

PLANNING & IMPLEMENTATION OF EFFECTIVE COLLABORATION WITHIN CONSTRUCTION



REQUIREMENTS CAPTURE REPORT

- Methodology

- Needs for the PIECC Project

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Summary

This document is the accumulation of work carried out in workpackage 2: Requirements Capture Survey of the PIECC project. The document summarises the methodology chosen to capture and analyse the findings from interviews and questionnaires conducted by the authors.

The information is collated together, analysed and presented using the PIECC Project methodology described. The document describes the key aspects of what industry deems the most important issues to consider in developing a protocol for the planning and implementation of effective collaboration in the construction sector. The document concludes with a summary of the key challenges faced in the future developments of the PIECC project.

Document Revision Sheet

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Abbreviations

CATWOE	Customers, Actors, Transformation, World view, Owner(s), Environmental constraints
PIECC	Planning and Implementation of Effective Collaboration within Construction
R&D	Research and Development
SSM	Soft Systems Methodology
UML	Unified Modelling Language

1. Introduction

Requirements analysis centres on getting all users to identify needs, problems and expected benefits. The main deliverables are a statement of the functional requirement (sometimes referred to as the user specification or the requirements specification), and at least the outline of an acceptance test plan which will stand as the main reference point during the later stage of acceptance testing.

Historically, the process of requirements analysis has been ill defined, and fraught with difficulty and misunderstanding. Nowadays, it is subjected to the discipline of structured methods and is becoming better understood. It is very important to the success of the project, and must be seen as the area of greatest investment of time and effort.

In order to achieve the objectives of the PIECC project the following strategies and research methods were suggested as first thoughts:

1. Use of published sources – through an extensive literature review to establish current 'state-of-the-art' practice on collaborative working, both in the construction and other industries.
2. Field studies – these will be conducted to establish current practice for collaborative working within collaborating organisations. These field studies will include questionnaires, semi-structured interviews and detailed case studies within the collaborating organisations to identify the requirements for collaborative working and the key issues to be considered at organisational, project and users levels.
3. Using a 'develop-test-refine' strategy (action research) – to perfect the methodology for effective collaboration. This is appropriate since this project is concerned both with developing real-life solutions and furthering the goals of 'science'. Thus, the initial methodology will be developed, tested and refined to ensure that it is comprehensive and cost-effective.

This suggested methodology to determine the factors for effective collaboration will consider the organisational culture; project; process and users' requirements for the implementation of collaborative tools and techniques.

This means that both 'soft' (i.e. organisational and cultural) and 'hard' (i.e. technological) concepts and tools, will be adapted and combined to achieve the objectives of the PIECC project. This approach was proposed because lessons learnt from past research initiatives suggest that the combined approach of 'soft' and 'hard' is the most sensible approach to be adopted.

In order to gain the requirements for the development of the collaboration methodology there needs to a high degree of collaboration among the participant group. This means that all participants in the data gathering, both researchers and participants need to be highly motivated. If this is to be achieved then, at least in part, the proposed interviews and workshops need the explicit backing of the senior

personnel in the participating industrial organisations. The people who are to participate in the interviews and workshops will need to be chosen carefully. The choice of people to participate needs to be made so that there is a recognition that people were chosen because their ideas and experiences are valued in the project. This was highlighted by Fulscher & Powell (1999) as a key aspect of a requirements capture methodology. The PIECC project is taking a user-based evaluation approach for three main reasons:

1. An important element of the project is to raise awareness of the opportunities provided by new collaboration and communication tools, and this is best achieved through the direct involvement of the end-users i.e. the business managers and project engineers;
2. Evaluations involving engineers and real working enable valid performance assessments to be made; and
3. User-based trials have the potential to uncover a greater number of usability issues and have a higher diagnostic value than a heuristic or checklist.

A summary of the different data collection techniques and sources has been made by Chung *et al.*, (2003). The summary provides a useful list of techniques that the PIECC project aims to use in its gathering of requirements for the collaboration method to be developed.

Level of data collection	Organisation	Project-team
Data collection techniques	Semi-structured interviews Electronic document review	Semi-structured interviews Unstructured interviews Electronic document review Observation
Informants	Cross-section of development community at representative sites, including: <ul style="list-style-type: none"> • R&D management • Engineering management • Research scientists • Process engineers • Market development managers • Application development managers • Technical services representatives 	Representative selection of project participants, including <ul style="list-style-type: none"> • Core team members • Functional management • Peripheral / supporting participants
Interview topics	<ul style="list-style-type: none"> • Organisational background and nature of current development activities • Culture of site and organisation • Meaning of collaboration and knowledge sharing in current activities • Use of collaborative technologies in current activities • Key barriers to dispersed collaboration and knowledge sharing 	Same as for organisation, plus: <ul style="list-style-type: none"> • Review of project history • Exploration of significant learning incidents / episodes, addressing the who, what, how questions • Perceptions of project performance • Perceptions of team relationships

Some of the techniques listed in the table are not appropriate for the time and budget constraints that we have on the PIECC project. However, the distinction made between the different ways of gathering data from a project team and the

organisation is useful for the PIECC project. The researchers wish to interview (through semi-structured and structured interviews) senior managers who influence collaboration policy; project managers who implement the policy; and the users who have to use the policy; in organisational and project contexts in the participating industrial organisations.

Figure 1 below summarises the importance of the requirements capture process to the completion of the PIECC projects' activities.

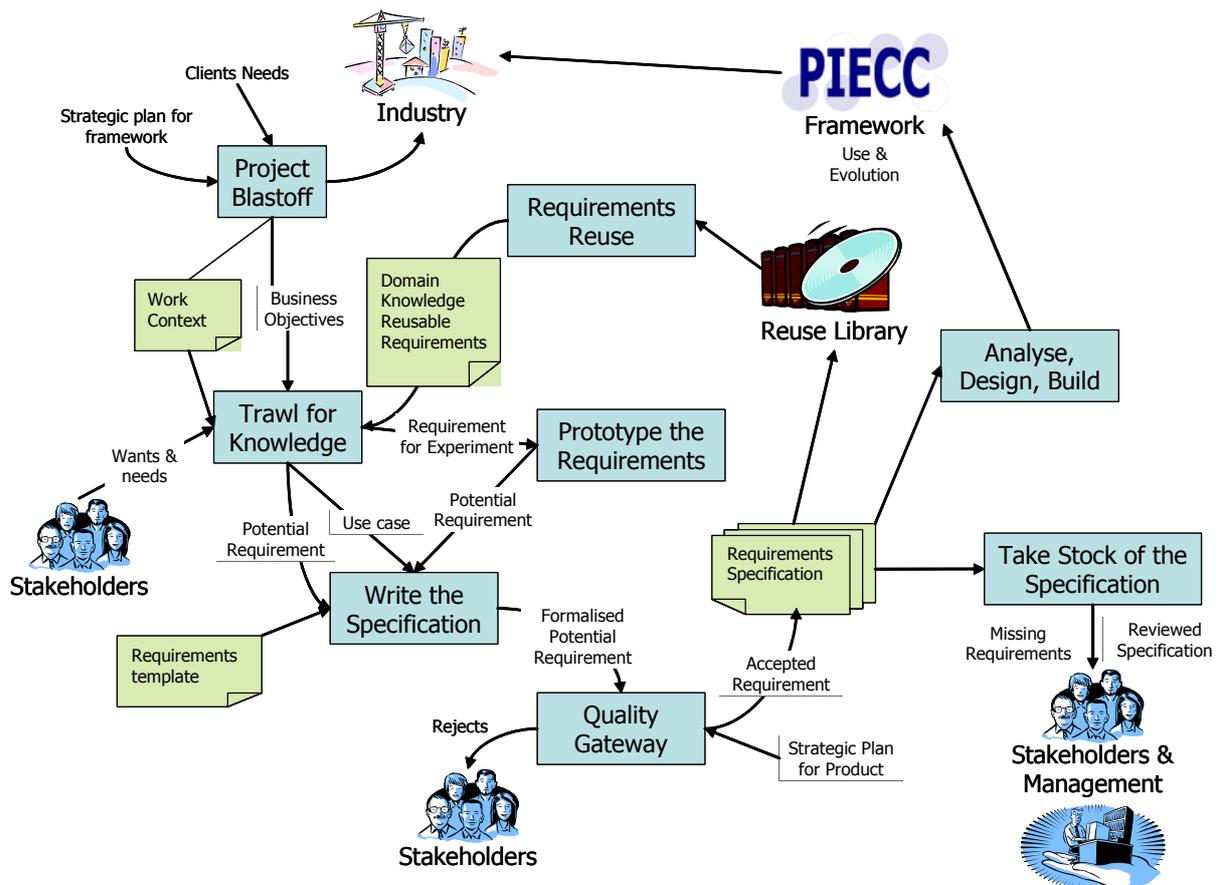


Figure 1: Typical requirements process (Robertson & Robertson, 1999)

The PIECC project will use a number of recognised techniques to capture, define analyse and disseminate requirements to the industry. The next sections will describe these techniques.

2. Semi-structured Interviews

Semi-structured interviews are conducted with a fairly open framework which allows for focused, conversational, two-way communication. They can be used both to give and receive information.

Unlike the questionnaire framework, where detailed questions are formulated ahead of time, semi structured interviewing starts with more general questions or topics. Relevant topics (such as cookstoves) are initially identified and the possible relationship between these topics and the issues such as availability, expense, effectiveness become the basis for more specific questions which do not need to be prepared in advance.

ACTIVITY	AWARENESS	PROBLEMS	SUGGESTIONS
COMPOUND PLANTING		QUESTIONS ABOUT PROBLEMS WITH COMPOUND PLANTING	
VILLAGE WOODLOT	QUESTIONS ABOUT AWARENESS OF VILLAGE WOODLOT		

Figure 2: Example of a matrix for a semi structured interview

Not all questions are designed and phrased ahead of time. The majority of questions are created during the interview, allowing both the interviewer and the person being interviewed the flexibility to probe for details or discuss issues.

Semi-structured interviewing is guided only in the sense that some form of interview guide, such as the matrix described in Figure 2 is prepared beforehand, and provides a framework for the interview

2.1 Purpose of the semi-structured interviews

- Obtain specific quantitative and qualitative information from a sample of the population
- Obtain general information relevant to specific issues, (i.e.: to probe for what is not known)
- Gain a range of insights on specific issues

2.2 Major benefits

- Less intrusive to those being interviewed as the semi-structured interview encourages two-way communication. Those being interviewed can ask questions of the interviewer.
- Confirms what is already known but also provides the opportunity for learning. Often the information obtained from semi-structured interviews will provide not just answers, but the reasons for the answers.

- When individuals are interviewed they may more easily discuss sensitive issues.
- Help field staff become acquainted with community members. Outsiders may be better at interviewing because they are perceived as more objective.
- Using both individual and group interviews can optimize the strengths of both.

2.3 Using the semi-structured interview approach

1. Design (facilitator and/or interview team) an interview framework such as the matrix example. Include topics or questions for discussion.
2. Establish the sample size and method of sampling.
3. Interviewers can conduct a number of practice interviews with each other and/or with a few community members, to become familiar with the questions, and get feedback on their two-way communication skills.
4. Record only brief notes during the interview. Immediately following the interview elaborate upon the notes.
5. Analyze the information at the end of each day of interviewing. This can be done with the interview team or group.
6. Discuss the overall results of the analysis with the participating organisation members so that they can challenge the perceptions of the interview team. This can make the process even more participatory.

2.4 Precautions in using the semi-structured interview approach

- A lot of extra information may surface during interviews. Team meetings can help identify similarities in responses.
- Assure that, in a personal interview, the person being interviewed understands and trusts that the responses will be confidential.
- It may take some practice for the interviewer to find the balance between open-ended and focused interviewing.
- In a semi-structured group interview people may interrupt one another or 'help one another out,' or not take turns. They may get off the topic completely.

Interviewers need some skills. The most common problem with interviewers is asking leading questions. Other problems are: failure to listen closely; repeating questions that have already been asked; failure to probe when necessary; failure to judge the answers; and asking vague or insensitive questions.

3. Unstructured Interviews

An unstructured interview is a spontaneous conversation, not a specific set of questions asked in a predetermined order. Information is gained by asking broad questions during a natural, free-flowing chat. Issues maybe discussed with some participants and not others.

An unstructured interview can go in any direction. There is no one right way to do an unstructured interview. The important thing is to gather and record information about what you are trying to develop. The interview can proceed in any order that is natural, and issues may be returned to discuss after they were first mentioned. Notes should be made to remind the interviewer to return to certain topics to gain clarification or seek more data on a particular subject / topic.

Some general rules for conducting unstructured interviews are:

- Avoid leading questions;
- Probe beyond the expected answer;
- Explore inconsistencies; and
- Record participants' own words.

Field notes should be reviewed and rewritten as soon as possible after each interview. Do not wait until the end of the day. After several conversations, it may be possible that the interviewer may forget who said what. The time spent on reconstructing each interview is as important as the time given to interviewing.

If a certain order is followed when rewriting the notes, it will be easier to summarize and compare the information obtained from all the participants. For example, the outline of the interview guide may be followed adding information that identifies and gives some background about the key informant. If the field notes are rewritten by hand, it is useful to make a form for each informant that leaves plenty of space to add information collected during follow-up visits.

4. Questionnaire

In this section, the key stages of implementing a questionnaire are discussed.

4.1 Designing questionnaires

There are many useful texts and guides to designing questionnaires, such as Newell (1993), Burns (2000), Bloom and Fischer (1982) and Kidder and Judd (1986). For the purposes of this document this section has summarised these resources into extensive guidelines that the PIECC project questionnaire should adhere to.

4.1.1 Getting started

Before starting to design any questionnaire, the objectives must first be identified. More specifically, the kind of information that the questionnaire is to elicit from its participants must be identified. This involves brainstorming ideas, and documenting all possible questions for incorporation into the questionnaire.

4.1.2 Constructing questions

In all of the four researchers guides – Newell, Burns, Bloom & Fischer and Kidder & Judd – the actual construction part of developing a questionnaire is described as being the most difficult. Below is a list summarising some useful rules of thumb from these methods:

- Keep questions *simple*. Avoid ambiguous, leading, double-barrelled and hypothetical questions, double-barrelled questions being ones that ask two questions in one.
- Avoid words of more than three or four syllables and over-long sentences.
- In closed questions, allow the respondent the option of answering with 'not appropriate', 'don't know' or 'have no strong feelings'. This helps the respondent and avoids difficulties later in interpreting questions that have no responses.
- Avoid overly sensitive questions – you are unlikely to get a 'true' response.

4.1.3 Use of open and closed questions

Historically questionnaires contain both types of question, with consensus across experts being that this is advisable. Closed and open questions are appropriate in different contexts and provide different kinds of information. The next sections will describe them and places to use each.

4.1.3.1 Closed questions

Closed questions are questions in which all possible answers are identified and the respondent is asked to choose one of the answers. In the following example, students were asked to evaluate the quality of programme materials (handouts, etc.) by a series of five closed questions (Fitz-Gibbon & Morris, 1962. p.62).

Some advantages of using the closed question approach are summarised as:

- Closed questions are an appropriate means of asking questions that have a finite set of answers of a clear-cut nature. Sometimes this is factual information but closed questions are also used for obtaining data on attitudes and opinions.
- They oblige the respondent to answer particular questions, providing a high level of control to the questioner.

- They involve minimal effort on the part of the respondent.
- They provide uniformity of questions and student responses, so they are potentially easier for evaluating the opinion of the sample group as a whole.
- They save time. Closed questions are less time consuming for respondents to complete, and this allows the questionnaire to ask more questions.
- They avoid problems of interpreting respondents' handwriting.
- They can provide better information than open-ended questions, particularly where respondents are not highly motivated.

Question 1: Help us measure the success of the programme. Please tick one box for each of the questions.

Programme materials	Excellent	Good	Fair	Poor	Unable to judge
The availability of the materials	<input type="checkbox"/>				
The quality of materials	<input type="checkbox"/>				
The durability of the materials	<input type="checkbox"/>				
The quantity of the materials	<input type="checkbox"/>				
The suitability of the materials	<input type="checkbox"/>				

Some disadvantages of closed questions may be summarised as being:

- Closed questions are appropriate only when the set of possible answers are known and clear-cut.
- If poorly designed, closed questions may be misleading and frustrate respondents. Typical problems are poorly designed questions, inappropriate questions and questions that have answers other than those listed.

4.1.3.2 Closed questions with ranked answers

These are closed questions for which answers are located on a scale of alternatives. This type of question is often used in evaluation to uncover respondents' attitudes and opinions. The scale often represents degrees of satisfaction with a particular service or degrees of agreement with a statement.

Always balance scales around a mid-point in the response answer. For example, respondent may choose from the following alternatives: strongly agree, agree, have no strong feelings, disagree, strongly disagree.

The advantages of using closed questions apply – see 4.1.3.1 above. Answers can be pooled across students to derive summary statistics that potentially measure an

overall degree of satisfaction/agreement. Summary scores can also be obtained from pooling across different questions related to some overriding issue.

Disadvantages of ranked questions include:

- Attitudes and opinions are complex and not readily summarised in a scale.
- Ranked questions do not provide means for students to elaborate on or explain reasons behind the stated degree of satisfaction.
- Summary statistics are powerful and if based on poorly designed questionnaires can be damaging.

The following are examples of ranked closed questions drawn from questionnaires used to evaluate teaching in anonymous economics departments.

Question 2: Please fill in one response for each question:

5 = excellent, 4 = very good, 3 = satisfactory, 2 = fair, 1 = poor, 0 = No opinion

Skill of the instructor	5	4	3	2	1	0
Instructor's effectiveness as a lecturer						
Clarity of instructor's presentations						
Instructor's ability to stimulate interest in the subject						

Question 3: For each of the following questions, please ring your answer – the module as a whole.

1	The module stimulated my interest						
	Disagree	1	2	3	4	5	Agree
2	The module was easy						
	Disagree	1	2	3	4	5	Agree
3	The module objective was fulfilled						
	Disagree	1	2	3	4	5	Agree

The next example shows how ranked questions may be pooled to generate an overall index (from Henerson *et al.*, 1987). In this questionnaire teachers in a new experienced-based science programme filled out a questionnaire about each of several children in their classes.

The scores for questions 2, 3, 4 and 5 were summed to obtain 'an enthusiasm index' for each child, a point on a scale of 4–20. There are difficulties designing and

interpreting these results, of course. Designers of the questionnaire have to be sure that every question used in computing the index indeed reveals information about a student's level of enthusiasm, and that the scales of the questions are consistent, i.e. that high enthusiasm is always indicated by scores close to or equal to 5. The greatest difficulty lies in interpretation of the final scores – usually researchers consider scores above or beneath threshold levels as revealing something definite about behaviour and attitudes, but it is difficult to know where to fix the thresholds. The alternative approach here would be to ask teachers to rate the enthusiasm of students.

Here is a portion of the questionnaire:

Childs Name: _____ —	1 Almost never	2 Never	3 About 50% of the time	4 Usually	5 Almost always
Does this child arrive at class promptly?					
Does this child listen carefully to explanations?					
Does this child work on assigned tasks without supervision?					
Does this child ask questions?					
Does this child volunteer for extra work?					
Does this child discuss science experiences with other children?					

4.1.3.3 Open questions

Open questions are described as questions that allow the respondent to answer in any way they wish. For example, students might be asked to respond to the following question: 'What do you feel is the best thing(s) about the course?' Some advantages of open questions are summarised as:

- Flexibility – the respondent can answer in any way he/she wishes.
- They may be better means of eliciting true opinions/attitudes and identifying how strongly attitudes are held or not.

Disadvantages of using open questions are:

- They require more thought and time on the part of respondent and analyst. This dramatically reduces the number of questions that the questionnaire can realistically ask.
- It is more difficult to pool opinion across the sample when questionnaires use open questions.

- Respondents may answer in unhelpful ways.

4.1.4 Open versus closed questions

"...closed questions should be used where alternative replies are known, are limited in number and are clear-cut. Open-ended questions are used where the issue is complex, where relevant dimensions are not known, and where a process is being explored..." (Stacey, 1969).

Most questionnaires are 'mixed', containing both open and closed questions. This is often the best approach, avoiding an overly restrictive questionnaire and one that is too open and difficult to analyse. Open-ended questions can be used to elaborate on the reasons underlying the answers to the closed-form questions.

4.1.5 Supporting text

All questionnaires must be supported with some text. This should contain the following features:

- The purpose of the questionnaire should be communicated clearly to potential respondents.
- Where deemed appropriate, the confidentiality of responses should be assured.
- The supporting text should contain simple instructions on how to complete.
- At the end of the questionnaire it is a nice touch to thank the respondent for his/her time and consideration.

4.1.6 Questionnaires should be attractive

Some key issues to remember are:

- Warm-up questions are recommended. These are questions that are simple to answer, such as questions on the age of student, year of study, degree programme, etc. Use of such questions makes it less likely that the respondent will disengage from the questionnaire.
- A good questionnaire has a coherent structure. Where possible, collect questions under definable subject areas and develop a logical order of questionnaires.
- Do *not* leave important questions to the end of questionnaire.
- Do not split questions over pages, or ask questions that require answers to be completed on subsequent pages.
- Do not overcrowd the questionnaire with questions and text.

4.1.7 Length of the questionnaire

It is advised that questionnaires should not be too long (for obvious reasons). However, the appropriate length does depend upon the purpose of the questionnaire, the type of respondents targeted and the type of questions. Appropriately chosen and designed closed questions are easy to answer, so you can have more of them. For the validity of the questionnaire, it is often appropriate to include a number of questions relating to one broad issue.

4.1.8 Testing questionnaires

It is essential that questionnaires are thoroughly tested prior to use. Bloom and Fischer (1982) identify five key criteria that may be used in evaluating the quality of a questionnaire – these are listed and discussed below. To evaluate a questionnaire effectively, it should be tested on an appropriate sample, which, in our case, is a sample of students. Test results are analysed and any changes to the questionnaire made. After initial implementation, questionnaires should continue to be evaluated as an ongoing process.

The criteria to use in evaluating a questionnaire are:

- *Purpose.* In evaluating a questionnaire, one has to be absolutely clear about the purpose. Often, insufficient thought is given to the purpose of a questionnaire. Designers need to identify at the outset what kinds of knowledge they are trying to obtain from the questionnaire.
- *Directness.* Questionnaires should be as direct as possible, i.e. they should ask questions that address as directly as possible the issues you want to evaluate.
- *Utility.* This criterion relates to the practicalities of implementing and using a questionnaire. Questions to consider include:
 - Is the questionnaire easy to administer, score and interpret?
 - What resources are involved in implementing the questionnaire?
- *Reliability.* A study is reliable if similar results would be obtained by others using the same questions and using the same sampling criteria. Where questionnaires are administered at the beginning of the lecture, the sample is biased towards those students who attend lectures – of course, this bias may raise the quality of responses!
- *Validity.* A study is valid if it actually measures what it sets out to measure. Here, much depends on the quality of the questioning.

4.2 Administering questionnaires

The key elements of the process of implementing and making successful use of questionnaires in the PIECC project can be summarised as follows:

- Agree schedule of organisations and people to receive questionnaires.

- Prepare participants.
- Administer questionnaire.
- Analyse questionnaires.
- Write summary report of questionnaire and determine plan for effective collaboration.
- Report to project stakeholders, including non-organisation participants.
- Implement action plan.
- Review changes made to collaboration in light of questionnaire.

Successful implementation of all stages of the process of evaluation requires active involvement of various individuals or groups. The questionnaire designers are primarily responsible for administering, evaluating and acting upon the questionnaire. Participants are responsible for answering the questionnaire and, together with the responsible authority within the PIECC project, for ensuring that their views are heard and acted upon.

A combination of these techniques will be used in the gathering of data for the PIECC project. Once the data has been captured the next stage is to decipher what it all means. The next section describes the methodology to be employed within the PIECC project

5. Data Representation

Requirements analysis concerns getting the user to identify needs, problems and expected benefits. The main deliverables are a statement of the functional requirement (sometimes referred to as the user specification or the requirements specification), and at least the outline of an acceptance test plan which will stand as the main reference point during the later stage of acceptance testing.

Historically, this process has been ill defined, and fraught with difficulty and misunderstanding (Edwards et al., 1991). Nowadays, it is subjected to the discipline of structured methods and is becoming better understood. It is very important to the success of the project, and must be seen as the area of greatest investment of time and effort.

Once the data has been collected it will need to be modelled and displayed for verification from the industrial partners. The PIECC project proposes to do this using a soft-systems methodology that has been tried and tested on other research activities, mainly Checkland's mode 2 SSM (soft systems methodology) (Checkland, 1981).

This provides a framework for integrating and reconciling diverse views on a number of issues through the generation and exploration of multiple root definitions of the issues. This will mitigate against building a framework for effective collaboration that although robust, does not meet the needs of its potential users. Where appropriate the application of use-cases and object sequence diagrams from the Unified

Modelling Language (UML) suite of tools, will be used to display the information gathered. The use of such UML tools means that the development of the framework for effective collaboration is driven by user needs, user roles (actors) and user understandings of the issues identified through the SSM analysis.

5.1 Checkland's SSM

Checkland's 'soft systems methodology' is a response to the difficulty in applying the approaches of hard systems thinking (e.g. physics and engineering) to business (human activity system) problems. Hard systems engineering tends to place an emphasis on:

- Measurable and objective criteria
- The isolation and control over variables
- Top down decomposition of systems into sub-systems.

'Hard' science analysis may reveal systems with unexpected behaviour and complex feedback between components but such methods when applied to 'human systems' encounter problems. These are summarised as:

- Organisation goals may be politicised, fuzzy or even disputed. It cannot be assumed that all organisational members accept the unitary views and goals of top management;
- Formal methods usually begin with a problem statement, but fixing the problem too early where people are concerned tends to conceal problems; and
- The research method itself may limit the 'things that will be elicited'. Conclusions will reflect methods and starting positions. They are clearly affected by human perception and commitments.

Checkland's SSM approach is his distillation of experience accrued from many projects where, typically in a consulting capacity, he and colleagues have been involved in advising on high level problems (e.g. company market development, reaping the benefits of information technology).

Adopting an SSM approach involves a recognition that the process of analysis (human interaction) is as important as precision in the data and outcomes. Following and experiencing an SSM approach will itself affect change. The participants change, the organisation may change. This arises because of the very process of exploring views about the problem and possible solutions. (SSM may frustrate directive, task-oriented people as it may be that specific goals are never reached!)

In principle, an SSM project is managed by participants with a consultant-facilitator. Figure 3 illustrates the different parts of Checkland's SSM. Each of the different parts is described in more detail in the subsequent sections.

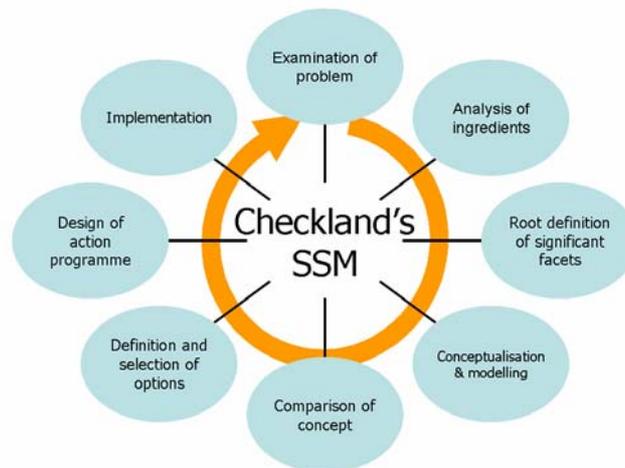


Figure 3: Checkland's Soft System Methodology

5.1.1 Problem Expression

Stating what the problem is requires situational and problem analysis - comprehending the problem domain of interest. What exactly the problem is will not be known until this analysis is done. A key feature of SSM is to keep the project vague and wide for as long as possible - don't jump to conclusions nor assume or ignore the current situation e.g. by concentrating on idealised futures.

The analysis may involve the use of many techniques such as a checklist of things to look for, question sets, models and frameworks of examination. It is important not to become fixed on the use of one technique or analytical approach only.

5.1.2 CATWOE Analysis - towards a 'rich-picture'

Part of 'problem expression' is identifying the situational elements and parties involved. Checkland uses the mnemonic CATWOE to describe the human activity and situation.

What is a CATWOE? A CATWOE is defined as:

- C** The 'customers of the system'. In this context, 'customers' means those who are on the receiving end of whatever it is that the system does. Is it clear from your definition who will gain or lose?
- A** The 'actors', meaning those who would actually carry out the activities envisaged in the notional system being defined.
- T** The 'transformation process'. What does the system do to the inputs to convert them into the outputs.
- W** The 'world view' that lies behind the root definition. Putting the system into its wider context can highlight the consequences of the overall system. For example the system may be in place to assist in making the world environmentally safer, and the consequences of system failure could be significant pollution.
- O** The 'owner(s)' - i.e. those who have sufficient formal power over the system to stop it existing if they so wished (though they won't usually want to do this).
- E** The 'environmental constraints'. These include things such as ethical limits, regulations, financial constraints, resource limitations, limits set by terms of reference, and so on.

NB: Actors, clients, owners etc may overlap.

CATWOE analysis helps in working out a 'root definition' and expressing the domain of the problem. Early conclusions about who and what is 'important' should be avoided.

5.1.3 Rich Picture Diagrams

Checkland encourages the problem researchers to illustrate the system of interest with diagrams or 'rich pictures' (a diagram 'without rules'). Rich pictures show

- the people involved
- the purposes they state
- their desires and fears (use think balloons).
- symbols to express environmental detail (activities, similar and contentious processes, relationships (push-pull) and transactions across organisational boundaries).
- how and where interests agree or conflict.

Rich pictures are cartoons - funny, sad, political, all at once. The pictures of course are generated by the analysts and hence are selective, representative of their perceptions / questions and their areas of uncertainty.

5.1.4 The Process View

Using CATWOE in analysis discussions and drawing a rich picture encourages a process approach. Participants can test assertions, assumptions, positions and the integrity of data/information.

SSM targets existing systems. The focus is on the investigation and definition of the existing features of the organisation and how these interact externally and internally with the system as a whole (hence 'holism') and sub-processes. Consideration must also be given to the situational and organisational 'climate' (efficient, tense, wet, cold, hot, neurotic, sloppy, democratic, sulky, joyous, etc.).

After problem examination and definition, SSM participants 'should' be able to 'see' the organisation:

- differently and more fully;
- differentiate levels and sub-problems of the whole.
- 'facts', positions and viewpoints at varying levels of detail
- articulate many 'problem' statements, some major and some trivial.
- debate the evaluated assumptions about the trivial and the major

5.1.5 Root Definition

A root definition for which there is a consensus – at a point in time – is an important outcome of the SSM process. The analyst-researchers next define 'the arena of

concern' more precisely i.e., synthesis the 'root definition'. A move is made towards a well-defined statement about the area of concern, its activities and components. This may represent a minimum that can be agreed in terms of the real activity domain. People should be able to see what they are agreeing to and what has been left out. It is for internal, creative use not public dissemination. A root definition defines both what is agreed **and** what is still unresolved plus associated things.

5.1.6 Conceptual Modelling

With a root definition and a CATWOE rich picture – the analysts can turn to an imagined, 'ideal' system. Creativity and solution generation time is spent exploring the wild and fanciful; defining the musts and the desirables; evaluating, choosing and agreeing criteria for choosing and deciding future actions. A 'best' model may be proposed and the criteria maybe implicit, but it must be clear about what the criteria are and what has been systematically left out of the formula!

5.1.7 Five Es for Decision Criteria

- efficacy (will it work at all?)
- efficiency (will it work with minimum resources?)
- effectiveness (does it contribute to the enterprise?)
- ethics (is it sound morally?)
- elegance (is it beautiful?)

Originally Checkland's approach was fairly formal – SSM was first presented as a regular, prescriptive, staged, logical model. But today a softer, looser, more flexible process approach with fewer steps is suggested. The loose 'process of engagement model' recognises the importance of related management and support activities. Root definitions, rich pictures and 'idealised' solutions need to be in sufficient detail to enable practicalities and implementation issues to be evaluated. Resource demands and performance measures need to be articulated. However a complete specification is unlikely to be fully implemented as it stands. Identifying implementation steps is the next phase.

5.1.8 Compare the Concept with the Current

The conceptual model should provide inspiration. Its purpose should not be seen as criticism or threatening (these however may arise in any human activity system) but seen as simply comparing the concept with the current system.

The current system exists. It does something. The adage 'if it works, don't change it' may spring to mind but after such analysis that has already taken place, a number of questions may now arise. Typical ones are:

- why aren't we doing it the 'ideal' way?
- what reasons explain our current practice and behaviour?

- how do we, at present, measure up to the ideal given the criteria of efficiency, effectiveness, ethics and elegance and group/political opinion?

5.1.9 Agree on Changes

If the current system is imperfect then an agreement on desirable changes needs to be made. These presumably may move the organisation towards the ideal. Typical issues to consider include:

- retrace the footsteps and revisit the synthesis;
- re-evaluate the insight gained from each stage;
- examine how proposals may affect and be received by stakeholders;
- in what way will changes for which there is no consensus/agreement result in problems?

The outcome should be that there is some form of agreement, and permission is given by the organisation to move to the next stage.

5.1.10 Action/Implementation

The outcomes of such a process are often not predictable. Implementation is a new human activity. It means new compromises. If the root definition and option analysis is still fuzzy and if there is no ownership by those who hold the reins of power (the decision-makers) then the SSM process could go into an infinite loop and start the whole thing over again, this should be avoided at all costs.

The final outcome will not completely match the planned change. It is often , and should be measured, to see how close they are.

Does an SSM project ever finish? It doesn't need to as it embodies learning – mainly: the human learning and adaptation philosophy. There may be convergence. Issues debated early on may dissipate. Implementation discussions may focus more on participant confidence, ability and understanding of the enterprise.

5.2 Criticisms of Checkland's SSM

- It is not a 'how to build a system guidebook'. It is heuristic not algorithmic;
- There is no real method. SSM does encourage commitment and it provides a forum to bring diverse interests together;
- The open endedness makes it difficult to manage. An SSM project is unlikely to be a complete success or a failure but it should reflect a natural, evolutionary approach;
- SSM can too easily ignore environmental and structural determinants and questions of power. Organisational members do not have equal choice and it is naive to think that everyone can openly discuss problems, perceptions and

- needs. Yet open, willing and supported discussion is more likely to open up organisation culture, thus encouraging learning and joint problem solving;
- Openness and togetherness are implicit and explicit values of SSM. These are not easily understood values in a confused, conflict and contradiction-oriented or power-centred organisation.

5.3 Summary of Methodology

The PIECC project aims to gather information from a number of unstructured and semi-structured interviews in each of the participating industrial organisations. We aim to interview people from the policy making, implementation and use levels of collaboration tools and methods from each organisation.

The collection of data will be recorded and analysed using Checkland's SSM techniques. These results will be verified with the participating organisations. The analysis will provide the project with the needs and requirements for the development of policy, methods and tools to enable effective collaboration in the construction sector.

A graphical representation of the methodology is provided in Figure 4.

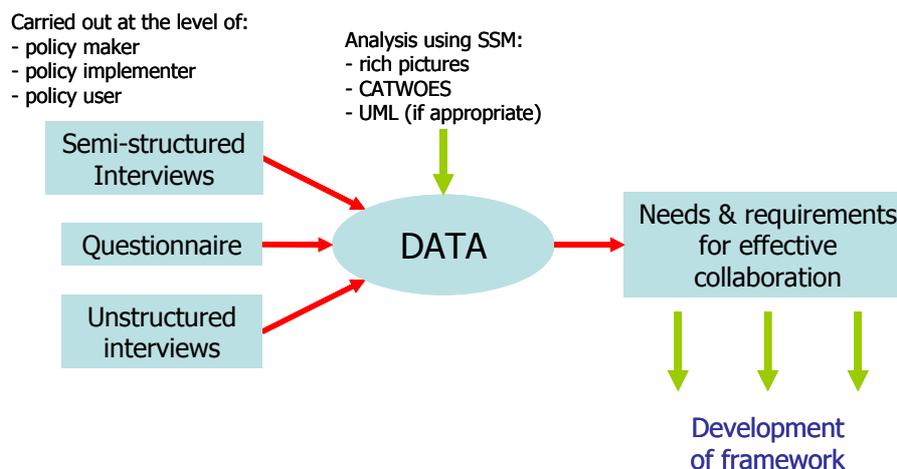


Figure 4: The PIECC projects' requirements capture methodology

6. Requirements for Effective Collaboration

To enable an organisation (or organisational unit) to 'effectively collaborate' there must be a harmonisation of three key strategic areas: business, people, and technology.

Usually collaboration enables participants to build up capacity to complete a set of tasks that one sole organisation would find difficult to achieve. The collaboration eliminates fragmentation, duplication and distrust. This is achieved by intelligently using available resources wisely, sharing the multiple project risk factors across

multiple domains, and enhancing staff and organisational motivation. This can only be achieved 'effectively' by bringing together and aligning the three strategic areas of business, people and technology (see Figure 5).



Figure 5: Key areas for effective collaboration

6.1 Key areas for collaboration

There are many factors that are likely to influence the success or failure of working collaboratively, many of which have already been discussed in this document. It is important to realise that no two collaborations will progress in exactly the same way or within the same time frame. Each collaboration must find a way to proceed that is consistent with its unique circumstances and composition.

There are 6 key areas that are deemed critical for effective collaboration in construction:

- **Vision** – all members of the collaboration agree on the collaborations aims and objectives;
- (Stakeholder) **Engagement** – collaboration leaders need to ensure that all key participants are consulted as to the practices to be employed during the collaboration;
- **Trust** – time and resources are needed to enable all participants to build trusting relationships;
- **Communication** – a common means of communication is decided by all key participants in the collaboration;
- **Processes** – both business and project, that describe to all key participants how the collaboration is to work on a day-to-day basis;
- **Technologies** – an agreement on those to be used to ensure the collaboration is easily implemented and maintained.

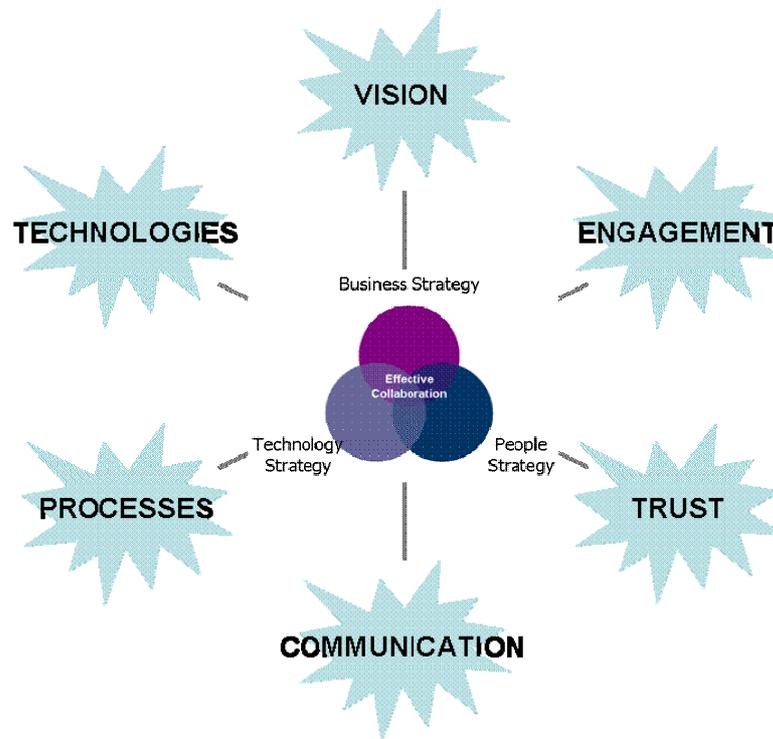


Figure 6: Areas to be addressed in the strategies to enable effective collaboration

All 6 areas need to be addressed in the three strategic areas described to have 'effective collaboration' in the organisation / project context. However, the strategies may be different depending on the context of the proposed collaboration. Differences exist in effective collaboration at the project and organisational level.

One of the aims of the requirements capture exercise was to determine the importance of each of these areas for a strategy for effective collaboration. A set of questions were devised to determine which, if any, of the strategies depicted in Figure 5 were of most importance to effective collaborative working. Other questions were devised to determine the importance of the 6 key areas (depicted in Figure 6) to working collaboratively. The results of these are discussed in section 6.2 and section **Error! Reference source not found.** respectively.

6.2 Results from questionnaires

The PIECC project sent out (via partners, contacts and the project website) the developed questionnaire. For the first iteration of the needs and requirements document the PIECC project has thus far received responses from 16 people in 7 different organisations their views on collaborative working.

The aim of this section is to bring together information from these questionnaires and provide a summary of information found in some of the key questions asked within the questionnaire. One of the key questions asked was:

4.1 Please rank the following three areas in order of importance to effective collaboration

	Essential	Very important	Important	Not important
Business Processes & Procedures	[.....]	[.....]	[.....]	[.....]
Technology	[.....]	[.....]	[.....]	[.....]
People	[.....]	[.....]	[.....]	[.....]

The results of this question are depicted in Figure 7. Each of the options in *Question 4.1* was given a score. *Essential* was given 3, *Very important* 2, *Important* 1, *Not important* 0. This enabled the %s shown in Figure 7 to be worked out. The results are shown in Table 1.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
People	3	3	3	3	3	2	2	2	3	3	3	3	3	3	2	3
Business Processes & Procedures	3	2	2	1	3	2	1	3	3	2	3	2	2	3	3	2
Technology	3	1	2	1	3	1	0	1	1	1	3	3	1	3	2	2

Table 1: Results from Question 4.1 of the PIECC questionnaire

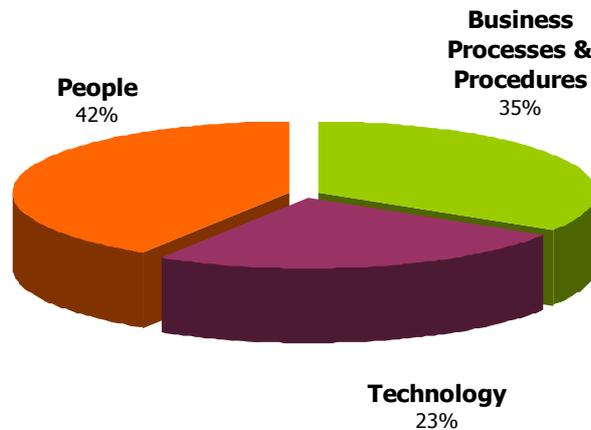


Figure 7: The importance of the 3 key strategies for effective collaboration

The results show that respondents believe that 'people' are the most important aspect of a successful collaboration. This is followed by 'business processes & procedures' and 'technology' aspects respectively. This means that the focus of any developments of the PIECC project should concentrate on the people and process aspects of collaborative working. However, no study of collaborative working can exclude the technology. It is the intention of the PIECC project to highlight tools and techniques that allow technology to be used in collaborative working, and show how these technologies may be used in a supporting role of the processes and people aspects.

Another question to be asked was designed to determine the importance of the 6 key areas shown in Figure 6. The question was:

- 4.2 Research has shown that there are 6 critical success areas to ensure effective collaboration. Please rank the importance of these – (1 is highest, 6 the least, you may only use each number once).

A shared vision	[.....]
Engagement of stakeholders	[.....]
Building trusting relationships	[.....]
Good communication	[.....]
Clearly defined processes	[.....]
Well integrated technologies	[.....]

The users were asked to rank the success areas between 1 and 6, 1 being the most important down to 6 being the least. In order for a ranking to be made easily the results were scored from 6 for the most important down to 1. This is shown in Table 2 for clarification.

Importance score from questionnaire		Score for ranking purposes
1	~	6
2	~	5
3	~	4
4	~	3
5	~	2
6	~	1

Table 2: Clarification of scoring system for success areas question

The results for question 4.2 are shown in Table 3 and Figure 8.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Communication	5	5	5	2	5	5	6	6	3	6	4	6	2	6	3	4
Trust	2	6	3	6	4	6	3	4	4	5	3	5	6	2	4	5
shared Vision	4	3	1	5	3	4	5	1	6	4	1	2	4	5	5	6
Process	3	4	4	3	6	2	2	5	5	2	6	3	3	3	2	2
Engagement	6	2	6	4	2	3	1	3	1	3	2	1	5	1	6	3
Technology	1	1	2	1	1	1	4	2	2	1	5	4	1	4	1	1

Table 3: Results for question 4.2 of the PIECC questionnaire

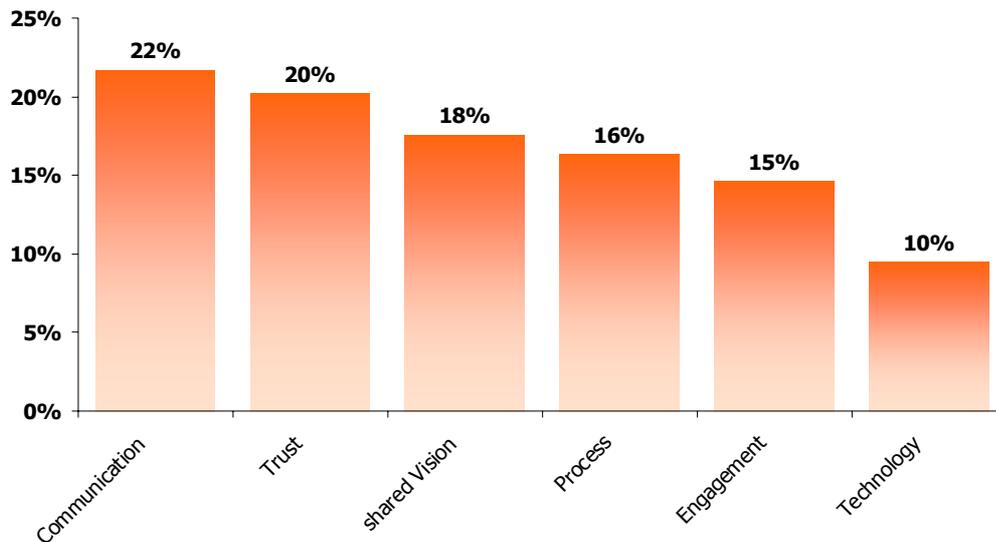


Figure 8: Graphical representation of the results to Question 4.2 of the PIECC questionnaire

6.2.1 Other results

Of the participants who have completed the questionnaire 81% of them have been part of a team who have been responsible for the planning and implementation of collaborative environments / projects. In this 81%, 77% of environments / projects had protocols available that described processes to aid in the planning and implementation of the project / environment, with 66% of participants finding such protocols useful. When asked "...do you think that such a protocol would aid the collaboration planning and implementation process..." 66% of respondents said they would, 7% said that they would not, and 27% did not know.

When asked what were essential contents of such a protocol, Figure 9 summarises the results in order of importance. Figure 9 tells us that all the aspects listed are important to the development of a methodology that enables the effective planning and implementation of collaborative working in the construction sector. However, there are a number of aspects (communication procedures; interoperability standards; building trust; a common vision and priorities; and engaging key stakeholders) are the aspects that really make a significant contribution to the success of planning and implementing effective collaboration. It is the intention of the PIECC project to provide a framework that brings together these aspects listed in Figure 9 in the next stages of the project.

As well as completing the project questionnaire, pertinent questions were also asked in a number of interviews to determine the needs and wants of personnel working in the construction industry. Much of what was said during these interviews complimented the answers given in the questionnaires. However, there were some issues that were not covered, and are described in section 6.3.

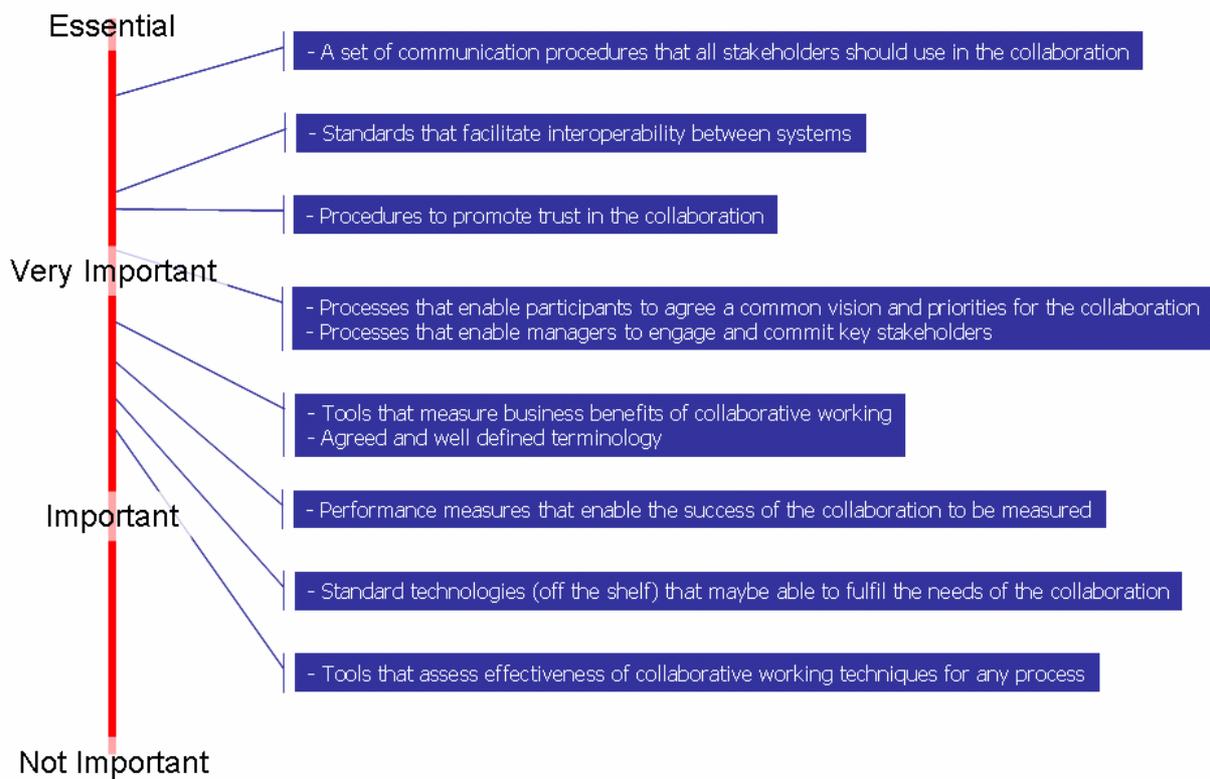


Figure 9: Importance of aspects of a collaborative working protocol

The PIECC project took the opportunity to determine which of the collaboration tools available to the construction industry was being used in projects. Figure 10 summarises these results. We can see that 'Asite' is the most commonly used with 'BIW' and '4projects' the next popular.

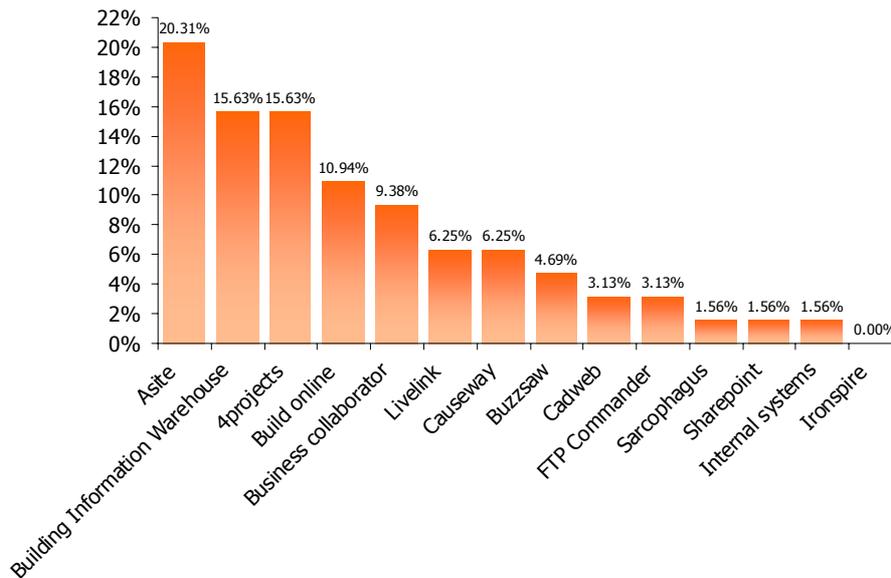


Figure 10: Results of the use of different collaboration software

The questionnaire also asked the respondents what were the key aspects for collaboration software / system. Figure 11 shows the results of this question.

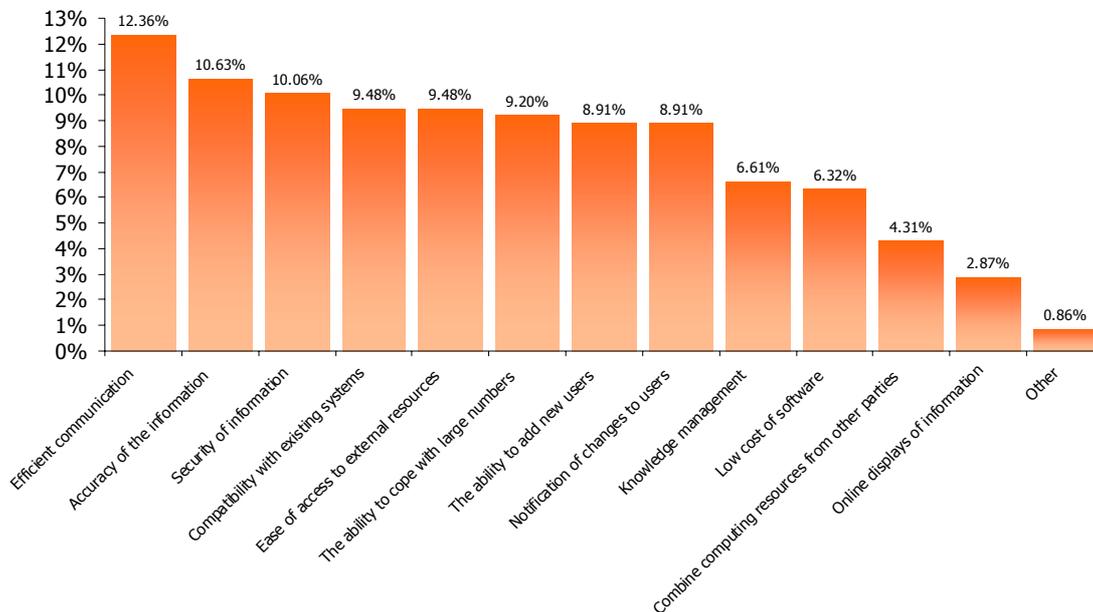


Figure 11: The most important aspects of collaboration software

Although the development of software to enable effective collaboration is way beyond the scope of the PIECC project it is important for the project team (PIECC) to realise what are the important aspects of collaboration software, and build procedures into the framework that can be addressed by collaboration software.

6.3 Results from interviews

Many of the different collaboration software that is available have failed to address the familiarity of the tools used by participants in the collaboration. Many lessons can be learnt from the Knowledge Management areas. It is desirable to have some form of "help template" that is available to new users of the tools. Once they are familiar with the tool, then this template disappears and does not bother the user in the future, unless requested by them. Respondents commented on "...being frustrated with collaboration software...". Evidence is needed to show those that are frustrated need not be in the future because of new developments in the planning and implementation of collaboration software and systems.

Respondents also voiced concerns about collaboration software adding an extra layer to communication amongst participants in a project. This has often led to a single person being employed to interface between the collaboration software and the design team to prevent time being added to the design phase of a project.

Any framework developed must address the issue of "conflict resolution" and the "blame culture" of the industry, i.e. it must prevent the "shutters coming down" as soon as any problems are identified in the workings of the collaborative environment

/ project. Information is needed to enable conflicts to be managed, and reduced to a minimum throughout the duration of the collaborative project / environment. The industry needs to work towards a culture of 'identification of the problem – address it – solve it – and then move on' rather than try and appoint blame for the problem and its associated ramifications.

Another issue raised by some respondents concerned contracts – namely there does not seem to be one available that allows for collaborative working. There is a need for contracts that are different from traditional construction projects – they take into account long term relationships with clients and other project stakeholders, and should build upon the principles laid down in the Latham report. Other contractual aspects that need addressing include: payment mechanisms – the traditional methods are not appropriate for collaborative working.

It is worthy of note that although many of the respondents described their organisations working towards collaborative and strategic partnerships with their supply chains, there is actually little evidence of this actually being achieved. There are many reasons for this but one that was continually voiced in the interviews was a lack of contract that takes into account the new ways of working that working collaboratively now entails.

One issue that is beyond the scope of this project, but has been raised by a number of the interviewees concerns the "*ease of use of interfaces*". Respondents felt that the intuitiveness of these at this time means that much training is needed before project participants can use them. The actual layout of them also proves difficult with some respondents commenting that "*...there seems to be a lack of thinking by designers...*". Respondents would like to see simpler interfaces designed for project collaboration software.

Any developments made within research projects such as PIECC should be aiming to build upon aspects developed by the AVANTI programme. Nearly all interview participants stressed the importance of the work currently being undertaken by AVANTI and see the PIECC project as adding to this work.

A small number of respondents queried the inclusion of vision and engagement (of stakeholders) as part of a framework for effective collaborative working. Their view was that if people are already sat around 'the table' then the vision and stakeholders are already chosen. Why waste time choosing them? Why not get on with the project with who you have? A recognition that these issues exist and may need addressing, but they are not as significant as the processes and technology to be used in the project, and it is on these that participants should concentrate their efforts.

6.4 Summary of needs and requirements

The interviews and questionnaires have enabled a clear set of needs and requirements to be determined for the PIECC project. The captions below summarise the comments and questions provided by the industry (represented through the project partners and other key personnel) for a framework to plan and implement

effective collaboration. They provide an overview of what is required to enable effective collaboration to be planned and implemented in a more productive manner in the future.

- *"...a recognisable model for collaborative working does not exist at this time – needs developing to enable a move forward..."*
- *"...processes that enable participants to agree a common vision and priorities for the collaboration – a route map for how the project is going to proceed, and must include suitable time for review of progress against vision and priorities..."*
- *"...standards that facilitate interoperability between different software and systems – we are fed up with learning a new system for every new project!!..."*
- *"...examples of good practice / case study material that shows tangible business benefits of collaborative working..."*
- *"...procedures to promote trust in the collaboration – a key person needs to be in charge, they provide leadership, leading (hopefully) to better performance of the team, to build trust within the team..."*
- *"...a set of communication procedures that all stakeholders should use in the collaboration..."*
- *"...intuitive interface design of software to reduce the requirement for training on new members of a collaborative project / environment..."*
- *"...suitable (and appropriate) help templates / screens for users to familiarise themselves with the software tools. They are removed when a level of competence is reached..."*
- *"...evidence of good practice of collaborative working to be published to alleviate frustration of the industry..."*
- *"...must build upon work being done in other aspects of collaborative working – the AVANTI programme for example..."*
- *"...clarification of professional liability of information generated is needed. Who is responsible for the information generated and its trustworthiness? A right balance between the technology and professional liability is the issue to building trust..."*

7. Conclusions

This deliverable has described the methodology for the capture of the needs and requirements from the UK construction industry for the planning and implementation

of effective collaboration. Using this methodology the research team sent out the questionnaire to a number of industrial organisations to determine their needs. From these results a number of interviews were arranged to gain more detailed information from key individuals from the industry.

The results from these interviews and questionnaires were then analysed, reported on and summarised in the latter sections of this document. The results show a wide range of needs. Not all of them will be addressed specifically by the PIECC project. However it is the intention of the project to highlight information that may address these needs in the development of the framework on the PIECC project.

Acknowledgements

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