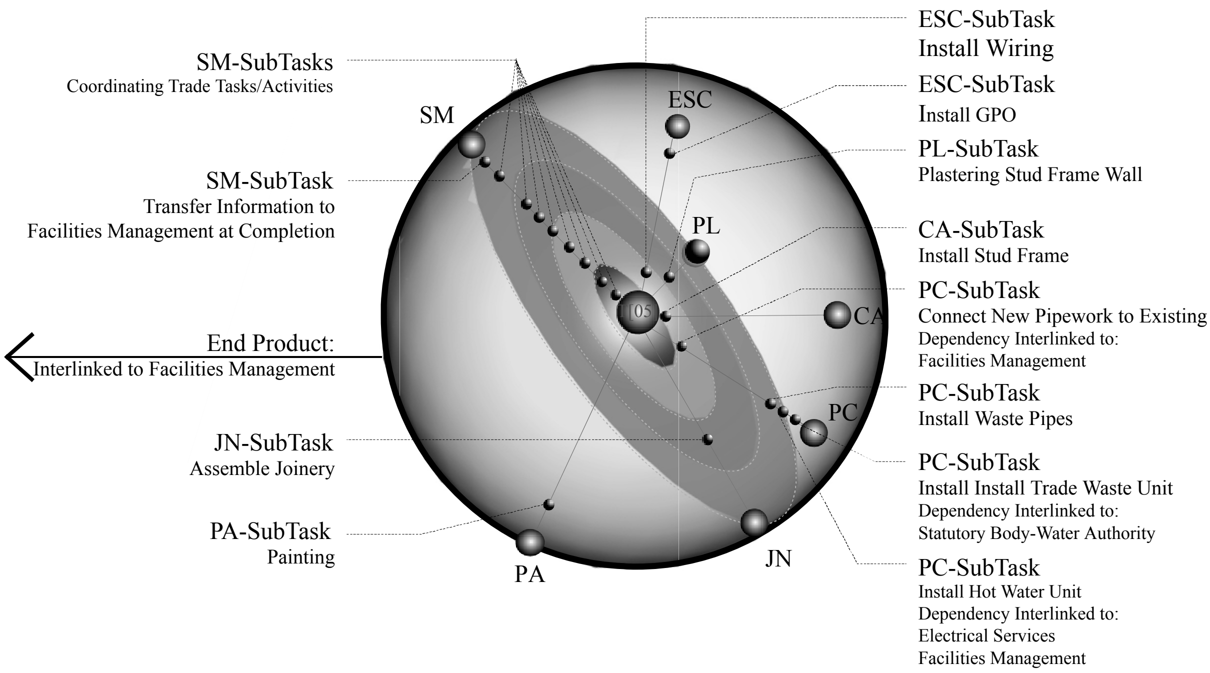

Figure 5. Aggregate View – Construction Phase

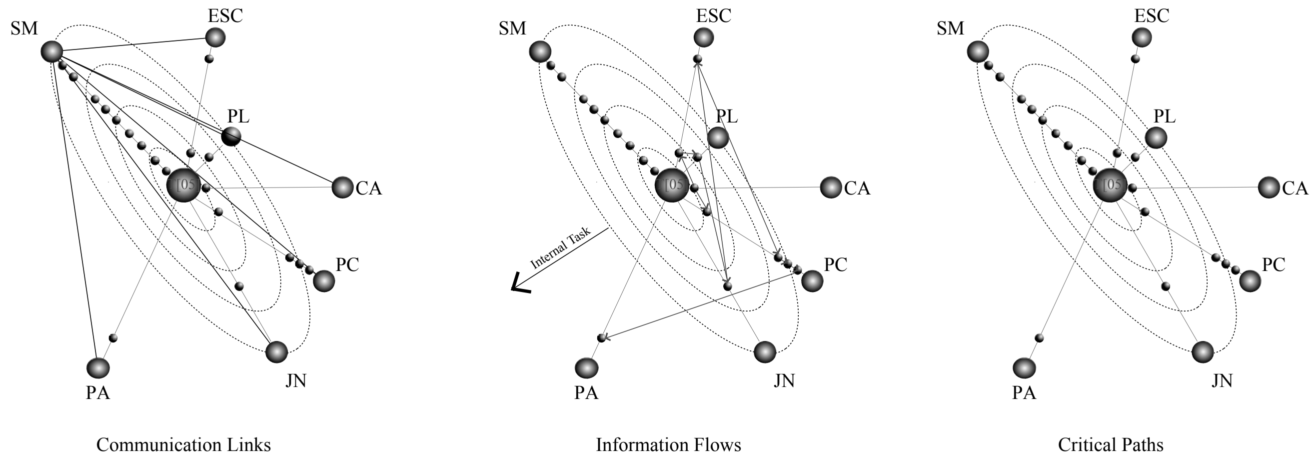

Figure 6. Construction Phase – Time Dependant Views

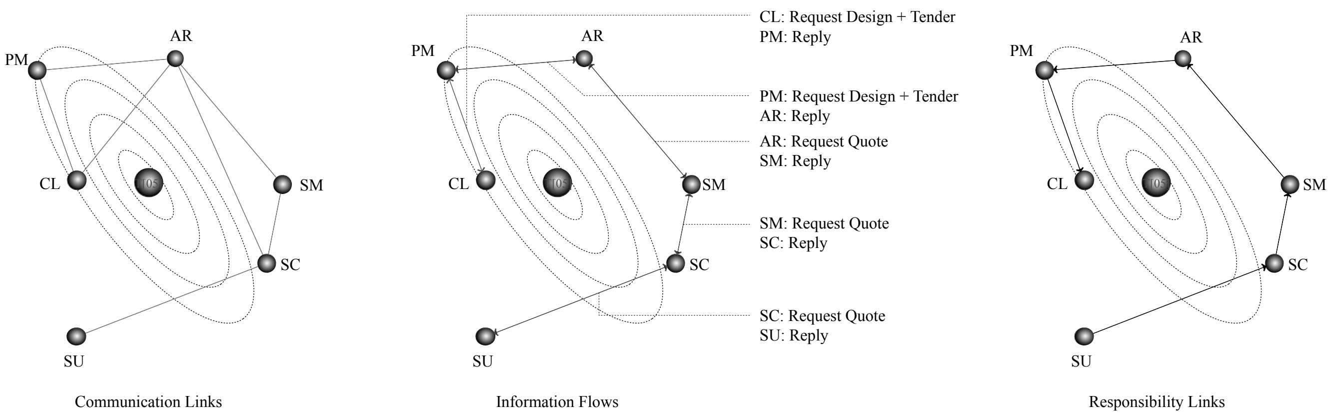

Figure 7. Construction Phase – Stakeholder View

It is apparent that both the existing conditions in the building and errors made by others had a direct impact on the joinery work. Some of the conditions could be (and were) allowed for, including the floor slope and the wall conditions. Other issues were not predicted. These included delivery of the incorrect panels to the joinery shop resulting in a delay to the assembly and problems with the sink which was of the incorrect size creating additional work and delays in completion. The options for resolving the sink problem were either deal with the problem that arose or not install the joinery until a new sink was manufactured and delivered. Making alterations to the joinery was the chosen option with the cost of the additional work and materials born by the joiner.

Other participants in the construction process also reported similar issues throughout the project, again causing delays.

4 INDUSTRY STRUCTURE

The building industry has certain key characteristics which are a fundamental part of both its operation and the way industry stakeholders expect to operate. The industry is founded on small specialist sub-contactors each operating independently from one another and competing against each other for work. Some level of alliancing does develop with a relatively small number of contractors working consistently with each other within niche markets, generally in residential housing. These alliances often develop on an informal basis rather than with formal long term contractual relationships. Such a competitive industry based on subcontracting has several key impacts.

4.1 *Cost Driven Focus*

The focus on cost in a project has a number of consequences:

1 Obtaining work is based on cost competitiveness not on the quality of outcomes or product,
2 There is a tendency for a flat rate for work irrespective of the level of complexity,
3 Competition tends to drive costs of work down such that there is a perception by clients that they can get more for less,
4 The pressure for driving costs down starts with the client and continues down through the project, putting pressure on project quality,
5 Pressure on project budgets reduces the ability to provide for unexpected events in the construction process.

The cost driven focus results in the percentage of profits being highly variable and dependant on the smooth progress of a particular job. One contract may be highly profitable while a loss is made on the next. This leaves little reliable surplus income for process improvement and investment in skill development or technology.

4.2 *Risk Shedding vs Risk Management*

As a consequence of a highly competitive commercial environment and the increased preparedness for the use of legal action to settle disputes, there is increased risk shedding as a means of managing risk. This has developed in an environment where, if a subcontractor needs to be more competitive, they may be prepared to take on more risk than they would normally accept. The contractor has therefore effectively shed that risk to someone further down the contracting hierarchy. This also applies to clients shedding risks to head contractors. The process of risk shedding has the tendency to pass the risk on to others irrespective of whether they are able to manage that risk or not. This occurs whether accepting that risk may be seen to be part of the activities which may normally be expected of a project participant. The classic note on drawings related to checking or verifying dimensions on site (see Figure 8) shows an attempt to pass responsibility for dimensional accuracy of the design documentation to the recipient of the documentation.

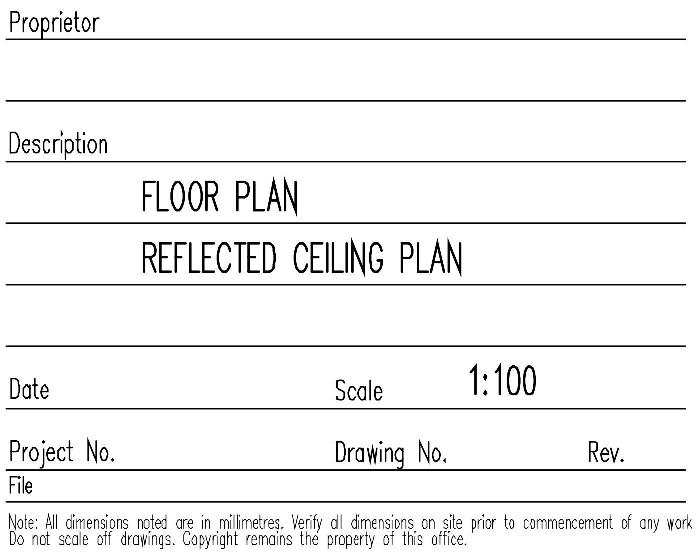

Figure 8. Extract of Drawing Title Block

4.3 *Trust (or lack thereof)*

In the adversarial and competitive environment described above, trust between participants in the building industry is difficult to develop. This results in most participants in the industry expecting relationships with others with which they deal to be adversarial and potentially litigious.

The outcome of this is that all dealings with others in the industry are treated with suspicion. Along with the process of risk shedding, this makes downstream participants in the design and construction process highly suspicious of any work which has previously been carried out. This encourages and often mandates a checking of all work previously done by others and with which you need to interact.

4.4 *Pressures on Skills*

In an industrial environment in which a level of robustness in dealing with others is required and where much of the on site work is dirty and considered dangerous, it is very difficult to both attract and keep highly skilled participants. In the areas other than the professions such as architects, engineers, quantity surveyors and construction managers, this is particularly the case.

5 DISCUSSION

The development of ICT is moving toward a level of usability by the building industry with increasing support for the virtual building model and the building information model by three major CAD vendors. Developments in interoperability have reached a standard where there is an opportunity for the transfer of data between software packages although this by no means applies across the industry. It is clear that a further commitment to interoperability standards, such as the IFCs, is required before comprehensive and seamless data transfer can be achieved.

While full interoperability and full integration of the design and construction processes may be highly desirable and achievable from a technical standpoint, whether it is achievable within the current industry operating structure is doubtful. Fragmentation has been targeted as an issue preventing integration of processes within the industry. This of itself should not prevent process integration. What prevents integration is the participants expectations of an industry which is fragmented.

Buildings generally get designed and built mostly by individuals or small organisations which compete with each other to carry out focused and limited tasks within the overall building operation. The nature and extent of the tasks are only described using instructions which recognise that each participant has a set of specific knowledge and skills which they contribute to the project. The instructions they are given are often only a general description of the outcome required for the specific part of the building for which they are concerned. For each participant, there is generally little or no need to give consideration as to where the task they carry out fits within the design or building operation as a whole. The participants, particularly during construction, generally wish to get in and out as quickly as possible and get on with the next job.

This type of fragmentation encourages a culture of isolation and self interest within the industry.

While this may be less true of the design professions, particularly architects, who need to integrate a range of disciplines to complete a design, there appears to be developing an increased level of specialisation and therefore isolation even within the design process.

This self interest and isolation mitigate against the development of trust within the building industry. This results in information being regenerated multiple times on multiple drawings across multiple design disciplines and is the outcome of not trusting that the information received is accurate. The industry workshops have provided several examples. A door supplier will prepare their own door schedule as they do not trust that the one prepared and supplied by the architect is accurate. Drawings will not be provided in editable electronic format as the architects are not confident that their intellectual property rights will be respected. The cabinet maker can not be confident that the space in which the joinery work is to be installed will be constructed accurately to the dimensions on the drawings.

6 CONCLUSIONS

In the current building industry there are several key elements which are missing if ICT is to be fully used in core methods of operation:

– A strong level of connection with others in the building industry,
– A cooperative approach which focuses all participants on quality outcomes,
– Reliable availability of capital for technology and skill development at all levels,
– The ability to develop and retain high skill levels in all segments of the building industry,
– Continuous skill development in all segments of the building industry,
– Trust that others will achieve the highest quality outcome.

Without these elements, the development of ICT in the building industry will be on the fringes of core operations in most segments of the industry now and into the future. The lack of development of high levels of advanced IT implementation in the building industry is not a technical problem; it is primarily social and cultural. Without addressing these issues, the best technical solutions in the world are doomed to failure.

7 ACKNOWLEDGEMENTS

The authors wish to thank the client, contractors, suppliers, design engineers, site and project managers, and architects who gave time and information to enable the field study to be undertaken in such a comprehensive manner.

The IAI-AC of which Dr Dawson is a Director and the Treasurer of the Australasian Chapter wishes to thank the Federal Department of Industry Tourism and Resources and the CSIRO for supporting the Technology Roadmap project.

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