A Hybrid Approach to Upstream Requirements: IBIS and Cognitive Mapping

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We address the problem of eliciting requirements for large-scale technical systems with multiple stakeholders, significant technological uncertainties and extended timescales. Our focus is on the early, 'upstream' stage where options and commitment are just beginning to emerge. Drawing both on problem structuring methods found in management science and on design rationale techniques found in software engineering, we have developed a hybrid process and accompanying software tool support to facilitate consensual problem definition. Negotiation occurs through a combination of informal group problem structuring (cognitive mapping) and incremental formalism (dialogue mapping with IBIS) of requirements. The process and tool have been successfully used in 1) strategy development for revision of a UK Government administrative system, and 2) the negotiation of a twenty-five year vision by stakeholders in a major technology company.

1. Introduction

Large-scale systems do not come into existence easily. Stakeholders rarely share a unique problem definition, and political, social, economic and environmental factors can have a significant and often dominant influence on the decisions made [16]. An initial obstacle is to get from an unstructured mess [24][17] to a workable problem definition, and from that to an early set of requirements [19]. This is what we term the 'upstream' stage of requirements engineering.

Existing approaches to requirements engineering acknowledge that requirements stem from different stakeholders, from the operational environment, from the enterprise, and from the availability of new technologies. These approaches also acknowledge that the gestation period may be many years, in which time the staff involved, the available technologies, the organisations priorities and economic situation may change. Reconciling the requirements and implementing them is a crucial issue and is logically and technically difficult [16], is political [1] and is prone to points of crisis [22]; however, eliciting the requirements is often treated as if it were simple, if it is discussed at all. In fact, elicitation is often a highly fraught, conflictual undertaking requiring careful and intensive management by project managers and engineers.

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Deleted: Moreover, existing approaches do not tend to consider the upstream stage of requirements engineering where elicitation must address what needs to be done and why, and not yet how this is done. Finally, whatever specification of requirements ultimately emerges, the process of elicitation should itself need to be seen as accountable.

In this chapter we present a process and tool entitled Wisdom that supports the activity of requirements elicitation. The Wisdom process and tool addresses the primary obstacle in eliciting requirements: problem definition. This phase revolves around how to structure the problem or need which the system will answer. These early stages of requirements elicitation are primarily concerned with the high level business or organisational requirements. Failure to get these right means that the more detailed requirements will not be aligned with the needs of the organisation. At this early upstream stage, getting the right information (from multiple sources) is only part of the problem. Interacting around that information to structure it in ways that people will accept is also crucial. Conflicts are inevitable at this phase of negotiation [16]. The Wisdom process and tool negotiates these conflicts using a combination of formal and informal group processes supported by software. It also seeks to render this kind of negotiation accountable. We are concerned with how expansive rationale can be

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Deleted: . By using the name Wisdom we are not attempting to specify what it means to be wise or receive wisdom, there being a diverse literature on this. Rather, the name is used to emphasise use of the process and tool to draw out existing organisational knowledge at the right time.

captured at the beginning of a project, and issues be explored without decisions necessarily being made.

In section 2 of this chapter, we provide a description of the Wisdom process. In section 3 we provide an account of the Wisdom tool, which is designed to support the process, with examples of usage in section 4., Finally, in section 5, we reflect on experiences with the system.

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2. The Process

The Wisdom process is a hybrid of existing techniques from management science and software engineering. This section will begin by describing those techniques and then continue by explaining why Wisdom brings the two together and describing how this is done.

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2.1. Background

Figure 1: Cognitive Map

Figure 2: IBIS Dialogue Map

Two problem structuring techniques provide the background to Wisdom. The first is cognitive mapping, used in conjunction with the SODA (Strategic Options Development and Analysis) [12] approach to assisting strategic decision making. The second is dialogue mapping with IBIS. Cognitive mapping as a problem structuring technique has previously been introduced into requirements engineering [16]. The design rationale field, while not explicitly focused upon requirements engineering, has historical links to the problems faced: design rationale was originally proposed in the context of software system design as a means of presenting 'the design alternatives which were considered, the arguments for and against these alternatives and the reason why final design decisions were made' [21]. Dialogue mapping with IBIS is a particular technique useful for capturing and structuring design rationale.

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2.1.1. Cognitive Mapping

The development and use of cognitive maps within management science owes much to the work of Eden. [12][13]. An idea is represented in a cognitive map by a node and links between different nodes are intended to represent the relationship between the concepts [13]. These links are causal, in that 'concept A' may lead to, or have implications for 'concept B'. This linking structures the concepts into a hierarchy showing the positive or negative cause and effect between individual concepts across the model (see figure 1). A complete model that represents the problem space comprises a series of interconnected maps.

Node types can be distinguished in the cognitive map by using different fonts and colour coding for each goal, strategy, option and issue. Ad-hoc coding of the concepts helps with visualising or navigating the map, as well as analysing it. The key to supporting decision making with cognitive maps lies in the SODA process of building maps collaboratively in workshops with groups sharing and negotiating problem issues.

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Deleted: Maps can be built for groups, either by merging individuals' cognitive maps or directly using a facilitator in a brainstorm-type workshop [13]. These SODA workshops are computer assisted using Group Explorer software in conjunction with Decision Explorer and a networked set of PCs [13]. The group workshop needs to provide relevant tasks to facilitate group communication, and manage the group dynamics. Its process must demonstrate to participants that the decision making procedure is sensible - that it is procedurally rational.

A SODA workshop usually begins with a relatively free ranging brainstorm prompted by a question such as, "what are the issues facing the organisation over the next x years?" These concepts are clustered and further developed by the group. Links are added between concepts and concepts colour coded according to their type. This problem structuring helps build the big picture and identify key concepts. These key concepts are then ranked by voting to prioritise the issues on which to spend workshop time. The choice of activity at any particular point depends on what the facilitator considers most appropriate to the task.

During the course of a typical SODA workshop a group might cycle through several different brainstorming activities and elaborate various key issues through in-depth discussion. Goals, objectives, strategies and options will be established before agreeing actions and a way forward. Commitment to the action plan is achieved through developing shared understanding between participants through participation in the workshop process. Beginning problem definition in this way negotiates conflict upfront, rather than trying to resolve it after requirements have been articulated.

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2.1.2. Dialogue Mapping

Here we discuss dialogue mapping, a facilitated form of argument visualisation [7] that can be used as a means to capture design rationale. In dialogue mapping, maps of linked nodes similar to cognitive maps are produced, but with stronger semantics and a finer grain of detail. There are a number of different argument visualisation approaches with supporting software tools [15]. Most of these have been inspired by the work of Rittel [25] who devised IBIS. Of these, the most expressive is DRL, implemented in SIBYL [18]. The expressive power of DRL stems from a rich polymorphic node type hierarchy and a set of typed relations that can be used to connect node instances. In contrast to DRL, QOC [20] is a much simpler notation which involves three node types: question, option, and criteria. Options can be evaluated in terms of criteria by linking instances of these node types using supports or challenges relationships. IBIS differs from the other design rationale notations in that it is not concerned with evaluating alternatives, but is geared towards the deliberation process. Conklin has further extended IBIS with regard to the process of using it in face-to-face meetings [8]. Buckingham Shum [5] provides a comprehensive introduction to the aims, uses and applications of the principal design rationale notations and presents the realities of using them.

The nodes of an IBIS map are labelled as questions, ideas or arguments (pros and cons). A map begins by asking a question around an issue that prompts for ideas. The pros and cons that are raised are added against each idea. The links are not causal, rather nodes are connected by links with different semantic types. For example, ideas respond to questions and arguments support or object to these ideas (see figure 2). The IBIS notation ensures that the map represents the dialogue taking place in the group, rather than representing the decision space. The IBIS notation represents both the argument and provides a protocol for interacting. Questions are central to IBIS, particularly when there is disagreement or misunderstanding around an issue. The issue is transformed by the facilitator

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into a question, which is then explored as part of the map. This diffuses the personal issues that arise from adversarial discussion and supports collaborative enquiry of the "Yes, and ..." rather than "Yes, but ..." kind.

A session does not begin with a wide-ranging brainstorming activity, instead a question is posed that prompts for ideas (options) that directly address the problem. A map is built outwards from this, with parallel maps being added. This initial stage is less wide-ranging than SODA and risks elaborating a side issue in great depth before the true problem is identified [31]. It relies on the group self correcting itself to identify the real issues. It does however lend itself to fine-grained analysis of a specific issue and its structure makes it easier to maintain the map over time.

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2.2. The Wisdom Process

Both cognitive mapping and dialogue mapping address different aspects of the problem of eliciting upstream requirements. While both techniques have been used in isolation by the management science and computing communities respectively, we are not aware of any work that has combined them. The value of the Wisdom process lies in capitalising on the strengths of both cognitive mapping and dialogue mapping; we view the two techniques as complementary.

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For typical systems engineering projects, thie upstream requirements phase is essential to generate a sufficient level of understanding of the project. Furthermore, this understanding should be agreed and common to the many stakeholders who have an interest in the project. The Wisdom process is not a hard process leading to finalised requirements but aims to provide stakeholders with a common and agreed understanding with which they can proceed. Cognitive mapping is used in the initial phases of the Wisdom process. As reported earlier, cognitive mapping is fundamentally used with a group process to support procedural rationality. The result of cognitive mapping is agreement and commitment to a way forward that will likely have involved negotiation. Dialogue mapping is used in later phases of the Wisdom process. Dialogue mapping differs to cognitive mapping since its starting point is a relatively narrow issue. Dialogue

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mapping is more suited to situations where the key issues tend to be known and the focus is a more detailed analysis of these. In addition, argument visualisation languages are more formal, being based on a type system with defined semantics. In the context of the problem definition phase, we use dialogue mapping to explore key issues that have been identified during cognitive mapping. The more formal maps enable rigorous discussion and analysis of individual issues. During the early phase, cognitive mapping gives a macro view of the problem, and in the later phase, design rationale maps provide a micro view.

We suggest that for systems engineering projects, cognitive mapping and dialogue mapping are not just complementary, but necessary. Cognitive mapping naturally promotes divergent brainstorming activities that are necessary to understand the systemic nature of the problem. Furthermore, cognitive mapping avoids groupthink, which is where a single issue becomes the focus of a group. This constrains creativity and impedes divergent thinking. Having identified the key issues, dialogue maps can be used to explore each issue in greater depth. A dialogue map explicitly captures the arguments that emerge for each issue. In essence, cognitive mapping is better at developing an understanding of the whole, while dialogue maps enable in-depth and detailed deliberation around particular issues. The benefit is twofold, not only is the rationale 'captured', but in the process of doing so that rationale is forced to be expansive and well articulated.

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The effectiveness of a meeting is dependent on the skills of a neutral facilitator [30][9]. A facilitator is not merely a passive agent who minutes a meeting. Rather the facilitator's objective is to foster procedural rationality, where stakeholders agree that sensible decisions have been made and commit to them. In practice, a facilitator ensures that a meeting remains focused, that the evolving cognitive map accurately reflects the ongoing discussion, that stakeholders get the opportunity to air their views and that the decision process is sensible. During the problem definition phase, such decisions will have an impact on the subsequent requirement definition phase. It is clearly important that where compromises have been made, affected stakeholders are aware of them and are willing to commit to them.

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Deleted: The management science community (both academic and commercial) has long recognised the value of skilled facilitators.

In developing the Wisdom process, we experimented with three methods of representation: QOC, DRL and IBIS. With DRL, we found that its complex type hierarchy caused people without a background in computing difficult to use. QOC is a much simpler language, but similarly to DRL, is concerned with evaluating options to relatively well-understood problems. QOC is well suited to making long-term rationale explicit [11]. Since IBIS has been designed to support deliberation and discussion as opposed to evaluating particular design options, we have found it better suited the problem definition phase. Moreover, its simple and intuitive type system is easy to use by non technical personnel.

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Deleted: Given that many stakeholders in systems engineering projects are non-technical, we ruled out the use of DRL.

As final comments on the Wisdom process we will discuss preparation, and final documentation. We recognise that stakeholders are likely to be represented by senior personnel from geographically distributed locations. These factors mean that organising meetings is difficult and that they should be as productive as possible. We emphasise the benefit of holding face to face meetings at times such as the upstream stage where the 'what' and the 'why' must emerge. Distributed, facilitated meetings are possible but are still not as rich as face-to-face interactions [9]. Prior to meetings, we suggest a preparatory activity where all stakeholders are invited to provide initial input. Based on these inputs, a first-cut cognitive map is generated in terms of nodes but without links. This enables the facilitator to gain familiarity with the problem, in terms of issues, and to do initial work such as removing synonym issues. Furthermore, the preparatory activity allows meetings to be constructive more quickly than having to start from a blank sheet. Documentation from the problem definition phase is critical since it determines system requirements. Moreover, personnel who join a project can use the documentation to understand how and why requirements have been derived. The maps that result from the problem definition phase are the first of many documents that should be held in a project repository.

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Deleted: However, the informal interactions are also of great benefit here. They are useful in the formation of a group of stakeholders who have some understanding of each other and a basis for communication, if not agreeing on issues. For this reason we suggest that a Wisdom workshop is face-to-face and preferably involves an overnight stay.

3. The Tool

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3.1. Background

Cognitive mapping and dialogue mapping software exists (including Decision Explorer™, Questmap™ and Compendium™), and it is also true that whiteboards or sticky notes can be used to support the processes. So why develop a new piece of software? For a start, software is essential to manage the scale and complexity of data. For example, it is not uncommon for half-day workshops to generate 300 nodes. More importantly, during successive 'gathers' each participant may input several dozen ideas. The facilitator needs software to manage the flow of text that results from asynchronous and synchronous input. It is also important to store the data to make the rationale for decisions accessible at later stages of development. Given that the Wisdom process combines cognitive mapping and dialogue mapping, a software tool that allows users to work with both techniques is clearly required. Furthermore, for hybrid maps, the use of separate tools for each technique is unworkable. Although cognitive mapping and dialogue mapping software exists, no other tool readily supports both techniques.

3.2. The Wisdom Tool

The Wisdom tool (figures 3 and 4) supports facilitated meetings with functionality to create, edit, store and browse cognitive maps, dialogue maps, and hybrid maps. Hybrid maps allow cognitive mapping and dialogue mapping activities to be intermixed where appropriate. For example, where a particular issue is being deliberated using IBIS, inclusion of cognitive mapping elements that relate to the holistic view may be desirable to clarify the context of the specific issue or to resolve uncertainty.

Based on formative evaluations, we have refined the tool in order to minimise its overhead in a facilitated session. A cumbersome tool is detrimental to the effectiveness of the facilitator. Indeed, this is consistent with our argument to use cognitive mapping as opposed to dialogue mapping in the early stages of problem definition since the overhead associated with using dialogue mapping may unduly constrain brainstorming work. The tool does little more than support meetings and store maps from those meetings. Features associated with management of rationale over the duration of a project, or over a number of projects are deliberately left absent. We concentrated on producing a tool that runs at a consistently fast speed and offers nothing that is not core to the process. In particular we concentrated on producing a streamlined user interface. Rather than include features for rationale management, we decided to create a facility to export maps to dedicated rationale management software.

To address pre-meeting preparation, the tool provides a distributed gather service. Initially, the facilitator uses this service to construct a questionnaire. The tool generates a web-based form which remote participants are then invited to complete. Based on the participants' responses, the tool generates a cognitive map. The facilitator uses this map to prepare for subsequent facilitated sessions. The same functionality can be used during meetings so that meeting participants can simultaneously build a cognitive map which the facilitator can structure 'on the fly'. For trace-ability, the tool stores maps and provides simple reporting facilities in addition to the graphical views.

We investigated whether we should provide support for the transition from cognitive to IBIS maps. For the latter, we considered building a set of heuristics that could be used. For example, one guideline involved finding cognitive mapping nodes which are tightly connected to others and make such nodes candidate IBIS questions. In this way, issues would be prioritised. However, based on experiments, it appears that active human involvement in this process is important to maintain a group's collective cognition of the problem. Furthermore, the transition requires human judgement, experience, and intelligence. More generally, the need to generate more formal representations of maps remains an important avenue of further work.

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4 Example

Figure 3: Wisdom Screen, Cognitive Map

Figure 4: Wisdom Screen, Dialogue Map

In section 5 of this paper we will discuss real experiences of using Wisdom. As a result of the sensitivity of the information produced during those sessions we cannot publish the results in any detail and so will first use a scenario to illustrate the use of Wisdom. The scenario will concern upstream requirements in procurement of a high performance computing service.

Eliciting requirements for a national high performance computing (HPC) service is a complex procedure, encountering all of the problems a typical requirements engineering project might expect [26], including multiple stakeholders, extended timescales and limited resources. HPC procurement involves negotiation and agreement of multi million pound, custom built machines. Different architectures suit different types of scientific computing and thus different stakeholders, and in addition different stakeholders will have different requirements for the services surrounding these machines including data visualisation, acceptable queuing times and data security. Managing requirements is an intensive task, and in particular the upstream stage is complicated and difficult to get right. Bad decisions made at this point can have serious and costly repercussions later on. The upstream stage must address many issues, including how UK science might benefit from a new machine, which forms of science will be catered for, and whether the timing is right. The upstream stage will involve general discussions of possible technologies, but at this point should not involve decisions about them.

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Using the Wisdom process to address these upstream issues, a workshop for senior stakeholders in national HPC would be convened. The stakeholders must include those with responsibility for the project, those with a good understanding of national scientific policy and practice, and with a good understanding of HPC.

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A few days prior to the workshop, the facilitator should gather information from participants via Wisdom's web based gather facility. The facilitator will pose a very open question such as "What issues must the procurers of a new national HPC service address?" This will help to get stakeholders to start thinking about what they will discuss at the workshop. The facilitator will arrange the issues on a cognitive map to provide a starting point for the workshop. The workshop proper

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would begin with further brainstorming. In figure 3 we give an imagined cognitive map from such a brainstorming. The initial node on this map is node 20: 'single or multiple machines?' This node will have been taken from a larger, more general map made earlier and is surrounded by issues that have arisen in response to it. The node has links to two other nodes: node 28 'multiple' and node 29 'single'. Note that these two nodes have been put in later than some of the nodes they lead to. This has resulted from the facilitator reorganising the map after a number of nodes have been added in response to node 20. Doing this reorganisation makes the map easier to read, and also makes it easier to see that stakeholders are not fixated on, say, issues surrounding multiple machines

At this point the facilitator will hold a discussion on what issues need to be focused on in the remainder of the workshop, and if necessary a vote. Later in the workshop, dialogue maps will begin with the issues selected. In figure 4 a dialogue map is begun with the question "should we have a single machine or multiple machines?" This question echoes the node discussed in the cognitive map. The facilitator has deliberately not divided the answers up into 'single' and 'multiple' here to avoid the stakeholders being pushed into conflict or to make a decision that would be too early at this point. Selected nodes from the cognitive map have been written up as ideas. The stakeholders are asked to focus more on the pros and cons of ideas here, and the idea 'multiple machines would suit more users' is supported with the pro node 'the increasing costs mean we should expand the user base'. By focusing on the issue however, a stakeholder has begun to question its validity. The stakeholders have up until this point made the assumption that different scientists require different architectures, but the question is raised 'Do users actually require different architectures?' and it transpires from this that different algorithms require different architectures and so the relationship between scientists' needs and their algorithms comes into question. From discussions such as this, the problem becomes much better articulated and understood and the following steps in establishing requirements for, in this case a high performance computer, can be taken more competently.

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5. Experience

This section will outline two uses of Wisdom and discuss the broad issues that arose. We discuss the revision of a UK Government administrative system, and negotiation of a 25-year vision for a military technology organisation. The first took place as formative evaluation, with an early version of Wisdom, and a 'friendly' client. The second took place with a completed version of Wisdom. We were fortunate in being able to use Wisdom in these major upstream requirements exercises, but with that comes the problem that we cannot reproduce the data from these exercises in print.

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Substantive formative evaluation took place with a 'friendly' client undertaking a major project. A UK Government department was looking at wholesale revision of its administrative system and logistical support, and invited the Wisdom team to run a three-hour workshop with six of its employees. The client had devised an interim set of proposals and used the workshop to develop a strategy to take work forward. It was an ambiguous and complex problem with distributed stakeholders. Decisions made at that point would have a knock on effect for the remainder of the project. The client found the workshop useful, and proceeded using the strategy begun there. The workshop was a test case for Wisdom, in which we were able to get a good grasp of the divergence and convergence that the Wisdom process affords and to gain practical requirements for the software tool (such as the speeds it must allow node entry, appropriate font size and more) and to expose bugs.

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Later, substantive evaluation took place with a planning project for a major military technology company. The client wished to hold a series of workshops to consider what they should be producing in 25 years time. Given the very long lead time for complex military systems, this meant that they were interested in developing high-level systems requirements now that could serve as a basis for technology assessment and conceptual system design. They had organised training in dialogue mapping for two of its employees, who became interested in Wisdom. The Wisdom team were invited to part run three workshops in collaboration with these two client employees. The Wisdom process and tool were used in two workshops and the Wisdom process and a commercially available tool in the third. Many high-ranking members of the client company were brought together, each with their own viewpoints, concerns and agendas. Wisdom is ideal for the upstream combination of ambiguous problem and multiple stakeholders. No decision or explicit consensus was sought as an outcome of the workshops but a map of the various issues.

The workshops were held with approximately ten to fifteen stakeholders attending plus a trainee facilitator from within the organisation sharing the facilitator role with an experienced facilitator from the Wisdom team. In the first workshop, Wisdom was used to support a brainstorming session that produced 83 separate nodes. These were then discussed and reduced to 15 key issues. One of these issues, to give an example, was safety. Thus Wisdom was used to support an initial divergent phase and a following convergent activity. At this point the stakeholders wished to vote on the importance of each issue. This vote is not a part of the generic Wisdom process, but the process is flexible enough to allow for its inclusion. The importance ascribed to each issue was used to determine how long was spent discussing it. The Wisdom process was then continued with a dialogue mapping activity. The outcome of the workshop was an agreed map of the issues small enough to be printed on one side of A4 paper. The second workshop was dominated by brainstorming and clustering of ideas and by use of the Wisdom tool for cognitive mapping. Dialogue maps were used for the clustering of ideas. The third workshop was almost entirely composed of dialogue mapping, complementing the outcome of the second.

Our experience in the workshops was that the wisdom process led to divergent followed by convergent group activity and that this was demonstrated to be particularly useful in relation to conflict. One issue that was raised by a participant was met be hostile groans by other participants and met with indifference by others. The issue was a cross cutting concern with potential relevance to much of the decisions to be made. The participant who raised it felt strongly about it. The facilitator was able to handle this by entering a divergent phase of mapping out the issue, covering why it might or might not be relevant, what the implications might be and attempts to recall precedents set for this issue in other planning situations and indeed legal issues related to it. This issue became accepted as having relevance, but as being of low priority. A very small IBIS map was produced around the issue.

The Wisdom process was used in all three of the workshops described above, however the tool was not used throughout as the facilitator wished to use a commercially available tool for dialogue mapping. This was through no short-coming of the Wisdom tool but because, as a product of a research project, the Wisdom tool cannot be given guaranteed support after the project is complete. This did not seem to adversely affect the workshop as the stakeholders did not seem to notice the change of software, although we question whether more hybrid maps might have been produced had we used the Wisdom tool throughout. The significant problem that arose for us was that when asked to comment on the effectiveness of the workshop, the workshop participants did not differentiate between Wisdom and the commercial tool. The comments made by participants at the end of the workshops were exclusively positive, but again were not simply attributable to Wisdom as the participants had rarely been in the same room together and so commented not just on how effective the Wisdom workshop was, but on how effective it is to have any sort of workshop in the first place.

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6. Discussion

Evaluation and requirements engineering methodology do not always go hand in hand. Evaluation is very difficult in this situation; as we have discussed in the previous section, comparison of a particular technique with another, or of one tool with another is often impossible in practice. Dix [10] points out that in situations such as this, evaluation can be methodologically unsound, and that rather than attempting to conform to some model of experimentation we must concentrate on qualitative insight. Research in this instance is investigation and exploration and not the construction of a product. Wisdom is not a product but a research project and our writing here is to communicate the insights from the research. We do not wish to persuade people to specifically use the Wisdom process and tool but to pick up upon the lessons learned and incorporate them into their own research or practice. It is true in much requirements engineering and design rationale research that the results presented are qualitative insights, and we believe that is no bad thing.

Given that the participants in our workshops were rarely in the same country, let alone the same room together, and that they had not used any visual argumentation in a facilitated requirements workshop before, they were unable to separate the value of Wisdom from the value of simply holding a workshop. Given that these were workshops to plan a twenty-five year vision, the outcomes and the connections of these outcomes to work done over the next quarter of a century are ambiguous. In this situation we cannot make substantial claims about Wisdom being any more effective than alternative methods, but can conclude that Wisdom as a hybrid technique does work and is seen by participants to be better than no technique at all. This might be seen as a small claim, but it is a foundation for the legitimacy of the insights offered in this chapter.

We have focused on the early stage of requirements engineering, the upstream stage, where the 'what' and 'why' of a system must emerge. This is a stage where eliciting rather than managing rationale is required, and in conjunction with handling conflict, encouraging coverage of possibilities and formation of a team with ownership of the system. As a decision support tool, Wisdom is a tool for not making decisions, our notion being that it is too easy to rush into decisions without sufficient grounding. We put conflict up front, using early sessions that allow conflicting issues to be mapped out without forcing judgements to be made. We then seek to manage conflict, but not necessarily resolve it, by using a convergent technique that supports "yes…and" rather than "yes…but" argumentation.

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Deleted: Coverage too is encouraged in this way, firstly divergent coverage and secondly convergent. We have tried to encourage ownership by keeping the transitions between maps manual, by mapping what is said and by encouraging face-to-face meetings with an overnight stay.

A negotiation technique that has covered similar issues is Win Win [2][3] whereby stakeholders iteratively negotiate shared 'win' conditions for software and systems requirements. The Win Win technique is longitudinal and attempts to balance the discovering, negotiating, elaborating and prioritising of objectives with things like maintaining a creative flow of ideas [4], and ensuring validity of the models produced [14]. Compendium [29][27] is a method (with a suite of associated tools) for combining argumentation with knowledge management. It differs to Wisdom in that it does not address divergent cognitive mapping (although it has been put to other innovative uses [28][6]) and that it offers extensive facility for longitudinal knowledge management. At the time we compared the Wisdom tool to the Compendium tools we found the latter ran marginally too slow for our purposes.

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Deleted: purposes (probably as a result of the extensive back end), although this is likely to be solvable by investing in a more powerful computer

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Deleted: We found that the knowledge management facilities would add little to and possibly obstruct a Wisdom workshop. Turning off these facilities would be beneficial in this situation. We have addressed the upstream stage of requirements engineering.

Nguyen and Swatman [22] give an interesting account of the requirements engineering process as necessarily containing a number of crisis points where the problem space must be reconfigured. Our intention was to draw out conflict up front, but while doing that might be useful, it is probable that conflicts will always arise at points in a project. It is possible that a Wisdom style workshop would be appropriate for use at these various crisis points. We end with two broader points useful when thinking about what has been achieved in Wisdom and where future work may be needed. Law [17] makes the point that when representing complex situations we usually try to make the mess absent. He suggests rehabilitation of mess, or finding ways to know mess. Finally, making an interesting contrast to our intention to capture expansive rationale, Nietzsche has said “There is a great deal I do not want to know – wisdom sets bounds even to knowledge” [23,p73].

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