DETERMINING EXPECTED COST IN THE TARGET COSTING PROCESS

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ABSTRACT

Previous IGLC papers have presented a target costing methodology that begins with reconciliation of the client's allowable cost and the expected cost of the product they want to accomplish their purposes. This methodology has been derived from publications describing how target costing is used in product development. This paper evaluates the extent to which target costing applied to construction matches up with the target costing methodology from product development and also presents a building information model to define expected cost. The information model uses customer requirements for the spaces and site conditions as initial information and develops the life cycle costs of the spaces. It models building components in relation to customer requirements and prices them with market data, consistent with product development practice.

KEY WORDS

cost modeling, expected cost, knowledge management, project management, target costing

INTRODUCTION

In target costing, cost is to be estimated directly from client requirements rather than from designs offered to satisfy those requirements. Expected cost is determined in the definition phase of projects when deciding if the project should be funded, with what budget and scope. If expected cost is underestimated, projects may be funded that should not. If project costs are overestimated, projects may not be funded that should. This paper presents a method of determining expected cost from client requirements that has been proven to be very accurate.

The paper starts with a review of target costing as practiced in product development, covering publications not previously included in literature reviews (Sakarai, 1989 and Tanaka, 1989 and 1993), followed by a review of the target costing methodology previously presented in IGLC papers by one of the authors of this paper (Ballard & Reiser, 2004; Ballard, 2006). Description of TaKu, Haahtela's cost model, follows. TaKu is shown to be consistent with the practice of target costing in product development and with Ballard's adaptation for construction, enabling determination of expected cost directly from client requirements. The paper closes with conclusions and recommendations for future research.

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TRADITIONAL COST MANAGEMENT VS. TARGET COSTING MANAGEMENT

Traditional cost management determines the cost of the product based on the design of the product and an estimated cost of realizing the design. In target costing the cost of the product is determined before design (Sakurai 1989). Therefore target cost has to be based on the information before design, such as

- required performance of the product
- acceptable market price
- client's willingness and ability to pay for the product

Design has then to achieve a solution that fulfills the target cost while also satisfying product performance and quality. Thus target costing involves a proactive cost planning during budgeting and design.

Why does target costing management act upside down in comparison to traditional management? In the literature, the following reasons have been offered:

- In traditional management, cost information is used to make decisions about pricing and investments. In target costing, cost information is used to control the costs (Tanaka. T. 1993)
- Cost should be decided my management, not by designers. Target costing is an attempt to attain in the design phase a specific cost decided by management (Tanaka. T. 1993).
- 80-90 % of the life cycle costs are determined at the design phase of the product. In target costing, cost control is focused on the design phase (in contrast to techniques to improve production processes to lower costs in the production phase) (Tanaka, M. 1989).

Target costing is a cost management tool for reducing the cost of the product with the help of cross-functional teams (management, design, R&D, marketing, accounting) (Sakurai 1989). Traditional cost management finds the allowable cost by iteration of management decisions, design, estimating, testing in the marketplace, new management decisions, redesign etc. Target costing reduces waste as design knows the target cost from the outset. (Sakurai 1989)

TARGET COSTING PROCESS

In Tanaka's system the target cost is set based on the product's functionality and performance (Tanaka, M. 1989). He has defined a target costing management system with five phases. The first two deal with project definition and concept design:

Step 1: Product definition (Planning) summarizes the product plan that clarifies the design requirements

- Outline the product's concept and mission
- Generate specifications for the product's performance
- Define product target cost

Step 2: Concept design formulates the basic concept of the product based on the design requirements

- Formulate main functional areas
- Assign the target cost to the functional areas

- Design the product concept under the target cost
- Use a rough cost estimate to ascertain whether the product concept has been designed to fit the target cost

TARGET COSTING IN THE CONSTRUCTION INDUSTRY

REQUIREMENTS FOR TARGET COSTING PROCESS AND APPLICATIONS

As described in the previous section on target costing in product development practice, a target costing process and applications should fulfill the following requirements:

- Target cost must be based on the customer's function(s) and performance
- The client must be involved to define the function of the building, performance, values and the cost the client is willing to pay for functionality and performance
- Target cost must use market cost data
- Target costing process must encourage cross-functional teams to co-operate in designing to the target (project managers, architects, engineers, construction managers, clients)
- Target cost must be achievable, not too low. Target cost must not be exceeded.
- Target cost must not be too high. Process should create intense but realistic pressure on the designers.
- Target cost should be decomposed to the components, as cooling system, frame and external wall.
- Rapid estimates should be available to help designing to the target.

The target costing process is focused in project definition (when target cost is determined) and design (when the functional targets and cost target will be achieved). This paper discusses project definition and how to determine expected cost directly from customer requirements rather than from designs proposed to satisfy those requirements.

TARGET COSTING AND PROJECT DEFINITION

What is the role of design in project definition? Some programming concepts include design in project definition. It has been argued (Whelton & Ballard 2002) that in complex projects the exploration of design solutions is required in order to understand the programming problem. On the other hand, some authors (Pena et al. 1977, Pennanen 2004) have advocated excluding design from project definition.

If we follow Tanaka's process, performance, specifications and target cost should be defined before conceptual design. However, it does not prevent a cross-functional team (client stakeholders, designers, construction managers) from searching for client values and defining a target cost. The path from customer's business needs to a design solution can be understood as language transitions. Customer language includes expressions of purpose and instrumental values for achieving the purpose (We cannot satisfy a client request for radiators. We need either better assembly process or extension of the assembly hall). In the project definition process this language is translated into design criteria (an assembly hall for 10 jigs with certain dimensions, 5 ton crane, pneumatic outlets with certain pressure…) In Tanaka's description this is included in planning, in construction it is placed in project definition. In design this is translated into language for production (drawings, scope of work, scope of elements…). If exploring design solutions is used as a means for crystallizing customer purpose and constraints, it would be best suited to the target costing process if the findings were expressed in terms of design criteria.

In the car industry, target cost is derived by analyzing market data (how much people are willing to pay? How much the competitor's product cost?). Defining target cost directly on the basis of markets in construction industry is somewhat difficult. In construction the project definition (and required performance of the spaces or building) is linked to a very complex socio- economic system (owners, users, city planners, investors, AEC-specialists…) (Pennanen 2004). Building as a physical object cannot be predicted and initially the activities the client requires, the extent of the building, mass and equipment are unknown (Pennanen & Koskela 2005). Therefore most buildings are unique (excluding standard designs e.g. in residential housing production). The name of the building type does not describe internal functions; in an office building there might be car parking hall, a dentist's practice, a pub, a shop, gym, meeting activities, catering activities, conference activities, therapy pool, cellular workplaces, open plan workplaces, good or bad internal climate control etc. Besides, in renovation projects only part of the building will be renovated. It is difficult to define the target selling price of a unique product by making market analysis among competing products. The more unique the product, the more difficult it is to accurately estimate both revenues and costs. In such a complex environment, target costing requires an iterative project definition process.

Two cost perspectives can be used to define target cost in construction (Ballard 2006 and Ballard 2007): 1) Allowable cost is defined by the customer. It is a cost that the customer is willing and able to pay for a facility with defined performance. Allowable cost should be specified in the project business plan. 2) Expected cost is defined by the project team. It is the cost if the facility with determined performance were provided at current best practice.

Target cost definition can be described as a dialogue of allowable and expected cost. If the expected cost is bigger than allowable cost, the project should not start. The building with defined functionalities and with defined performance is not valuable enough for the customer's business and core activities, or the customer is simply not able to afford what it needs. The specification of the project has to be developed, either to be cheaper or more valuable for the business. It can be done either by improving the efficiency of the facilities by using strategic workplace planning techniques (Pennanen 2004), or if that is insufficient, by sacrificing lesser important values (Ballard 2006). Expected and allowable cost must be defined again. When the expected cost is less than or equal to the allowable cost, the target cost can be set to be equal with expected cost or below it. Setting target costs below expected often is done along with a sharing of cost savings between customer and project team, thus increasing the incentive to innovate.

TARGET COSTING PROCESS

The proposed target costing process includes market driven costing, product level target costing and component level target costing. It is in concordance with M. Tanaka's (Tanaka, M. 1989) step 1 (outline the product's concept and mission, generate specifications for the product's performance and define target cost). The target costing process during project definition can be defined as follows (modified from Ballard 2006):

1. Assess the business case
2. Determine stakeholder values and define specification of the project
   - responsibility of the client, with help of a team consisting facility planners, workplace planners, architects…
   - *business plan*
   - *business activities that require spatial investment*
   - *spaces required*
   - *performance requirements set on the spaces (Pennanen & Haahtela & Väänänen 2005)*
3. Determine the allowable cost (market driven costing)
   - responsibility of the client since the spatial investments compete for the same resources as the other investments for business (salaries, machinery, marketing…)
   - *minimum acceptable ROI*
   - *maximum available funds*
4. Determine the expected cost (product level target costing)
   - responsibility of project team (project and construction managers, accounting, designers)
   - *benchmark*
   - *information modeling tools*
5. If expected cost is bigger than allowable cost then modify the specification (step 2)
   - develop business operations in relation to spaces in order to improve the temporal utilization of the spaces by using workplace planning techniques (Pennanen 2004) (meeting hotels, hot desk workstations, combine activities to same working environment, define flexible spaces to enable more functions, use rent- spaces if utilization for own use is low…)
   - remove less important functions and related spaces (e.g. functions that are more expensive than valuable. "we don't need catering activities because there are lunch restaurants nearby, long term storing can be removed to a cheaper location")
   - re-define space performance ("only entrance floor is in heavy use, requirements on durability can be lower")
6. Go to step 3
7. When expected cost is equal to or less than the allowable cost, start project delivery by setting a target

cost equal to or below expected cost in order to drive innovation beyond current best practice (or set target for the customer value beyond current best practice)

8. Launch design phase
9. Decompose product level target cost to component level target cost
   - for enabling the steering of the design in component level
   - for setting targets for the design-and-build subcontractors

DEFINING EXPECTED COST THROUGH INFORMATION MODELING

INFORMATION MODELING

Construction lacks best practice estimating applications (Ballard 2006 and Nicolini, et al. 2000). Project definition is linked to a very complex system. Customer requirements (and buildings) tend to be unique and customer's requirements tend to drift during project definition (iterative process). How to define expected cost in such a complex environment without excessive iterations? Expected cost (and finally target cost) cannot be too low in order to prevent unrealistic targets and not too high in order to create realistic pressure on the designers to innovative solutions. Possibilities could be: using benchmark projects, incorporating suppliers (contractors and sub-contractors), producing rough design solutions + estimating them and using information modeling

If we follow target costing principles, expected cost should be defined before design. Target costing should price customer's functions and performance rather than proposed design solutions. In general, contractors have got accustomed more to estimate drawings than customer's functions. Benchmarking may not be sufficiently accurate to price a unique and drifting set of customer requirements, though that is a matter for future research to decide.

In Finland an information model has been in use for more than ten years to describe customer requirements and to price customer requirements (Pennanen & Haahtela & Väänänen 2005). It is constructed to use as far as possible the language understood by both customer and designers (design criteria); the client does not want cooling beams, switchboards or columns, instead the client may want space for a 15,000 volume library, good internal climate in rush hours and appropriate lighting.

TaKu™ information model's input information consists of spaces needed by client (200 m2 library hall, 35 m2 operation theatre, 40 m2 dining room…) and requirements the client sets on the spaces (internal temperature control within +- 2 degrees, 20 pneumatic outlets, 6 m height, 400 lux…). Furthermore information on constraints concerning soil and urban environment are to be added. Model results expected life cycle cost (investment and maintenance costs) for new buildings or rehabilitation projects

COMPONENT LEVEL COSTING

The information model produces first component level costs and combines the component level costs into product level cost. The application models the building components with which the customer requirements can be provided. The result is priced quantities of "reference systems" that exist in the market. Modeling follows Nam Suh's independence axiom (Suh 1990), "a good design is made up of design parameters that result in the independence of the functional requirements from each other". It means that complexity can be reduced if each design components satisfy only one functional requirement. Let's have a look at two requirements for internal climate: CO_2 content and air cooling. They can be controlled by variable air volume system or by CAV system and cooling beams. Independence axiom argues that latter solution reduces complexity of whole system; if you want to have better cooling, inlet air volume remains the same.

Some examples of component level modeling: Number of luminaries is modeled by the formula <N= ExA/(FxnxUfxMf)>, where E is illumination required, A is size of the space, F is efficiency of the lamp…

It is not necessary to design first a design solution to count out the number of luminaries (or size of main switchboard, or…) if we know client requirements (assembly hall 1200 m2, 600 lux), as the designers use the same formula to determine the number of luminaries. Cost then can be based on component level market data. Luminaries can be priced by unit prices of luminaries sold in the market.

Lifts are modeled by Round-Trip Time and required Waiting Time. Beams are modeled to bear required load (calculations for bearing torque and bending). This kind of modeling results in very accurate information on cost changes caused by changing client requirements (…if the space is bigger…, … if lighting has to be 800 lux instead of…). It is valuable information; you can immediately tell your client, how much his/ her decision increases/decreases the budget.

PRODUCT LEVEL COSTING

However, component level (from bottom to top) product model does not yield accurate information concerning the total life cycle cost of the whole building project. In construction there are emergent features. It means that it cannot be managed only through components since costs are also affected by human factors in the design process (if I ask for design solution from 1000 different architect offices, I will get 1000 different solutions), human factors in production-in-site, and market fluctuations (e.g. contractors expectations of profit right now). Many of the factors are random and chaotic. From top to bottom calibrating is needed, too.

To find reasonable market-cost-level adjusting has been done by cybernetic closed loop with a black box (Beer 1966). The client requirements of already finished projects are first modeled to expected cost, and the result is then compared to market costs, tenders. If the model acts as in the left picture, it describes well what happens when clients change their requirements. Expensive in the product model is expensive in reality. But, because of emergent reasons, there is a difference in cost level. This difference is stored in a black box (right picture, component level costs are adjusted), and black box is updated once or twice a year (black box means that we do not know, or do not need to know the mechanism inside the box). The black box is adjusted so that there are several possible solutions for a design problem (set of client requirements), in the range where costs do not correlate strongly with quality (see next chapter).

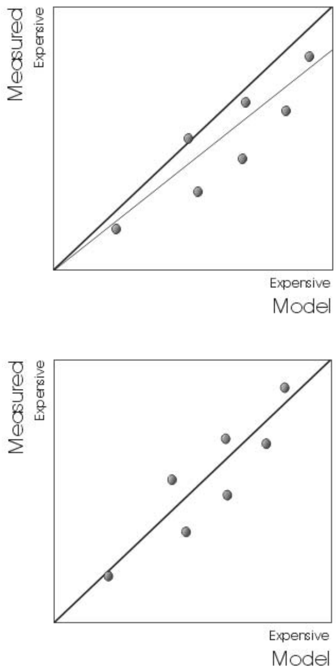

Figure 1: Adjusting model to market costs

The information model is mainly used in renovation projects (because there are more renovation projects than new building's construction). If an old building do not provide a certain requirement (cooling, a space…), it has to be provided by renovation. By comparing customer requirements to the features the existing building provides the renovation ratio and expected costs are determined.

REDUCING COSTS? SOFT CRITERIA VS. HARD CRITERIA.

Reducing costs was one of the major aims in Toyota target costing, reducing costs through continuous improvement, "cost kaizen". This is becoming relatively less important because the efforts made throughout the company will inevitably lead to fewer opportunities to cut costs (M. Tanaka 1989).[1] How far we can reduce costs in the construction industry?

One reason why a socio-economic inductive system easily moves into a chaotic state is that some of the driving functional requirements are measurable (internal temperature in a room must be 24 +-1 degrees) and some are based on "soft" values, e.g. beauty, habitability, internal comfort. There is a big variety in design solutions. Architect Niukkanen (Niukkanen 1980) has studied the correlation of architectural quality and building costs. The population of the study was design & build competitions in Helsinki City residential building production. The competitors competed with architectural design solutions and price tenders. All the design solutions fulfill the measurable criteria (certain amount and sized bedrooms, living room, possibility to have a shower, internal temperature controlled in a certain allowable limits…). They all are good quality in terms of measurable criteria. The architectural quality (external beauty, internal comfort, habitability) was analyzed by a delphi-group and value analysis matrix. The result of the study can be seen in the following figure.

As far as costs are concerned, the possible range is shown on the x-axis. If we do not steer the design in economic meaning, possible range covers all the possible design solutions (that fulfill measurable requirements). Minimum cost seems to yield poor quality in terms of soft criteria.

[1] We should condition Tanaka's claim with the recognition that cost reduction opportunities are limited only within a given level of technological and managerial invention.

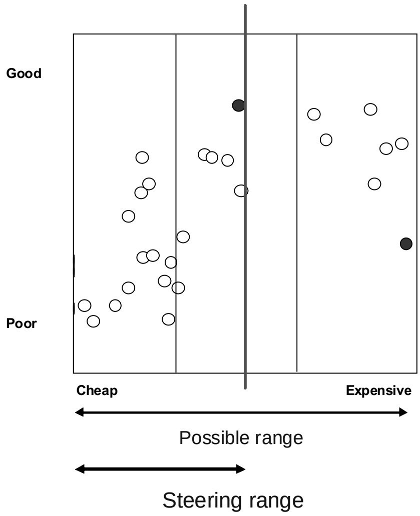

Figure 2: Cost and Quality

If we move cheaper from there, we are out of possible range, in an area where there is no design solution that meets all the measurable criteria. In this area we have to sacrifice, but soft values, also some measurable values. But very soon, when moving to the right from minimum to "reasonable cost" production, the correlation between quality and costs disappears. The most expensive design solution was quite poor in terms of quality and the best quality was achieved with a reasonable price (of course, high price did not prevent good quality).

If we operate in the "reasonable costs" area then the quality cannot be assured by allocating more resources to production, indeed, this may just as well lead to a poor quality solution as a high quality one. It seems that architectural quality is linked to creativity and artistry of the design group in interpreting our culture and its changes rather than to money (Pennanen 2004).

The steering range (range within the design has to be steered) can be adjusted narrower than the possible range, e.g. the variety of design solutions could be reduced, without sacrificing architectural values. In the steering range, the range of architectural quality can be achieved. If the target cost is placed in this area, then the cost can be considered as a fixed variable (one design criteria among the others) and the architectural quality is the variable that is managed (by steering the design). TaKu™ application sets expected cost in the middle of the observed cost distribution (after extremes has been removed) twice a year. Typically the observed costs vary +- 20 % from the mean value. Project management can then decide where to set the target cost. If it is set in BIM–level then the more expensive half of the cost distribution will be cut off and costs will reduce. If it is set on the level –10 %, it is possible to find a good quality solution, but you have to do work for it. If it is set on the level -20 %, you will risk the quality of the product.

ARCADA POLYTECHNIC CASE STUDY

One project on which TaKu™ was used is provided here to demonstrate consistency with the target costing process adapted for construction by Ballard (2006) and the benefits in practice of determining expected cost directly from customer requirements. The case was originally described by Whelton (2004), who did not apply the target costing lens.

- Assess the business case
- Arcada Polytechnic serves the needs of the Swedish speaking community particularly in the Helsinki metropolitan area. Target costing started at in late 2000. The main strategy for

Arcada was to create a centralized campus area which would create a cohesive identity for the Swedish speaking education community.

- Determine stakeholder value and determine specification of the project
- The business plan in this case can be manifested as degrees important for Swedish speaking people in a Finnish speaking environment and as courses needed for those degrees. The first plan required 14,100 usable area for the Arcada campus.
- Determine the expected cost
- The expected cost to provide the customer with required performance was defined to be 40 million euros. Expected cost was defined through use of a building information model (TaKu™).
- Determine the allowable cost
- The board of Arcada declared that the building costs should not exceed 33 million euros. The allowable cost was defined based on Arcada's business plan, on their plans to improve teaching and predicted income growth. The gap between allowable and expected cost was seven million euros. The project did not start until that was closed or it became evident that it could not be closed.
- If expected cost is greater than allowable cost then modify the specification
- Proposals were made to reduce space demand by increasing space utilization and by removing unneeded functions for the strategy. Health care activities were combined to multi-use-spaces instead of highly specialized laboratories, library volumes were reduced and some activities were outsourced (tv-studio work…). Also some activities were added in the specification.
- Determine the allowable cost and expected cost
- Expected cost was defined to be within the required budget (former allowable cost).
- President of Arcada requested that the allowable cost should be reduced further to 32 million euros. The Arcada board could not get income and expenses in balance.
- If expected cost is bigger than allowable cost then modify the specification
- A student's club was removed to be financed and realized later. Teacher's working area was placed in a landscape configuration.
- When expected cost is equal to or less than the allowable cost, start project delivery by setting a target cost equal to or below expected cost.
- The board accepted version 5d of the project definition. The space required was 11,020 usable m^2 and expected cost 32 million euros. Allowable cost was the same. Target cost was set to be equal to expected cost.
- Launch design phase

- The design was finally steered to the targets.

CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

A building information cost model has been in commercial use in Finland for more than ten years. At the moment it is widely used by project managers, contractors and facility owners. The model was created to plan costs in relation to design criteria and to support a dialogue between allowable and expected cost. The aim was rather to prevent too high costs than to systematically reduce costs beyond current best practice. At the moment most users accept the cost level of the application (in the middle of the distribution). In general (among those projects) the costs have been reduced since the more expensive half of the cost distribution has been cut off. Costs have also been reduced because of increased awareness of construction economics among architects, other designers and project managers when multifunctional teams have been used in order to steer to the targets (Haahtela & Kiiras 1991). But, if we look at individual projects, options to reduce cost by setting target cost below expected cost in order to drive innovation beyond current best practice may not have been pursued enough.

In many cases target costing is integrated with the strategic planning process and ABC management (Pennanen, 2004 and Pennanen et al., 2005). Among those cases 7-25% cost reductions have been measured (Whelton 2004). In those cases, the innovations have been directed to customer's operations in relation to the built environment (better utilization, new process models). Cost reductions have been achieved by dialogue between strategic and operational management. This dialogue has been supported by ongoing calculation of expected cost, allowable cost and activity-based costing.

TaKu's successful use demonstrates the feasibility of determining expected cost directly from client requirements as opposed to estimating cost from designs offered to satisfy those requirements. Future research is needed to explore the application of this type of cost modeling to other geographic and industry domains, and also to explore the use of targets to spur innovation and systematically reduce cost. In addition, research is needed on later stages in the target costing process; namely, designing to targets and building to targets. The authors of this paper invite collaboration from others in this future research.

REFERENCES

Ballard, G. (2006). "Rethinking Project Definition in terms of Target Costing". *Proceedings of the 14th annual conference of the International Group of Lean Construction*. Chile

Ballard, G (2007). *Target Costing in the Construction Industry*. Presentation in P2SL 2007 Conference Feb. 7. 2007, Berkeley, California.

Ballard, G. and P. Reiser (2002). "The St. Olaf College Fieldhouse Project: A Case Study in Designing to Target Cost". *Proceedings of the 12th annual conference of the International Group for Lean Construction*, Elsinor, Denmark, July, 2002.

Beer, S. (1966). Decision and Control. The meaning of operational research and management cybernetics. John Wiley & Sons, London

Cooper. R & R. Slagmulder (1999) “Develop new products with target costing”. *Sloan Management Review,* Cambridge, p. 23-33

Haahtela, Y. & J. Kiiras (1991). *Talonrakennuksen kustannustieto* (Construction economics). Rakennuskirja Oy, Helsinki (in Finnish only)

Nicolini, D. & C. Tompkins & R. Holti & A. Oldman & M. Smalley (2000). ”Can Target Costing and Whole Life Costing be Applied in the Construction Industry?”: Evidence from Two Case Studies. *British Journal of Management*, Vol. 11.

Niukkanen, I. (1980). *Quality and Cost Factors in Architectural Design (Rakennussuunnittelun sisällön ohjaustekijät).* Helsinki University of Technology, Department of Architecture (in Finnish only).

Peña, W.M. & W. Caudill & J. Focke (1977). *Problem Seeking: an architectural programming primer*, Cahners, Boston

Pennanen, A. (2004). *Workplace Planning*. Haahtela- kehitys Oy. Finland. Internet: http://www.haahtela.fi

Pennanen. A. & L. Koskela (2005). ”Necessary and Unnecessary Complexity in Construction”. First International Conference on Complexity, Science and the Built Environment, 11-14 September 2005. University of Liverpool, UK. Internet: http://www.haahtela.fi

Pennanen A. & Y. Haahtela & H. Väänänen (2005). “Workplace Planning and Target Costing Techniques in Project and Facility Management”. CIB conference Helsinki 2005. Internet: http://www.haahtela.fi

Sakurai, M. (1989). ”Target Costing and how to use it”. *Journal of Cost Management*, 39-50

Suh, N.P. (1990). *The Principles of Design*. Oxford University Press

Tanaka. T. (1993). ”Target Costing at Toyota”. *Journal of Cost Management* (Spring):4-11

Tanaka, M. (1989) ”Cost planning and control systems in the design phase of a new product”. Japanese management accounting, *A world class approach to profit management.* Productivity press, Massachusetts, USA, p 49-71

Whelton M. & G. Ballard (2002). ”Wicked Problems in Project Definition”. *Proceedings of the 10th annual conference of the International Group of Lean Construction*. Brazil. August 6-8, 2002)

Whelton, M. G. (2004). *The Development of Purpose in the Project Definition Phase of Construction Projects: Implications for Project Management.* University of California at Berkeley.