DESIGNING TO TARGET COST: ONE APPROACH TO DESIGN/CONSTRUCTION INTEGRATION

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Abstract
One approach to a more integrated construction delivery process is the concept of ‘designing to target cost’ of which the first examples of application within a lean construction framework have recently been seen. This paper introduces the main principles of the design to target cost method and discusses the applicability of this approach to construction. The low degree of organizational and technical continuity from one construction project to the next limits the applicability of the design for target cost approach when compared to its origin in product development of mass manufactured artefacts. The approach can, however, be applied as a way of substantially involving the production organisation from the earliest phases of schematic design and thus contribute to enhanced value and reduced waste for the overall project delivery as well as for the many assignments of which it is ultimately composed. It can be argued that design to target cost may also provide a frame for developing the supply chain towards better coordination and collaboration. Thus methods of design to target cost may serve to facilitate the development of a more integrated supply chain.

Keywords: Collaboration, design to target cost, lean construction, supply chain integration, value engineering.

INTRODUCTION
Construction is a project-based production activity exposed to various factors of uncertainty, complicating cost estimation, production planning and management and the control of cost development. A major problem to managing costs in construction projects is that final costs are usually not known until relatively late project stages where many parameters have become fixed. This often leaves project management with a very limited range of adjustable parameters through which action can be taken to prevent costs exceeding budget, or to limit the wider (project) consequences of specific cost escalations. Significant conflict often arises when project participants are faced with the unavoidable need for dealing with the allocation of the unforeseen burden. A typical scenario could include the need to settle for one or several of the following outcomes:

- Acceptance of budget escalation - which includes the need to identify the participant(s) bearing extra costs,
- Acceptance of delayed project completion or postponement of the meeting of agreed milestones,
- Acceptance of design changes with technical consequences undesirable to one or more of the members of the supply chain,
- Acceptance of design changes with undesirable consequences for design intent and value delivery.

Frequently cost escalations end up involving not only project participants but also the system of justice if participants fail to reach agreement on responsibility and further
consequences. Such action adds no value to the project concerned and is desirable to solicitors only. One conclusion to be drawn from such experiences is the need for project-scoped cost management techniques addressing early design phases where the scope for cost-restricting action is considerably larger than during detailed design or during production. One cost management technique addressing early design phases is that of designing to target cost. This method is originally a technique for product development evolved by Japanese lean manufacturers seeking to develop products with potential for continuous reductions in manufacturing costs throughout the product’s market life in order to stay competitive (Cooper & Slagmulder 1997; 1999). Today the method is well known within lean manufacturing but is less explored in the area of construction. It has some obvious constraints for use in the built environment, but many of its principles are fully applicable to design and construction. Despite its origin as a tool for managing costs the method may bear an additional potential for strengthening supply chain collaboration and innovation in construction while enhancing value delivery and fulfilment of design intent. It is from this perspective the method will be discussed in this paper, which is written in connection to the author’s ongoing Ph.D. studies on integration of (lean) design and construction. The primary aim is to introduce the basic principles behind designing to target cost and to inspire further studies, experiments and debate regarding integrated approaches to design, construction and supply chain collaboration.

A METHOD FOR DESIGNING TO TARGET COST

The design-to-target-cost method builds on the principle of making costs and cost data direct inputs to the design process instead of an outcome of it. It is in other words an example of the more general issue of designing to target characteristics, sometimes referred to as ‘design for x’ (DfX) (Cooper & Slagmulder 1997; 1999). In Japan the concept evolved as a strategy for developing products with a higher potential for meeting the manufacturer’s profitability objectives throughout the product life time (Shingo 1988; Cooper & Slagmulder 1997; 1999). According to research by Dekker & Smidt (2003), applied techniques similar to the ones described by Cooper & Slagmulder are likely to be found in many manufacturing companies around the world. In an example from construction, Ballard & Reiser (2004) draw attention to three primary challenges when designing to target characteristics:

1. how to incorporate the relevant specialists in the design process,
2. how to make trade-off decisions between the characteristics, and
3. how to drive design decisions to achieve targets.

While Ballard & Reiser limit their focus to exploring of the third of these issues, this paper is written with the intention of contributing to the exploration of the first.

Setting cost targets

Target costing methods are basically a structured way of identifying the costs and quality that must be achieved for a product to be successful on the market while bringing a satisfactory return. Traditionally profitability has been estimated through the equation:

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\text{Expected selling price} - \text{production costs} = \text{profitability level}
\]

Target costing takes a different point of departure by first deciding on what profitability level will be satisfactory which hence presents the equation:
Expected selling price – profitability level = target cost

When this paraphrasing of the equation makes a difference to practice it is due to what some refer to as the cardinal rule of target costing (e.g. Cooper & Slagmulder 1997; 1999) prescribing to never launch a product above its target cost. This rule can only be violated under very special circumstances where launching a product with dissatisfactory earning prospects is considered necessary to gain or protect a certain desirable market position or because the product itself is a requirement for another product with satisfactory profitability. An example of the first situation could be a manufacturer of consumer electronics who for strategic reasons needs to offer a competitive model within all price categories of a certain type of products (e.g. cellular phones or cameras). A well-known example of the second situation could be the razor market, where a razor in itself is likely to be completely unprofitable but constitutes a necessity for selling highly profitable razor blades and thus make an overall satisfactory return. However the general principle is that if keeping within cost targets must be given up, the product will not be launched. By this method costs, similar to functional requirements, become well-defined design requirements from the very beginning of the product development activities. An important part of the philosophy is to set the fixed targets at a level that, despite being lower than current abilities enable, is nevertheless realistic to achieve and thus worthwhile the effort. The largest potential of target costing lies in a collaborative supply chain approach to meeting all cost targets and hence satisfy all supply chain members’ demands for profitability. From this perspective the setting of cost targets is largely a matter of identifying what is realistic, but yet sufficiently low to motivate innovation and reengineering of inter-organizational processes among the members of the supply chain.

Multi-level target costing
The principles of setting and working according to cost targets are applicable to sub-levels as functional systems, individual components and even parts of components. At sub-levels cost targets are established on the basis of the overall product target cost. Defining these is the next step in the target costing procedure.

Target cost = target cost (component/subsystem A) + target cost (component/subsystem B) + ......

Through the setting of target costs on the basis of market selling prices the company facing the cost pressure in the market place can transmit this cost pressure to its suppliers, sub-suppliers and so on. Multi-level target costing procedures can be applied to the extent that long-term relations exist beyond the level of 1st tier suppliers, i.e. not only to suppliers but also between suppliers, sub-suppliers, and their suppliers etc. By designing according to these cost targets it is possible to concurrently identify solutions that fulfil design intent while enabling an appropriate production process through which manufacturer, suppliers and sub-suppliers can reach their profit targets. Under this procedure cost targets are not dictated solely by the purchaser or achieved through traditional competitive tendering. Targets need to be negotiated in order to identify realistic expectations based on collaborative search for improved methods of production and/or procurement.
Grouping of cost targets
Individual targets for components/tasks can be grouped so that individual costs, while not their sum, are allowed to exceed targets. This serves to provide a higher degree of flexibility and thus increase the scope for harvesting existing potential for cost reduction. Just as important is that this motivates inter-organizational collaboration about identifying and exploiting synergies across the company boundaries within the supply chains.

Supply chain relations – a critical parameter
It is obvious that successful application of such procedures require strong collaborative supply chain relations with an ‘open book’ policy to secure transparency of cost data. The method builds on acceptance of the assumption that the organisations involved no longer compete as individual companies but as members of supply chains competing against other supply chains, as argued by e.g. Lambert & Cooper (2000). With this method it is common practice to work with a relatively small number of suppliers with whom continuous relationships are built. To engage suppliers in pursuing further potential cost reductions they must feel confident that they themselves will benefit from their efforts and that contracts are not subsequently awarded to their competitors to harvest the benefit of this work. Continuous relations are a prerequisite for achieving further cost reduction through re-engineering the supply chain’s production of sub-systems and components (or the execution of tasks), and move or merge assignments across company borders to benefit from synergies. These and other aspects of target-costing require high levels of trust, which the method seeks to build on factors of transparency, continuity and through the establishing of common interests by applying the ‘all for one’ principle of not accepting excess of the target cost, which thus guarantees individual supply chain members a satisfactory profitability. In the assumption that a given technical or cost advantage will be very temporary, abilities of learning as a team are an important aspect. An aspect which is critical when having to continuously reduce costs after the launching of a product in order to remain competitive throughout the span of the product’s time on the market. In this perspective past or current performance of potential suppliers is less relevant than that of their potential for further development and improvement. Following this argument, suppliers should not simply be evaluated as individual firms but (from a system’s perspective) as sub-supply-chains; and their potential be considered from the perspective of developing the downstream relations to sub-suppliers and their suppliers.

Cost reduction targets and product life profitability
Developed for repetitive production the method operates with targets for cost reduction during the expected manufacturing period. Reduction targets are a consequence of the expectation that competition from new products and price pressure from competitors will drive down selling prices over the manufacturing lifespan of the product. For a product’s profitability to remain satisfactory there must thus be a continuous reduction in manufacturing costs. With the pressure from an annual cost reduction target, the supply chain is faced with the need for developing products and manufacturing processes that (in addition to meeting the original cost targets) bear sufficient potential for further reduction of production costs, thus enabling the product to remain competitive without violating the profitability level satisfactory for manufacturer and supply chain. It is important to realise that the method does not aim at reaching the ‘lowest possible cost’ but focuses on reaching an explicit cost target. The crucial factor for success is whether the supply chain
manages to continuously comply with its cost reduction targets throughout the period of which the product is intended to be on the market.

**Early stage value engineering**

Value engineering (VE) techniques is an essential tool in the target costing approach. To some designers the term *value engineering* may have a negative ring as it describes activities aimed at cutting costs; cutbacks which many designers have experienced to include ‘engineering away’ features representing value to some stakeholders and which designers have structured their approach and work in order to deliver. VE in its purest form is essentially a tool to cut costs out of a design after realising that the production will be too expensive, while design-to-target-cost is aimed at designing costs out of a product. This ‘upstream approach’ is pursued by involving suppliers (internal and external) throughout all design phases in order to get immediate cost feedback, so that VE techniques can be applied from the earliest conceptual design stages when designers have the best possibilities for choosing alternative solutions that meet established targets for cost as well as quality. This method is intended to help avoid ending up with an undesirable need to severely compromise value delivery and design intent through cost-cutting exercises during stages when it is too late to change some of the basic concepts on which the product design is developed if these are found to cause budget overruns.

**APPLYING TARGET-COSTING TO CONSTRUCTION DESIGN**

Construction design can be considered a sub-category within a more general framework of product development (Kagioglou *et al.* 2004). The philosophy of developing designs through extensive use of target-costing principles is in principle fully applicable to construction design. Within the framework of construction few examples of designing to target cost have been studied and reported. Action research into two British pilot projects where target costing procedures were applied, with limited success, found that existing practices of collaboration and cost estimation along with norms and culture of the UK construction are a barrier to satisfactory exploit the potential of target costing (Nicolini *et al.* 2000). The study suggests that a fully-fledged target costing system, with all its ramifications, can only be achieved with sufficient time and considerable effort being invested in supply-chain relationships together with improved methods of collaborative cost determination. Kern & Formoso (2004) introduce target costing as part of an integrated application of various cost management tools to construction. Primarily based on previous publications Granja *et al.* (2005) introduce cost reduction targets (using the term ‘kaizen’) and call for further case studies and research into theory and practice of applying the method to construction. Ballard & Reiser (2004) discuss a case covering the design-build delivery of a US$ 12 million college sport facility, where designing to target cost was applied to enhance value generation within a given budget while managing costs for the contractor. The latter authors mention that methods for designing to target cost are likely to be more used in some form in construction design, but without being well documented. Arguing for a adopting a more systematic approach to design for target cost in construction, Ballard & Reiser proposed five next steps for research into (construction) design to target cost: descriptive research, translation of concepts and techniques from other domains, determining appropriate applications of target costing in construction, understanding the change in roles and relationships, and, understanding the conditions for producing a target cost. While all three publications apply a cost management
perspective, this paper will deal primarily with the perspective of using the method as a framework for collaborative design to enhance value delivery and innovation. Ballard & Reiser (2004) warn against mistaking ‘target costing’ and ‘designing to target cost’ for target cost contracts which in a UK government publication was found referring to a specified way of sharing deviance from actual and target cost between contractor and client.

**Preconditions**

Design-to-target-cost requires that all design phases are undertaken collaboratively with strong engagement from all parts, e.g. designers, contractors, subcontractors and suppliers. This requires closer relationships in the supply chain and also demands a different way of inter-organizational working and collaborating. Collaborative design requires much more than enhanced communication and the design process must be structured and managed to enable reliable cost feedback on the right development stages. As designers are known to take very different approaches to the design process (Jones 1992; Lawson 1997) this may require considerable experimentation and learning to achieve in practice. Suppliers must be capable and willing to adapt to different procedures for working with upstream customers and downstream sub-suppliers, which implies social and organizational consequences as other fundamental changes in business processes. The method is obviously sensitive to changes in client wishes or demands. Efficient application thus requires an efficient briefing process and ‘stable’ client decisions. Working with design solutions that are open to fundamental changes, dependent on cost feedback, also requires a client willing to progress with a less well-defined schematic design and who possesses the resources to engage over a longer period of time when durable design solutions are gradually identified (Brandon & Powell 1984).

**Constraints for the method’s application to construction**

The target-costing method is developed for repetitive manufacturing, while construction in general is a one-off production. Naturally this limits the potential of continuously driving down costs through permanent targets for cost reduction during the production phase. It should however be recognised that construction often bears a high degree of repetition and that there often are considerable repetitions from one project to another where reduction targets could come into play as a framework for improving design. Working under pressure to finish new design assignments in a short time may take development resources away from efforts to optimise or re-engineer production processes. If approaching construction design as an activity to be optimised independently there is a risk that target costing may not succeed to satisfactorily addressing overall project performance.

An obvious constraint to design-to-target-cost appears in the case where a project’s conceptual design has been predefined through the outcome of an architectural contest, thus limiting the scope for the method’s application. Also certain (public) regulation may provide problems for the application target costing procedures. A critical aspect is the liberty of assigning contracts to suppliers without being subjugated by rigid requirements for procedures of competitive tendering or other regulation de facto preventing supply teams to collaborate in an integrated way under long-term relationships.
NEW OBJECTIVES FOR DESIGN-TO-TARGET-COST IN CONSTRUCTION
Designing to target cost is essentially a method for managing the development of (production) costs. It is not unlikely that the pure cost management perspective will be the strongest motivation for further adopting the method to construction design, as in the example reported by Ballard & Reiser (2004). It can however be argued that the method also possess a potential for facilitating a development towards a more integrated construction delivery process enhancing not only cost management but also value delivery and the development of the construction supply chain.

Developing the construction supply chain through designing to target cost
The method of designing to target cost builds on establishing long-term inter-firm relations enabling the supply chain to work in a more integrated way with design as a collaborative activity. While there are other methods and approaches for involving the downstream supply chain in upstream design activities, it is characteristic for design-to-target-cost that the approach offers the combination of a methodology, a strong pressure for engagement and collaboration, and a common interest in reaching the cost targets (since these are I: demands for project continuation, and II: the mechanism ensuring that the individual supply chain members make a satisfactory return on the project). Since return targets are the very basis for the cost targets that serve as criteria for project continuation, successful compliance with these cost targets is the prerequisite for every individual participant’s performance. Thus the method – in principle - provides participants with a strong incentive for supporting all other parts involved in achieving their targets. Motivating participants for actively searching synergies by moving or merging activities across company borders within the supply chain is enhanced by the aspect that while tasks, assignments and turnover may be shifting hands, this is done to support the meeting of defined return targets for all participants. ‘Hand-offs’ between assignments and supply chain members is generally critical to production performance (Shingo 1988; Hopp & Spearman 1996; Koskela 2000). One could hope that a framework, in which participants are encouraged to optimise hand-offs, may similarly serve to increase integration while decreasing uncertainty and risk. One critical aspect needing further attention is the management of the remaining cost uncertainty that cannot be eliminated. How is this best absorbed? And are the traditional use of various contingencies on subsystem level the most appropriate solution when seeking to apply a pressure for process development and innovation while preventing sub-optimisation?

Long-term relationships may considerably stimulate both motivation and abilities for participants to engage in such development activities, but there is a need for further exploration into the extent that designing to target cost can be implemented in temporary project organisations. The method’s potential for facilitating development of the construction supply chain deserves further attention in experiments and studies.

The innovation perspective
Construction has often been blamed for unsatisfactory levels of innovation (e.g. Egan 1998). An important aspect of the design-to-target-cost-method is the pressure for innovation in processes and technical solutions in order to meet targets and/or cost reduction targets that cannot be achieved merely through optimising tasks individually. Collaborative design in combination with long-term inter-firm relationships can provide circumstances advantageous to production feedback, double-loop learning and the...
building up of shared competencies. Additionally it may serve to motivate a more structured approach to common development activities on issues that may require a perspective longer than a single project. Design-to-target-cost as a framework for innovation activities would thus be an obvious focus of future studies.

Value delivery
The method described in this paper can also be considered as a set of design principles strengthening the information basis on which design decision is carried and thus stimulate the possibilities for comparing different design decisions in respect to their overall value/cost consequences. This of course under the precondition that the time required will be allocated to this activity. This demands that efficiency of building designs is viewed in a perspective wider than just in terms of resources spent on developing the individual project’s design. Producing individual designs should in this regard be considered a product development activity that, in synergy with other designs, is to improve delivered value on future projects. If succeeding to reduce uncertainties regarding cost consequences and production constraints, designers will be in a more favourable position for enhancing value delivery for client and stakeholders and the design intent will be less exposed to the risk of being compromised by later cost-cutting exercises.

CONCLUSIONS
The principles of designing to target cost are in principle applicable to construction design and may, in addition to serving as a cost management tool, provide an alternative framework for developing construction supply chains towards more integrated inter-firm relations and activities. The method can also be seen as a methodological framework for conducting innovation activities or as an approach to enhancing the relationship between value delivery and cost. Little research into this method’s application to construction, especially from the perspective of enhancing innovation and supply chain development, has been reported and there is a need for more comprehensive studies of its applicability and potential within the built environment.

References