5th International Conference on Mass Customization and Personalization in Central Europe (MCP-CE 2012)

Customer Co-Creation in Central Europe
September 19-21, 2012, Novi Sad, Serbia

CAD AND PLM PROGRAMS SUPPORTING TARGET COSTING

Matti Sievänen, Henri Wihinen
Tampere University of Technology, Cost Management Center, Industrial Management, Finland

Abstract: *Research and development costs are an important cost factor in some industries. Even more importantly, many costs are affected by product design and development. Thus, product engineers and designers are very important customers in cost accounting. If the cost information is not easily available for designers, they will most likely make a decision based only on technological preferences. The objective of this paper is to study current CAD and PLM programs and how they support the target costing process. Six costing modules for CAD and PLM programs are chosen, and their usability, advantages, and disadvantages are discussed.*

Key Words: ***Target Costing, PLM, CAD, Cost Management***

1. INTRODUCTION

New product development has often been technology oriented. Being too technology oriented may result in advanced products, but the cost might be too high. Even though costs are incurred mostly during the production phase, most costs are committed during product development. The most efficient way to keep costs down is to design them out of products rather than reduce the costs after the products have entered production. However, there is a gap between the need for and the supply of cost information in product development.

Reducing costs through product design is the most critical step in attaining target costs. The key to cost reduction is asking a simple question: How does the design of this product affect all costs associated with the product from its inception until its final disposal? Including all costs, not just manufacturing costs, may appear farfetched at first. However, costs such as distribution, selling, warehousing, service, support, and recycling can be greatly affected by product design.

During the last few decades, software programs have greatly increased the amount of available product information. Computer-aided design (CAD) and product life-cycle management (PLM) solutions are widely used, and they store a lot of product information. Software companies have also recognized the potential of the solutions to store and manage cost information. Several programs and add-on modules can handle and report cost information.

The aim of this paper is to study commercial CAD and PLM software and their ability to support the target costing process. Six software solutions were studied to understand how they calculate cost estimates. Moreover, we also examined in which phase of the process they are most useful. The aim is to give practical recommendations for when to choose CAD- or PLM-based software to estimate costs. CAD and PLM support product development and target costing processes; however, in this study we concentrate on the solutions' cost management features.

2. TARGET COSTING

Target costing, as it is seen today, was developed by Toyota during the 1960s [1]. However, the idea of target costing can be found, for example, in the words of Henry Ford: "Build a motor car for the great multitude . . . It will be so low in price that no man making good salary will be unable to own one" [2]. Ford's idea was far-reaching because it changed the entire automobile industry. Standardized products and assembly lines made low costs possible, and even today target costing is most often used in the automotive industry [3].

Target costing can be approached from at least three different views [4]. It can be simplified to the equation "Sales price - Target profit = Target cost". Or it can be seen as a technique for managing costs and profit. The broadest view is that target costing is a company-wide strategic tool that integrates the marketplace and customer interest in the company's interests. This idea can be found in the definition of target costing by the Consortium for Advanced Manufacturing-International (CAM-I):

"Target costing is a system of profit planning and cost management that is price driven, customer focused, design centered and cross functional. A Target costing initiate cost management at the earliest stages of product development and applies it throughout the product life cycle by actively involving the entire value chain." [5]

Being a strategic management tool, target costing differs from the traditional approach to cost management. CAM-I presents following six differences [5]:

1. Price-led costing
2. Customer focus
3. Focus on product and process design
4. Cross-functional teams

5. Life-cycle cost reduction
6. Value chain involvement

Dutton and Marx [4] talk about a paradigm shift. One of their ideas can be added to the list:

7. From cost forecast to cost commitment

Target costing focuses on customer requirements. The selling price of a product is given. Every effort is made to achieve the target cost. However, the product's performance cannot be reduced below the limit defined by a customer. According to Cooper and Slagmulder [6], there is one cardinal rule: "The target cost of a product can never be exceeded." If the target cost is not met, the new product will not be launched. Otherwise, the target costing will lose its effect as a managerial tool.

Certain tools are used during the target costing process. Some tools are quite often used alone and can be easily integrated in target costing. Typical cost management tools used are cost tables, feature costing, and process costing. The cost accounting department is responsible for updating the tools. Other often-used tools are QFD, value engineering, and value analysis.

Target costing is typically used in assembly manufacturing firms. According to Kato and Boer [3], all Japanese transportation equipment companies use this process; however, Japanese paper and pulp companies do not. Furthermore, target costing is not used in process industries in the U.S., because it is more limited in making performance and cost trade-offs between different components [7]. Moreover, target costing is used in industries that have reached the maturity stage of their life cycle and face stiff price competition [6].

Although many articles on target costing have been published, not many have considered the downside. Typical problems are longer product development times and employee burnout. Much management attention is focused on the design stage. This may lengthen the design phase and does not guarantee that the target is met. Furthermore, constant pressure to meet schedules and target cost goals may cause employee burnout [3].

Target costing is a good and efficient strategic tool, based on open system theory, but requires a lot of work and commitment to the goals. Cost and profit are managed in the design stage. Furthermore, target costing is responsible for transferring customer needs to a product.

3. SELECTION OF THE PROGRAMS

The aim of the research was to study software programs that use product structure models to provide cost information for the target costing process. Programs connected to either CAD programs or PDM/PLM programs are the most useful during the R&D phase. Moreover, enterprise resource planning (ERP) systems was not included in the study because they are mainly used in the later phases of the product life cycle.

At the beginning, publicly available commercial programs were scouted. We found 24 programs that use product structure to define cost estimates. Six programs were selected based on publicly available material and program features. The selected programs covered most of the features of all the other programs. Many PDM/PLM programs sum up the cost based on the product structure and report the cost as a single figure. The programs we selected had more functionality and/or they can report more detailed cost information.

All selected programs had many demonstration videos made by the software producer or users. The videos were useful for analyzing the functionality of the programs. We also used manuals and other descriptions. Manuals were helpful for finding how these programs can be integrated as part of another software program. Moreover, programs' functions were studied by interviewing the software dealers. In some cases, we even tested the programs in a demonstration environment and thus gained experience and deeper understanding.

Three of the six selected programs were linked to CAD programs and the other three to PDM/PLM programs. First, all the programs are briefly presented and then compared to similar programs. The first selected program is SolidWorks Costing, an add-on to SolidWorks 3D CAD software introduced in 2012. It can be automated to generate cost estimates and, as a part of the CAD program, can be used simultaneously while modifying a design. The second program is Design for Manufacture and Assembly (DFMA) delivered by Boothroyd Dewhursts Inc. It is actually two separate programs, DFM Concurrent Costing and DFA Product Simplification; the former is the focus of the study. The software can deliver rapid estimates of manufacturing costs. However, it is a separate program from design software, and the 3D product structure model has to be exported from the CAD program to DFMA. It has many manufacturing environments and processes modeled, but accurate estimates require significant manual effort. The third software program using 3D CAD models is aPriori. It can be used in any life-cycle phase to generate cost estimations. aPriori is a separate program for CAD software, and the 3D CAD model has to be imported in aPriori. There are many predefined manufacturing processes from which the user can choose the most suitable. The user's own manufacturing processes can be modeled as well, but the user has to buy it as an extra service. aPriori can be integrated in several CAD solutions, but in that case, only predefined manufacturing processes can be used.

The other three software programs are part of PDM/PLM programs. First, Windchill Cost is an integrated part of the Windchill PLM program. It rolls up the cost for different bill-of-material configurations. However, the software cannot define any new information; the program sums up only existing cost information and thus is suitable for modular products. Second, Arena Solutions provides PLM software that can estimate costs. It can automatically generate cost estimates for assemblies as long as the item- and process-level cost information is available. Furthermore, several alternatives can be stored for a single item, for example, in a case of make-or-buy decisions. The third software is VariCost, which is part of VariPDM software but can be integrated in other PDM/PLM solutions. VariCost has been developed especially to calculate costs for configurable products. In general, it operates similarly to the other two, and sums up the cost of the final product. However, VariCost is the only program in which

mathematical formulas can be entered. Thus, it can easily compute costs for parametrical products. In addition, the cost can be saved to product attributes, which in some cases is useful for simplifying product structure models.

4. PROGRAMS' ABILITY TO SUPPORT TARGET COSTING PROCESS

4.1. Product costing features of SolidWorks Costing, DFMA, and aPriori

All three programs use analytical methods to estimate costs. The programs define parts as feature connected to the manufacturing operations, and based on time estimates and hourly rates, the programs sum up the costs. Thus, to estimate costs, these programs require detailed product information. However, a target costing process starts at the concept design stage where this kind of information is not yet available. This limits the use of these programs in early phases.

Even though the programs use similar cost estimation methods, the programs differ based on the unit of analysis and the level of cost modeling. DFMA and aPriori estimate assembly costs by dividing assembly work into separate tasks. However, only a bill of material can be used automatically, and the manufacturing and assembly processes have to be inserted manually. SolidWorks Costing and DFMA report the costs of manufacturing operations whereas aPriori does not report them separately even they are used in cost calculations. SolidWorks Costing and DFMA help the user understand how the estimate has been constructed, which was recognized by Tornberg et al. [8] as an important factor in improving cost consciousness in R&D.

Each program has its own limitations in linking product features to manufacturing operations. The number of possible manufacturing operations is too large to be fully covered, and thus, the programs mainly offer the most common ones. New manufacturing operations can be added to SolidWorks Costing. However, the program can use only simple product features such as dimensions and volumes, and defining complex manufacturing operations is complicated, and sometimes impossible. In aPriori, new manufacturing operations can be inserted as an additional service whereas DFMA has completely fixed options.

For the reliability of estimations accuracy has an important role. The accuracy is based on the program's internal features and the cost information provided by a user. Most of this information has been connected to manufacturing environments and operations modeled and saved in the programs. Information about the environments and operations varies significantly according to the level of detail. In SolidWorks Costing, operation costs are modeled by using a few hourly rates, which are connected to the operation time. DFMA uses much more detailed cost information. However, the level of detail does not always decide how accurate estimates can be provided; fewer variables mean more cost factors have to be included in one variable. Each program provides several built-in manufacturing environments except SolidWorks, which offers just one environment for rough estimates. aPriori and DFMA provide multiple, frequently updated, built-in environments for different market areas and factory sizes. Moreover, estimation accuracy depends on how well the product and its features are defined. All three programs can quickly provide cost estimates based on default values. For a more accurate estimate, a user can proceed by defining the part more detail and selecting the materials and manufacturing methods. The accuracy of the estimates improves while an R&D process proceeds and thus supporting target costing process. The programs' ability to interpret part features and connect them to manufacturing operations has a significant effect on the accuracy of the estimate. DFMA can handle a very limited number of geometric features, and the user has an active role in getting more reliable estimates. In contrast, aPriori and SolidWorks Costing can transfer the most of the cost-relevant product features to manufacturing operations; however, in these programs a user may need to add manufacturing functions such as coating methods. After all, aPriori and SolidWorks Costing can provide relatively accurate and useful estimates almost automatically.

Even though the programs have similar operating logic, the ability to help a designer understand cost effects differs between the programs. SolidWorks Costing has fully automated cost estimates and shows the cost of manufacturing operations. aPriori shows the total costs on an item level, but if the user wants detailed cost information about operations or to change the manufacturing process, the product model has to be opened with another software program. DFMA as a separate program does not provide costs simultaneously with the design, and the item information must be exported from CAD software to DFMA. However, the strength of DFMA is its ability to divide a product into features and show the costs on that level. This is also possible in Solid Works Costing. aPriori does not offer cost structure on the operational level, but in assembly evaluation, this program shows a component level cost structure. In aPriori, it is also possible to compare a product with another product by the average price per weight or another characteristic.

All three software programs that exploit product models offer many opportunities to support target costing. However, there are some limitations. First, these programs are usually used only in the product design and development stages. Second, only a few manufacturing environments are modeled within the programs. And finally, the accuracy of the estimate depends on how well the manufacturing environment has been modeled and how reliable the external cost information is. The three challenges mean that the programs' potential use in target costing varies by case.

Cost estimates are usually based on the operations linked to the features. The basic idea is to automate the laborious analytical process and make cost estimates available for anyone at any time. The advantage is that a designer sees the updated cost estimations all the time and thus gets continuous feedback about the cost consequences of his or her actions. This also increases understanding of how the estimate has been formulated. Traditionally, designers have trusted their own experience or experts' estimates. Consequently, these

cost estimating functions are especially useful for new designers. In addition, the information presentation emphasizes the importance of the target costs regardless of the information accuracy.

The programs also have potential for recognizing cost-cutting objects and target cost follow-up. Observing different assembly cost structures, material, and manufacturing options, a user can recognize cost-saving objects. However, the most remarkable cost improvements are based on the designer's skills. The programs can be also used to monitor if the target cost will be reached, but this requires already significant modeling accuracy.

Of the programs, SolidWorks Costing is the only one embedded as part of a CAD program. Hence, for example, the designer can easily add external processes outside the product model, change the manufacturing environment or materials, and look at and modify the machines' cost information. Possible disadvantages of SolidWorks Costing are the low number of manufacturing processes and limitations in calculating costs within a narrow scope.

DFMA is a separate program from CAD software, and does not present the cost information in the CAD program's interface. DFMA uses existing product models poorly, and thus a user has to input most of the data. Using this software requires a lot of time; thus, DFMA does not fit the concurrent control of the design process, where the greatest potential of these programs lies. DFMA's estimating process is detailed, and the cost structure is presented on multiple levels from the manufacturing and assembly perspectives. Hence, its greatest potential is in recognizing cost-saving objects and target cost follow-up.

Similar to SolidWorks Costing, aPriori uses product models efficiently, which enables an almost fully automated cost estimating process. However, to be able to change default values, report the cost structure in detail, or adjust the cost estimate, the product model has to be exported from CAD software. In addition, aPriori does not provide a detailed cost structure for a single part. This program's strength compared to the other two programs is that it uses cost estimates from other products to recognize potential cost savings at the part level.

4.2. Product costing features of Windchill Cost, Arena, and VariCost

Software programs using PDM information mainly estimate costs analytically and thus do not differ significantly in that sense from programs using CAD information. However, these programs only sum up the costs of the components to get the cost for the product (assembly). Thus, in practice all the programs use cost tables. VariCost has the most advantages by allowing the user to store different costs for an item based on attributes, for example, different costs for different colors. In Windchill Cost and Arena, new items have to be created for different attributes, which increases the complexity of the product structure models. Consequently, these programs are suitable only in later R&D stages when cost information is available and product models are quite complete. Since the programs depend on externally produced cost information, their role in estimating costs is more as a cost information reporter than a producer.

Only VariCost can estimate assemblies and items parametrically. A user can save mathematical formulas in the system, and thus, costs can be calculated. This makes it possible to estimate the cost of non-modular products as well as services. Moreover, mathematical models can be useful in estimating costs when new products have cost drivers similar to existing ones. From the target costing perspective, VariCost is more diversified and flexible than the two other programs.

Since the programs' analytical estimates are based on external cost information, the programs' accuracy depends on this information. Thus, the ability to insert metadata in addition to the estimates becomes important. This is possible in all programs; for example, in Windchill Cost a user can add a value describing the reliability of a single estimate. Based on these single values, calculating the reliability level for estimating the entire assembly cost is possible. Furthermore, the simplicity of the programs' analytical method makes it possible to automate estimations, and they can be calculated almost with a single click as long as cost information is available for each item. Automating estimates can be useful from the target costing point of view especially when assemblies contain many items or the same items are used in multiple products. When the cost of a single item changes, the cost estimates of all sub-assemblies with the same item are automatically updated. This speeds up the cost estimating process significantly. VariCost's parametrical modeling can be very useful in cases, when a company produces customized products, in which the cost factors have been recognized and are similar between the products.

For the target costing the programs help recognize potential cost-saving objects. Arena and Windchill Cost show the percentages of relative costs automatically, which makes it easy to recognize the most significant cost objects. It is also possible to save additional detailed cost information under each item. Windchill also analyzes the item cost at a detailed level and generates graphical reports of the item cost structure. In VariCost, a user can have several reporting views, for example, item, product, or product family views. In the end, the differences in identifying cost saving objects between the programs are the result of information, which has been entered in the program and attached to the items.

The programs can also compare cost estimates with target costs. However, it is not enough to know the current state; historical data and trends are as important for understanding if the target cost is reachable with the current design and efforts. Version management makes it possible to store historical cost information for these analyses. Graphical analyses are supported by Windchill Cost. In Arena and VariCost, graphical analyses from historical data are not supported, and thus, data must be exported to separate software, such as MS Excel. Windchill supports target costing by creating a 3D product model. In this visualization, a user can observe if single parts have reached their target costs and how trustworthy these estimates are.

The product model management and programs' role as an information distributor between different systems and partners make the programs a tool for target cost follow-up. A product model makes it possible to observe cost estimates and target costs as a single component and as an assembly level. A user gets the state of the target cost situation of the complete product quickly, if the item-level cost information is available and updated. Version management is useful, when a user wants to audit product cost improvement. This may lead to better resource allocation decisions.

As previously discussed, the programs can somehow support all areas of target costing. The programs are least useful during the early stage of the design process, since the programs need item-level cost information and detailed product models. The programs can recognize cost saving objects and monitor target costs. However, the programs' usefulness depends on the accuracy of the inputted data. Hence, the programs support achieving target costs more by improving information transfer, access, and format than creating information.

Windchill Cost's strengths are in visualization; analyses such as pareto, pillar, and sectors are included. The 3D model visualizes target cost achievement, and the line diagram shows the development of historical costs. Specific information can be added in the items. These functions make Windchill Cost useful for recognizing cost-saving objects and target costing follow-up. Arena's functionality is the most simple of the three programs. The relative cost percentage of each component is presented next to the assembly cost structure. Historical cost data is available, but the presentation style does not support its use for predicting the target cost. Overall, Arena offers a basic solution for cost information needs, cost-saving target recognition, and target cost follow-up. This program does not have big strengths or weaknesses in these areas.

VariCost's basic functions are similar to those of the other two programs. However, its parametrical models and flexibility in storing cost information make this program more capable of following up target costs. Compared to the other two programs, VariCost can be applied to cost analysis of non-modular products. The parametrical model makes it possible to estimate costs before a detailed product model is available. Hence, VariCost is suitable for product design cases, when the company has comprehensive experience about similar products. During the early stages of the development process, the company can have a rather clear picture of whether the product will meet its target cost. In addition, VariCost monitors the design process and recognizes cost-saving potential; however, the program's strengths are in the use of historical data and thus monitoring the target cost process.

Programs using PDM/PLM system information can increase a decision maker's understanding of the cost drivers. The case programs can construct assembly cost estimates instantly as long as item costs exist. Consequently, it is easy to compare the costs of different assemblies. In addition, cost visibility at the offering level is good; when there are changes in single item costs, all assembly costs including the same item are recalculated. However, changes in the assembly structure may distort the cost estimation reliability, and item changes can have the opposite total cost effects in different assemblies. However, the programs are most capable in monitoring the design of assembly-intensive products.

5. CONCLUSION

There are many ways to affect product costs during the design stage, and they cannot all be tested. However, these programs can help simulate different components, materials, and manufacturing operations and thus give a rough cost estimate. Programs also provide help finding cost-saving opportunities. Testing different options for the manufacturing method, production environment, and materials can still make sense, since the software programs provide only a limited number of default options.

Programs can show how different features affect costs and thus increase the cost consciousness of R&D engineers. However, this ability is mainly related to direct costs. Since a cost comparison between different solutions has been made easy, a design can be cost oriented even when done by a designer without a deep understanding of the cost effects. Instant feedback on how the features affect cost helps designers make changes in the early stages of the design process. Tornberg et al. [8] claim that cost estimates should be presented simply without limiting the options for more detailed levels.

Programs using CAD product structure models calculate cost estimates based on product features. Thus, the programs can estimate the time and cost of the manufacturing operations. These tools are useful in the design stage when it is the most effective to keep costs at the right level. However, in the beginning, the estimates are quite rough, and they improve during the R&D process. The quality of the estimates can be improved significantly by describing and modeling the users' own manufacturing processes in the programs, but it may require a lot of extra work and expertise.

Operation logic and abilities to support target costing in programs using product structures from PLM solutions differ compared to the programs using information from CAD software programs. Originally, PDM systems were developed to manage product design information, and the role was the same when it comes to the cost information. Cost estimates are based on summing up the assembly items' costs analytically. Hence, an estimate and its accuracy completely depended on the accuracy of external data. Hence, these programs work as cost information centers, and the more information, the more useful they are. However, they cannot be used in the early design and development stages, since these programs need product structures to operate. The table in Appendix 1 shows a comparison of the programs.

Target costing has sometimes been criticized because of the time it requires, and thus delays the R&D process. In addition, the weakness of the analytical methods is their high time consumption, which makes them problematic to use with target costing. However, with these programs the estimating process can be speeded up remarkably and can be executed almost in real time.

Consequently, the designer can compare solution options simultaneously, which would not be possible without automation. In that way, these programs can reduce the long development time typically considered a downside of target costing.

Anderson and Sedatole [9] claim that designers traditionally focus on things such as performance, reliability, and design, and financial aspects get little attention. It is possible to emphasize the importance of cost-efficient design and target costing by bringing cost information into the designing process. Presenting cost information has a value itself even without considering how it is used.

As the automated estimates are the most important feature of these programs, whether the program is part of a CAD/PLM solution or a separate program does not make a big difference because the data transfer can be automated. All the programs can improve an organization's cost consciousness. However, they do not substitute for a management accounting department. Rather, management accountants become more valuable because they can deliver the information without which the programs are useless.

We examined six programs, but we cannot offer any information how they are used in practice. It would be rewarding to continue the study by monitoring the use of the programs. Moreover, because we do not have extensive user experience of these programs we cannot be sure how useful they are in practice.

Appendix 1

	SolidWorks Costing	**DFMA**	**aPriori**	**Windchill Cost**	**Arena**	**VariCost**
Evaluation method and - object	Manufacturing costs for single pieces analytically based on product features	Manufacturing costs for single pieces and assembly costs analytically based on product features	Manufacturing costs for single pieces and assembly costs analytically based on product features	Assembly costs analytically by summing up item costs	Assembly costs analytically by summing up item costs	Assembly costs parametrically and analytically by summing up item costs, item costs parametrically
Accuracy	Dependent on modeling accuracy of manufacturing environment, and product	Dependent on modeling accuracy of manufacturing environment, and product	Dependent on modeling accuracy of manufacturing environment, and product	Based on entered cost information, estimation reliability adjustment	Based on entered cost information	Based on entered cost information, or cost modeling capability of the parametric model
Automation level	Almost fully automated, product model is exploited efficiently	Requires manual data input, product model hardly exploited	Almost fully automated, product model is exploited efficiently	Fully automated when cost information about assembly items is available	Fully automated when cost information about assembly items is available	Fully automated when cost information about assembly items is available or when parametrical model has been given
Cost information support for designers	Real time feedback of the cost effects of design choices	Reports cost effects of design choices, requires extra modeling	Real-time feedback of the cost effects of design choices	Cost effect estimates for component-level decision making	Cost effect estimates for component-level decision making	Cost effect estimates for component-level decision making
Presentation of cost information in order to find potential cost saving objects	Operational-level cost structure from which remarkable costs or cost pools can be recognized	Operational-level cost structure from which remarkable costs or cost pools can be recognized	Component-level cost structure for assemblies, high cost component, cost comparison to other objects based on selected feature	Assembly and item cost structures, numerical and graphical cost distribution presentations	Cost information reports in product structure models, percentage shares	Detailed assembly and item cost structures
Monitoring process for target costs	Real-time comparison to the target costs with the accuracy level achieved	Periodical comparison to the target costs with the accuracy level achieved	Real-time comparison to the target costs with the accuracy level achieved	Present state follow-up, historical development follow-up graphically, 3D visualization of cost information	Present state follow-up, historical information from version management	Present state follow-up, historical information from version management

5. REFERENCES

[1]T. Tanaka, "Target costing at Toyota", *Journal of Cost Management*, 1993, Vol. 7, No. 1, pp. 4 - 11.

[2] J. C. Collins and J. I. Porras, *"Built to last : successful habits of visionary companies"*, HarperBusiness, New York (NY), 1994.

[3] Y. Kato and G. Boer, "Target costing: An integrative management process", *Journal of Cost Management,* 1995, Vol. 9, No. 1, pp. 39-51.

[4] J. J. Dutton and C. A. Marx, "Target costing", *Handbook of Cost Management*(Ed, Edwards, J. B.) Warren, Gorham & Lamont, Boston, pp. D2-1-26, 1999.

[5] The CAM-I Target Cost Core Group: S. L. Ansari et al., *"Target costing: the next frontier in strategic cost management"*, Irwin, Chicago (IL), 1997.

[6] R. Cooper and R. Slagmulder, *"Target costing and value engineering"*, Productivity Press, Portland, 1997.

[7] K. M. Kroll, "On target." *Industry Week*, 1997, Vol. 246 , pp. 14 - 17.

[8] K. Tornberg, M. Jämsen and J. Paranko, "Activity-Based Costing and Process Modeling for Cost-Conscious Product Design: A Case Study in a Manufacturing Company", *International Journal of Production Economics,* 2002, Vol. 79(1), ss. 75-82.

[9] S. Anderson and K. Sedatole, "Designing Quality into Products: The Use of Ac-counting Data in New Product Development", *Accounting Horizons*, 1998, Vol 12(3), ss. 213-233.

CORRESPONDENCE

Ph.D. Matti Sievänen
CMC/Industrial Management
Tampere University of Technology
P.O. Box 541
FI-33101 Tampere, Finland
matti.sievanen@tut.fi

M.Sc. Henri Wihinen
CMC/Industrial Management
Tampere University of Technology
P.O. Box 541
FI-33101 Tampere, Finland
henri.wihinen@tut.fi