

IMPLEMENTING VALUE THROUGH LEAN DESIGN MANAGEMENT

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ABSTRACT

The philosophy of lean thinking has been adopted relatively quickly by contracting organisations, keen to reduce waste in the realisation of construction projects. The concept has, however, been slow to catch on in the earlier design and detailing phases where decisions have a major influence on the ensuing construction processes and the level of value realised in the project. Given a strong argument for greater synergy between design, manufacturing and construction there would appear to be considerable potential in moving the lean thinking upstream, starting with the briefing and conceptual design stages and managing the flow of decisions through to the completed building, thus helping to deliver value within a lean framework. Value is *the* end-goal and therefore value parameters are key to the achievement of improved productivity and client/user satisfaction. The three-phase Value/Process/Operation (VPO) model starts by identifying value parameters, then moves to designing the process and finally onto the operations. The model lies at the heart of a lean design process model implemented by a consulting company and a contractor in Denmark. The case study helps to illustrate the benefits of taking a more holistic and integral approach based on the agreement of value parameters at the project outset. Through the use of creative workshops, that encourage open communication and knowledge sharing, the lean design process model has been instrumental in delivering value and improving productivity.

KEY WORDS

Communication, Design management, Information and decision flows, Lean design, Productivity, Value parameters, Workshops.

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INTRODUCTION

The philosophy of lean thinking has been adopted relatively quickly by contracting organisations, keen to reduce waste in the realisation of construction projects. The concept has, however, been slow to catch on in the earlier design and detailing phases where decisions have a major influence on the ensuing construction processes. Given a strong argument for greater synergy between design, manufacturing and construction there would appear to be considerable potential in moving the lean thinking upstream, starting with the briefing and conceptual design stages and managing the flow of decisions through to the completed building, thus helping to deliver value within a lean framework.

The majority of the 'lean' literature is focused on the contractor and dealing with problems and challenges that arise on the construction site (Jørgensen et al, 2004). In some respects one could argue that the effort expended during the construction phase is misdirected. Many of the problems being tackled in the construction phase are the result of an ineffective communication and decision making in the design phase, which for a variety of reasons, results in some degree of uncertainty in the production phase, where there is little option but to confront the problem. This stems from a mismatch of values and failure to appreciate the existence of diversity and sub-cultures within the sector, the result being a failure to understand and better manage boundaries between organisations and individuals (Powell, 2001; Emmitt & Gorse, 2003). The lean philosophy (minimising waste, maximising value) should be applied as early as possible in the design and construction process, i.e. at the briefing and early planning phases. It is here that decisions concerning design, procurement routes, timescale and budget conspire to set the scene for everything that follows (in line with the ideals promoted by Womack *et al*, 1991; Womack and Jones, 1996), preferably using an integrated and concurrent model (Corbett et al. 1993). Combined with a clear set of values the briefing exercise (also known as 'programming' in Denmark and 'architectural programming' in the US) and early design operations can be managed in such a way as to reduce downstream uncertainty and associated waste of materials and resources.

Work in the lean construction field has tended to focus on process tools to identify and minimise uncertainty and hence improve workflow in production. Although uncertainty is unwanted in the production phase, the earlier design phases aim to generate as much variation as possible with a view to enhancing the client's values and going beyond the mundane to create real value for client and building users alike. This raises a challenging question concerning how far upstream a process model can go before it becomes a self-defeating intrusion on a critical phase of projects. Instead of a rigid process model, a management framework is required that allows and positively encourages creativity where it is most valuable, at the conceptual stage of the overall design and also at the conceptual stage of specific details (see Emmitt *et al* 2004) when values are discussed and agreed. Subsequent refinement and confirmation of design intent, which embodies agreed value parameters, is represented by a full set of production information (working drawings - 'blueprints' - and specifications). The focus in this paper is on some of the softer issues related to the use of a process method, with particular attention on interpersonal communication and the use of creative workshops to discuss and agree value parameters.

ESTABLISHING VALUES AND VALUE PARAMETERS

Establishment of common objectives and common values are important objectives in the drive for greater cooperation and reduced conflict in construction projects (e.g. Kelly & Male

1993). Value is *the* end-goal and therefore the establishment of value parameters at the outset of a project are key to the achievement of improved productivity and client/user satisfaction. Following this statement we are concerned with value-based management and the control of values through value management in the early stages of the project and through value engineering to deliver value in production.

A number of complementary views of value and value generation exist within the literature, indeed, it is a difficult word to discuss and define adequately. It is, however, important that some care is taken to explain what value is (usually defined as most value for the resources invested). So, how do we best define value? The word value has two characteristics (Christoffersen, 2003a):

- The perception of value is individual and personal, and is therefore subjective. Indeed, agreement of an objective best value for a group will differ from the individuals' perception of value
- Values will change over time

From these two observations an immediate question is posed: is it possible to discuss and define value at all? The answer to that question is itself subjective, however, if we view value as an output of the collective efforts of the parties contributing to the design and construction process; view value as central to all productivity; and provide a comprehensive framework in which to work, then the answer is likely to be positive. Christoffersen's argument is that value must be established before doing anything else, an approach now adopted on a great number of projects carried out by the consulting engineers NIRAS where emphasis is both on value creating activities as the initial framework for the entire building process, and the reduction of waste in the later value delivery phases.

Within the construction management literature Kelly and Male (1993) have provided a comprehensive overview of value management and have identified key phases when value management ('value engineering' in the US) exercises or workshops should be conducted. The view is that these 'value opportunities' are best applied early in the design process when strategic decisions are being taken that affect subsequent work. Indeed Kelly *et al* (2003) argue for the use of value management as a tool to aid the briefing process, primarily through the establishment of good interpersonal communication and the sharing of values: a sentiment echoed in other literature on briefing (see for example Blyth & Worthington, 2001). These workshops have parallels with quality management design reviews, meetings that help to improve communication between project participants. The difficulty with the value management approach is that the workshops are promoted as something additional to the management of process, a tool to enhance value in design management (see for example Gray and Hughes, 2001) rather than value as an integral element of professional design management. Looking outside construction to other areas, such as product design and industrial design, it is clear that the desire to maximise value and reduce waste starts at the beginning (initial team composition) in design management models and lean approaches.

At the level of the individual project it may be very difficult improve working methods even when all participants and organisations 'sign up' to some common values. Work by Maister (1993, 2000) into the workings of professional service firms has argued that many firms do not share values within the organisation and also fail to adequately discuss values with clients early in the appointment process. The implication here is that the sharing of values is a challenge for individual organisations as well as for individual and temporary project groupings. Such concerns are echoed in literature on architectural design management

where, for example, Allinson (1993) discusses the different values concerning (amongst others) architectural design and project management.

CONSTRUCTING COMMUNICATION

Research by Powell (2001) found that even where designers and manufacturers were making a significant effort to work together, there were still problems with communication, primarily because of the different values held on the supply and demand sides of the supply chain. The integration of design and construction remains a considerable challenge, both from developing an intellectual argument and from a practical stance that delivers real improvements. The challenge is not exclusively with the implementation of process tools to streamline the process, more it is about the interaction of organisations, or more specifically the efficacy of relationships between individuals within such organisations. Emmitt and Gorse (2003) refer to this as a 'boundary condition' that must be managed effectively if design (and hence client value) is to be realised within the constructed work. Communication, cooperation, competences and values of actors are vital components in helping to achieve integration and a level of synergy between these two cultures. Following this argument our attention turns to the issue of values. In a value perspective establishing a better match between design and construction is of major interest. Integration is not just a matter of eliminating waste and hence cut costs, it is also a matter of understanding the processes together enabling the creation of a built artefact to budget and programme, which also surpasses the client's expectations. To do this effectively all actors must engage in dialogue to explore and then confirm a set of values that form the basis of the project, and the most effective way of doing this is through face-to-face meetings that recognise the value of group process (Luft, 1984). Communication is key to the discussion and implementation of values.

THE IMPORTANCE OF CREATIVE WORKSHOPS

All actors are influenced and equally interdependent on others for the realisation of tasks and projects within the temporary social arrangement of the construction project. This interconnectivity places additional pressures on the ability to communicate and share information and knowledge. This is especially true of the design process, which was formerly very individual and hence more personal than it is today. Now everyone is dependent in some way upon other players in order to complete tasks and realise goals. Thus interpersonal communication, intra-organisational and inter-organisational communication is particularly pertinent to the establishment of an effective project communication network (Emmitt & Gorse 2003) and also for enabling learning to take place within the project, helping to improve the end value on this and subsequent projects.

Architects Konrad Wachsmann and Walter Gropius introduced a teamwork method for the development of complex building concepts in the 1940s. Although they never mentioned the possible source(s) of their system, the essence of their method can be found in Native American and Indonesian culture where problems were solved in a 'democratic' and harmonious way within the tribe. This early work has been further developed into the holistic participation method (MHP) by Schmid (for further details see Emmitt, Olie & Schmid, 2004), which promotes the sharing of values while also allowing the opportunity to solve problems in a cooperative environment. The method also seeks to encourage innovative thought and is designed in such a way as to try and avoid 'groupthink', which is known to frequently produce poor solutions. Literature on group performance and multi-disciplinary

working implies that the decisions made by groups are more workable, more accurate and more rational than those made by an individual because of the broader range of information and knowledge available to the group; the groups also tend to be more creative. However, the interactions within groups are an extremely complex issue and contradictory views exist as to the ability of a group to reach its defined goals (e.g. Stroop 1932, Bales 1950, Yoshida *et al* 1978, Hartley 1997, Emmitt and Gorse 2003).

The current focus on values, partnering and collaborative ventures has once again highlighted the importance of meetings and in particular the importance of creative meetings in which values are discussed, debated and shared with a view to achieving common values and goals for specific projects. Meetings encourage face-to-face dialogue and, if managed professionally, can go a long way in helping actors to understand the cultural values of others, thus leading to better integration and realisation of project values. This is illustrated in the following case study.

DEVELOPING A 'SUITABLE' MODEL: A CASE STUDY

The result of an ongoing creative collaboration and knowledge sharing between consulting engineers NIRAS and contractors MTHøjgaard has resulted in a simple process model. The underlying theory is represented in a triangular model, where lean theory is represented by method (structure and procedures), which are delivered through the effective implementation of appropriate tools, such as productivity indicators and measurement tools. The featured case study organisations have taken a very open approach to the adoption of lean construction and have published detailed information about performance (see for example Thomassen *et al.* 2003). By discussing and publishing data the organisations aim to continually improve the way in which it realises projects, being open to new ideas and constructive suggestions. This paper is part of that process, an exercise in critical reflection and appraisal.

A THREE-PHASE MODEL

There are a number of different models that can be used to provide a managerial framework for the management of construction projects. These range from the well-established Plan of Work first published in the early 1960s by the Royal Institute of British Architects through to more inclusive models, such as the process protocol model (Cooper *et al.*, 2004): the benefits of one over another largely a matter of circumstance and suitability to the context and participating organisations (Emmitt, 1999). The important features of the value based design model featured here are (Christoffersen, 2003b):

- All stakeholders are represented
- All competences/qualifications are represented
- Parallel design work is carried out in workshops, not serially
- Establish a fixed value structure for the product (building)
- Guide stakeholders through the cerebral phases of vision, realism and criticism
- Facilitate the process throughout
- Be aware of 'wicked' problems

- Allow adequate time for thinking and decision-making, do not make rash decisions
- Use Last Responsible Moment (LRM) thinking
- Work with multiple designs to explore different value streams
- Think value before price
- Maximise value in both product and process throughout the entire process

Related concerns relate to cultural values, since it is crucial that sub-contractors understand the culture of design and conversely that designers understand the culture of construction. The argument of the case study participants is that engaging in dialogue can only do it. Projects will always be complex undertakings; however, they should not be complicated further by poor information, poor communication and/or ineffective management. Thus project complexity needs to be dealt with at the front end and a simple system architecture designed to encourage creative activities and the exploration of complexity in the early phases. Wicked problems - the front end is about generating complexity within the process framework, identifying wicked problems and also a time deadline when they must be solved – try and delay the decision for as long as possible, thus allowing the potential for greater creativity. (Project complexity comprises process complexity and product complexity, both should be simplified)

The three-phase matrix of different values, namely Value/Process/Operation (VPO) has been developed by consulting engineers NIRAS and implemented in partnership with a number of contractors. The partnership between NIRAS and MTHøjgaard aims to capture the entire process through collaborative projects in Denmark. The matrix has similarities with Michael Porter's work, where he identified the value envisioned (value), value harnessed (process) and value realised (operation). The VPO model starts by identifying value parameters, then moves to designing the process and finally onto the operations. The model lies at the heart of a lean design process model implemented by a consulting company and a major contractor (operating under lean construction, *trimmet byggeri* in Danish). As noted above, it is important to have the process structure as a framework: a guiding tool. All members of the multi-disciplinary team are deemed to be equal stakeholders; therefore it is necessary to have a process facilitator to guide the discussions and record outcomes, an additional and complementary role to that of the design manager.

CREATIVE WORKSHOPS

The implementation of creative workshops is at the heart of the case study organisation's processes model. There are clear parallels here with quality management and other process orientated design and production models (discussed in more detail below). The model illustrated shows a very simple line of workshops, starting with client intentions and discussion of abstract ideals and working through workshops to a complete set of information prior to commencement of production. The term 'Workshop' is used, although in practice this will comprise a series of related workshops that deal with a particular issue, or value stage, in the development of the project. The workshops continue until agreement has been reached by all parties, thus a degree of flexibility in programming is required, simply because it is not possible to estimate with any certainty the exact number of workshops required before the project can proceed to the next phase. Where problems with understanding and attitudes exist, further workshops are convened to help explore the underlying values and

tease out the creative input to the project. Thus from the very start the whole process is consensus based. Bringing people together and facilitating workshops is time consuming and hence expensive in the number of hours committed. However, the argument put forward by the consultant and contractor is that the workshops are an essential tool to maximise value and to reach agreement, and hence reduce downstream uncertainty and waste – thus in the long run the workshops are a cost effective tool. Different cultures will exist from concept through to production and the workshops provide a vehicle for the addressing potential difficulties. The workshops are also continued at the production phase to better involve the sub-contractors (not discussed in this paper).

THE CREATIVE WORKSHOP METHOD

The workshop model has six stages, from Workshop 0, which is concerned with getting the right people together before proceeding further, through Workshop 1 to Workshop 5. The ‘front’ end is concerned with optimising and then implementing client value (value management as an aid to client briefing), the later stages with production and embedding of client values within the constructed works, the implementation of design intent. The workshops are seen as ‘value generators’ (or value drivers) with the delivery of value being achieved between the main workshops. Thus workshops are concerned with problem framing, while problem solving takes place between the workshops. Project team meetings are used between the formal workshops to discuss and agree progress. The number of participants present in the meetings varies between projects and stages, however numbers typically range from between 15 and 30 people, although the organisational format can be changed to accommodate more people if necessary by dividing into sub-groups. Organisations involved in the workshops typically include the client’s representative and users’ representatives, design architects, constructing architects, structural engineers, services engineers, and the construction process managers. It is a ‘demand’ of the project philosophy that the entire panel of participants is in place from the start to the finish. Using the journey metaphor the design and construction process is a change process, driven by the workshops.

A standard value agenda is used as a framework for decision-making in the workshops. The consulting engineers developed the agenda based on experience fed back from project work (this has similarities with other work, for example the recently introduced Design Quality Indicators in the UK -see www.dqi.org.uk - which use the three main headings of functionality, build quality and impact). The ‘basic value structure for buildings’ is based on six key areas of value, namely:

- Beauty
- Functionality
- Durability
- Suitability (for the site and the community)
- Sustainability (respect for the environment)
- Buildability

This value hierarchy addresses the primary project objectives and breaks them down into further sub-objectives as part of an iterative process carried out within the workshops. Each area explored until the value parameters have been mutually agreed through the use of quality function deployment (QFD) tool, essentially a tool that allows values (options) to be

weighted in a decision matrix to find the solution that provides the best value in the view of the workshop actors. Workshop participants need guiding through the discussion of values in a systematic and objective way, which is done by a process facilitator. The workshops are:

Workshop 0: (Partnering) Building effective relationships

The function of the preliminary workshop is to bring various actors together to engage in socialising and teambuilding activities. The intention is to build the communication structures, the system architecture for the project, thus allowing actors to engage in open and effective communication during the life of the project, the architectural dialogue. In addition to setting the stage for the events that follow the 'outcome' of the first workshop is the signing of a partnering agreement between the participants. This confirms the process values for cooperation on the project.

Workshop 1: Vision

This workshop is concerned with discussion of basic product values and the establishment of product value parameters. It is not possible to know the values at the start of a project and so the workshops are primarily concerned with exploring values and establishing a common vision. Knowledge and experience from other projects is brought into the workshop, for example facilities management values, knowledge and experience may help to inform the whole life approach to building design and construction. The main focus of the effort is the establishment of client values (value based parameters); on the basis that the better these are known the better the team can deliver.

Here the word 'client' needs some explanation. In the model described here the word client is used in its widest sense to comprise the values of the building owner, the building users, the authorities and the investors; thus it is a very complex system of stakeholders. Arguably, the only way of getting representatives from these disparate groups together so that they can discuss and explore values is via the workshop method.

Early workshops are also concerned with the selection of the most appropriate consultants to deliver the client value. The consulting engineers are adamant that the vision must be developed without any constraints and so consultants are asked to tender based on creative proposals and fee bid. Thus consultants are evaluated on their ability to contribute to the project, not, as is common practice for contractor led procurement in Denmark, on the lowest fee basis. Consultants' fees are the smallest cost in the project economy chain; therefore there is no need to pick the cheapest, it is more important to pick the organisations and individuals that 'fit' the vision, thus contributing to a healthy project economy over the longer timeframe. Collective dialogue helps to explore and develop relationships that can (or conversely cannot) develop into effective and efficient working alliances, essentially the preparation for the construction of efficient communication networks. Participants work with multiple alternatives until it is time to choose the 'best', i.e. the solution that offers most value for money. Critical connections between decision-making are explored so that everyone is certain before going into production, thus reducing downstream uncertainty. The result of Workshop 1 is the establishment of basic values for the project; a very pragmatic document that does not contain any drawings. These values are prioritised.

Workshop 2: Realism

Workshop 2 aims to discuss how the basic project values may be fulfilled. Project economy is introduced here along with restraints imposed by, for example, authorities and relevant codes. A number of alternative proposals are worked through and ranked according to value. Architects are encouraged to produce at least three schemes that can be presented and discussed at the workshop. During the realism phase normally at least two to three workshops are required, simply because there is a lot of material to work through. The basic project values and project economy are respected in this process and any changes justified within the value parameters. The outcome of the realism phase is the selection of the 'best suited' proposal.

Workshop 3: Criticism

This series of workshops is designed to criticise the proposed design solution chosen in the previous workshop. The solution is criticised; is it really the 'best' solution? Could it be 'better'? Detailed discussion is centred on the chosen solution and its improvement within the value parameters. Uncertainty and urgency is high on the agenda prior to the scheme entering the production phases. The project is approved for production and the contractual delivery specifications fixed.

Workshop 4: Design planning

In this model it is here that there is a shift in thinking, as the more abstract work turns into production information. Values are concerned with delivery. The designers, contractor and sub-contractors interface most here as value management techniques turn more toward value engineering and a process management tool, Last Planner, is introduced to help guide the planning of the process. This approach was taken for the first time on the DELTA project and deemed a successful innovation. Here the focus is on improving the constructability of the project, while trying to reduce waste in the detail design and construction phases.

Workshop 5: Planning for execution

These workshops involve interaction between the main contractor and the sub-contractors. A process plan is produced that helps to map the various production activities and help identify missing information. Information flow is an important consideration at this stage in the workshop model. On completion of the construction schedule, in an ideal world, the information should be complete and there should be 'no scope' for uncertainty of the delivered value at the production phases.

Meeting schedule

Workshops never last more than one day; although, since value management is founded on negotiation it is common to hold several workshops at a particular stage so that everyone is signed up to the outcome. The schedule of meetings may be extensive on a large project and there is a concern that the cost of the meetings may outweigh the value realised through them. All parties to the project need to constantly monitor the effectiveness of the meetings and critically assess their added value through the use of various benchmarking tools – there is the constant danger of holding too many workshops and the participants becoming jaded through over-familiarisation. There is considerable pressure on the process facilitator to keep

the actors together and thus prevent entropy. It is also critical that the process manager and design manager are able to communicate effectively on an inter-personal level. There are two types of communication in the workshop model; namely, workshop communication (to establish values) and process communication (to implement values). Again, it is critical that the actors are aware of these communication levels.

CUSTOMER SATISFACTION

Feedback into the effectiveness of the workshop method is measured through two tools, the customer satisfaction value control questionnaire and through the use of key performance indicators. The value control customer satisfaction survey is used to ask 'customers' (defined by the consultant engineers as all project participants, including the building sponsor and users' representatives) if they are satisfied (or not) on a range of areas themed under two headings, the product values and the process values. Here the customers are evaluating the result of the process and also the performance of the production team, which has proved to be mainly highly positive but also negative. Both the engineers and contractor have found this to be an important feedback mechanism for continued improvement. From a researcher's viewpoint the tool is likely to produce positive results simply because the participants are evaluating their own performance and a more critical approach to appraisal may be a beneficial development in the future.

REFLECTION – GOING 'BEYOND' LEAN

Much of the work within the IGLC community has been focused on process tools to achieve lean construction. Wider issues concerning the philosophy of lean and the underlying 'soft' issues have received much less attention. The case study material presented here demonstrates organisations committed to lean thinking within a value-based design management framework (distinct from value management or value engineering). Working closely together by way of a strategic alliance has enabled all parties to develop a simple, yet effective, design management system that delivers value to all parties. The workshop-based design management model is grounded in interpersonal communication and development of effective dialogue although it would be possible to criticise the model and suggest improvements (see below) the important issues to come out of this reflection is the concern for people within the model (something that many process models conveniently ignore). The approach is holistic and is aimed at developing a concept for the design(s).

CRITICAL FACTORS FOR CONTINUED IMPROVEMENT

The case study organisation and its consultants have adopted a considered and incremental approach to the adoption of management innovations. This strategy of gradual improvements is, according to the consulting engineer and the contractor's own records, starting to bring about improvements. Some positive results from the perspective of the consultants are:

- teambuilding was a positive 'side effect' of the workshop approach
- conflict reduction/solution was achieved through being able to discuss issues
- knowledge and experience was 'captured' for new projects
- a sense of 'ownership' was created with the actors
- project management was improved (mainly through improved communication)

- the value of the ‘space’ for collective decision-making by all stakeholders was recognised by all parties
- improved learning on projects
- positive effects on the management of projects

On a less positive note, some of the workshops have taken longer than anticipated for agreement to be reached. However, there has been no contractual problems with the process since it is a condition of the tender that parties to the project commit to the working method and commit to external evaluation of the method by By og Byg (discussed below) in the case of contracts involving the contractor MTHøjgaard.

In summary, according to the participants, the clear perception is that the workshops encourage integration. Both consultants and contractor are now committed to the implementation of lean thinking on all projects, supported by training and implementation schemes for staff and project participants. The improvements brought about by the model is confirmed in an independent study carried out by the national institute for building and urban research in Denmark (By og Byg), which found improved performance across a whole range of performance parameters when investigating a case study of one of the projects (By og Byg, 2004). More scientific work into the effectiveness of the group workshops, for example using Bales’ Interaction Process Analysis (Bales, 1950) that provides a robust tool for objective and quantitative measurements. This tool has successfully been used to measure the effectiveness of interaction between professionals in construction meetings (Gorse, 2002) and could produce some objective results for further practical development of the workshop model described here.

CONCLUDING COMMENTS

The case study helps to illustrate the benefits of taking a more holistic and integral approach to design and construction based on the agreement of value parameters at the project outset. Through the use of creative workshops, that encourage open communication and knowledge sharing through dialogue, the lean design process model has been instrumental in delivering value and improving productivity from the perspective of the project participants. Value (as perceived and shared by the actors) is embedded in the design intent. Although the term ‘lean design’ is used the model described in this paper is primarily concerned with the creation of workshops to encourage effective communication and create a sense of ownership in the decision-making process. This is a simple design management model that employs a value-based approach and incorporates the lean thinking philosophy. The workshops try to respect and manage the chaotic nature of the design process, with cooperation, communication, experience and learning as a group contributing to the clarification and confirmation of project values.

From the perspective of a researcher looking at the process there would appear to be some areas for future improvement, while still retaining the simplicity of the model. For example, there is no formal management of information flow between meetings, i.e. there are no soft and hard control gates, which can be found in similar process orientated models (although this function appears to be dealt with via the workshops and controlled by the process facilitator). Some comment also has to be made on the use of the term ‘lean design’. The design (and production) activities take place between the meetings; the model does not

explicitly deal with the design activities and other than provide a supportive environment to discuss issues it is difficult to see how 'lean' design is encouraged.

Further work is required to investigate the effectiveness of the workshop method in terms of the realisation of group goals. In particular, the role of the workshop method in promoting and delivering creative solutions would be a logical extension of this case study. So too would some reflection on lean production systems thinking in the detailed design phase.

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