International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Target Costing as a Facilitating Method for Aerospace Product Development

Yunyao Gu[a*], Siyi He[b]

[a,b]*Rhode Island School of Design, 2 College Street, Providence, 02903, the United States*

[a]*Email: ygu@risd.edu*

[b]*Email: she@risd.edu*

Abstract

This essays focuses on a design method named Target Costing and how this method is applied in aerospace industry. Before Boeing Company started to adopt this method, this method is still less popularly utilized the aerospace industry, than the automobile industry. Few case studies are used to demonstrate the how Boeing Company adopts Target Costing to provide insights from feasible practices. Besides, methodologies that enabled companies to successfully implement Target Costing into their current business circle have been discussed and elaborated as a further proof of its value for organizations, process, tools, and market.

Keywords: Target cost; design; product; aerospace.

1. Introduction

Designing for cost is not a new concept, but companies take different approaches to achieving design for cost. This paper explores Target Costing, which is a product development framework that ensures development focuses on the lifecycle cost of the product. The core concept of Target Costing is that the development team sets a lifecycle cost target based on market conditions, and the development team must reach that cost target.

---

* Corresponding author.

Target Costing has proven to significantly reduce product lifecycle costs without diminishing the technical capabilities of the product. This framework is being used increasingly by manufacturing companies around the world, and is now used throughout the auto manufacturing industry. Target Costing originated in Japan, and by 1999, 100% of Japanese auto manufacturers had employed Target Costing [1]. Although Target Costing has proven successful in the auto industry, it has not been widely adopted in the aerospace industry. This paper investigates best practices in Target Costing and studies how Target Costing could be implemented at Boeing Commercial Airplanes (BCA).

2. Background

2.1 Problem Statement

The importance of addressing cost early in the design cycle has been well established. Researchers agree that 70 to 80% of avoidable cost is built in during concept design phase [2]. Roskam investigated cost impact specifically during aircraft development and was able to further delineate the cost committed during various phases of aircraft development. Figure 1-1 lays out the cost committed (i.e., our ability to impact cost) during six phases of aircraft development, from conceptual layout to final disposal of the product. Roskam determined that 65% of cost is committed during the upfront planning and conceptual layout phase, and by the time designs are released, 95% of costs are committed. This mea ns that any company relying on continuous improvement for cost reduction after manufacturing begins is only able to impact 5% of the product cost. These companies must learn to address cost early in the development cycle.

Cost is becoming a more important factor for aerospace companies like The Boeing Company, with the threat of new entrants into the large commercial airplane manufacturing industry and customers that are becoming more and more cost-sensitive. While The Boeing Company can continue to differentiate its product from competitors like Airbus through technical excellence, market pressures will force The Boeing Company to address cost more aggressively.

2.2 Background and Development Context

The airplane manufacturing industry is dominated by a few large companies. Airplane manufacturing has large barriers to entry since airplane design and manufacturing has a long learning curve, large capital investment requirements, and customers who are unlikely to purchase airplanes that do not have a proven safety record.

2.2.1 Airplane Manufacturers and Airline Industry

The commercial airplane manufacturing industry can be separated into three major segments: small narrow bodies, narrow bodies, and wide bodies. The Boeing Company and Airbus dominate the narrow body and wide body markets, while the small narrow body market is dominated by Bombardier and Embraer. Airplane manufacturers typically face a tradeoff between payload (how much weight can be carried by the airplane) and range (distance the airplane can fly). Appendix 1 illustrates this payload-range tradeoff for the Boeing 777 family of airplane.

Since airplane manufacturers face this payload-range tradeoff, we can segment the market according to these features. Figure 2-1 illustrates the commercial airplanes currently in use, and the segments they belong to. When airplane manufacturers offer a new product, they will typically target an area of this chart where there is a gap. For example, Airbus' new A380 allows a higher payload than any other airplane in production. Since airlines have different payload and range needs based on their routes and demands, they will look for the airplane that will most closely suit their needs.

While Embraer and Bombardier have historically produced only small narrow bodies, they have more recently started producing airplane closer to large narrow bodies in terms of both payload and range. While pilot licensing regulations in the past limited airlines' ability to operate airplanes in this range, those regulations have been loosened and have allowed Bombardier and Embraer to creep towards the large narrow body market. While they have not yet mad e any overt moves into the market, their movement towards larger airplanes might be concerning for both The Boeing Company and Airbus.

In addition to the threat from Bombardier and Embraer, The Boeing Company and Airbus face new entrants such as Comae in China and the United Aircraft Corporation in Russia. While mainstream airlines have not yet started placing orders with either of these new entrants, they present a very real threat in the near future.

Even in the duopoly between Airbus and The Boeing Company, Airbus has been aggressively capturing market share from The Boeing Company. In a recent press release, Airbus claimed to have surpassed The Boeing Company in terms of open orders [3].

In addition to the potential for increased competition, airplane manufacturers must deal with the fact that airlines are becoming more and more cost sensitive. The combination of decreased passenger traffic due to the great recession and increasing fuel prices has put pressure on the airlines. With low cash reserves, the airlines are becoming more and more cost-sensitive, and with large expenditures such as airplanes, airlines do not have the appetite for larger upfront investments if they will not see the return for years to come.

2.2.2 Boeing Commercial Airplanes

Boeing Commercial Airplanes is the commercial aviation division of The Boeing Company. The Boeing Company (Boeing) is the world's largest manufacturer of commercial jetliners and military aircraft combined. The Boeing Company also produces network and space systems, and global services and support [4].

Boeing Commercial Airplanes comprises five programs of in-production airplanes: 737, 747, 767, 777, and 787. Boeing Commercial also offers aftermarket services and support (e.g., maintenance, spares, modifications, and training) through Commercial Aviation Services (CAS). Boeing Commercial primarily serves airlines throughout the US and abroad. Table 2-1 below highlights some key facts about The Boeing Company and Boeing Commercial.

Boeing Commercial is organized into airplane programs, and those organizations that support the airplane programs. Commercial Aviation Services, Supplier Management, Finance, and Marketing are all separate

organizations with support organizations for each of the programs.

Boeing Commercial operates in an industry with very Jong lead times. The 787 program, for example, was launched April, 2004, and the first 787 was delivered in September, 20113. If we ignore the time invested prior to program launch, The Boeing Company had to sustain the program for seven and a half years before the first airplane was delivered and The Boeing Company could begin recognizing revenues. Because of these lead times, The Boeing Company must take a large risk with each new airplane program.

2.3 Boeing program development process

Boeing Commercial follows a standard product development process. New products begin with an initial design assignment, followed by design phases that become increasingly detailed with each phase. During each phase of design, design engineers coordinate with other stakeholders. This coordination must occur with anyone who might be impacted by the design or who has an impact on the design (e.g., other design engineers, stress analysis, weight analysis, etc.). Once each design phase is complete, the design must pass a design review before the engineer can begin work on the next phase of design.

Since an airplane cannot be designed by one design team alone, The Boeing Company splits its design teams by airplane section (Appendix 2 illustrates these sections for the 787) and by component type (e.g., systems, structures, propulsion). Due to the complexity of airplanes, this development process requires significant communication between design teams.

2.3.1 Development of the 787

The 787 was developed conjointly between The Boeing Company and its partner companies. These partner companies were responsible for not just the "build" portion of product development, but also for much of the initial design work. In many cases, the selected partner was responsible for the majority of the design work, with The Boeing Company providing inputs and oversight. These partners were awarded major statements of work, typically covering an entire section of the airplane, as described above.

3. Target Costing Best Practices

Target costing is being used increasingly by manufacturing companies around the world. Target Costing originated in Japan, and by 1999, 100% of Japanese automotive manufacturers employed Target Costing [5]. In the aerospace industry, 95% of a product's lifecycle cost is determined by the time designs are released for production. Because of this, costs must be addressed earlier in the product development cycle. Target Costing has provided manufacturing companies, and in particular automotive manufacturing companies, with a framework that allows them to address costs early.

This section will discuss best practices in Target Costing based on a combination of literature review and interviews. Where possible, research was focused on the aerospace industry and the automotive industry since automotive design and manufacturing bears many similarities with the aerospace industry, and Target Costing is

more widely used in the automotive industry. This section will describe individual process steps as well as tools and techniques that should be employed. It will also discuss some key considerations and potential barriers that an aerospace company like The Boeing Company might face.

3.1 Benefits of Target Costing

Many production-heavy industries have adopted Target Costing, including manufacturers of cars, cameras, and heavy machinery [8]. In one study, all firms with medium to high Target Costing maturity reported reduced costs, retained or added features and functionality, faster non-recurring design, reduced new product risk, and improved intra-functional communications [6]. It is important to note that companies that implemented Target Costing did not trade off quality and functionality for cost. While Target Costing focuses on reducing lifecycle costs, all companies were able to simultaneously improve quality and increase functionality of their products. Separate research also shows that companies without good cost estimates during conceptual design are more likely to have programs behind schedule with higher development costs than those companies that know detailed costs throughout the development cycle [7].

3.2 Barriers to Target Costing

Many barriers exist to implementing Target Costing, and it is important for companies to understand these barriers so they can be planned for and overcome. Some companies will find it difficult to implement Target Costing unless the market conditions force them to be more careful about costs. Target costing will be found in highly competitive markets, where the competitive pressure forced companies to reduce cost to remain in the market. Firms that are not in competitive markets may not feel urgency around cost the will have to compensate for the lack of pressure that would normally come from competition.

Companies must be careful about how they message Target Costing. Employees must understand the relevance of Target Costing. Employees might see cost cutting as a reason to fear for their jobs, and may even work against Target Costing. Management must educate and reassure employees [8] that Target Costing will help them not hurt them.

Target Costing should lead to lower cost without impairing design quality or total development time, but companies need to be careful to avoid setting overly aggressive time constraints on the design team. Research has shown that under high time pressure, design engineers will work longer hours without a corresponding cost decrease [9]. According to this research, providing cost targets will only result in lower cost products when the design engineers face low time pressure.

This mea ns, that while development time reduction might be a goal for the company, this must come organically from the improved designs (e.g., fewer errors, less rework, shorter production lead times). Although upfront increases in design time may be concerning, companies must invest in adequate time upfront to allow for Target Costing. If companies put overly burdensome time pressure on its designers, the designers will get burnt out [10], and will not be able to think creatively to identify ways to reduce cost.

Companies must also be careful about supplier relationships. Target Costing can intensify problems with suppliers when cost-reduction requirements are passed down to them [11]. Suppliers with less power (particularly smaller suppliers) may feel over-burdened with the responsibility to find cost reduction, particularly when the more powerful suppliers defray cost targets by using their influence on the company [12].

Finally, companies must think carefully about how to estimate costs for features and technologies that are new. Target Costing is best suited to industries where products are incrementally different from the previous product [13] because companies have to have a good understanding of current cost breakdown in order to predict cost breakdown of future products. For products that are significantly different from previous products, companies cannot rely on historical information. Management must understand the risks associated with cost estimates for such products, so it is imperative that the development team reports risk in cost estimates.

4. Case studies of Boeing Company

With the best practices described above in mind, this study will now use the implementation of a standards cost and availability tool to provide insight into The Boeing Company's position relative to these best practices. This study will also explore case studies, where Target Costing should have impacted the design decisions already made. These case studies will help identify areas to focus Target Costing efforts.

While the implementation of the standards tool revealed that working-level engineers did not prioritize cost, there are other barriers to Target Costing at The Boeing Company. The following case studies will explore situations where Boeing design teams chose more costly design solutions than necessary and will explore why those more expensive design decisions were made. These case studies were chosen to explore barriers to Target Costing at The Boeing Company, so focus will be on how more cost efficient design decisions could have been made.

4.1 Bolt Grip Lengths

When engineers select a fastener, the fastener selected depends on the technical requirements of the fastener (e.g., strength, corrosion) as well as the stack-up of parts. Engineers will select the fastener length (grip length) that most closely fits the stack-up to minimize excess weight. This method of selecting parts can result in low-use fastener sizes being selected. This increases costs for The Boeing Company because there are significant economies of scale with standard parts due to high set up costs and low marginal production costs. When The Boeing Company consumes large volumes of a particular grip length fastener, the price per part is low, whereas when The Boeing Company consumes low volumes of a particular grip length fastener, the price per part is high.

A study by The Boeing Company's Value Engineering organization determined that demand is grouped around certain grip lengths, which results in uneven pricing of bolts. The Boeing Company's Value Engineering organization identified those expensive grip lengths on the 787 and determined that significant savings were possible by increasing certain grip lengths. In some places, a grip length change was not technically feasible and, where possible, the increased grip length added weight, but the total cost reduction far outweighed any

weight increase to the airplane. This project was "Project 1" in the standards tool pilot.

This was a case where the more cost effective solution was not complex. Any design team with access to the pricing data would have understood how volume drives cost and would have produced a more cost-effective solution similar to the one described (where low volume bolts are avoided). At The Boeing Company, however, the more expensive solution was initially selected because the design team did not have access to the relevant cost information and because weight was prioritized strongly over cost. During initial design, any solution perceived to add cost to the airplane would not be approved because the priority was to produce the most lightweight airplane possible. While the cost reduction more than offsets the weight increase, this solution would not have even been considered during initial airplane development because weight was prioritized so intensely.

4.2 Temporary Fasteners

For the 787 program, The Boeing Company receives subassemblies from its partners around the world and puts them together in its final assembly factories in South Carolina and Washington. One of these subassemblies, the wing box, comes from Fuji Heavy Industry (FHI) in Japan. These wing boxes use temporarily fasteners that are replaced when the wing is joined to the body in final assembly. When Boeing final assembly replaces the temporary fasteners, they are discarded because they cannot be reused due to airplane certification requirements. These fasteners cost several thousand dollars per airplane.

Boeing's Value Engineering organization is looking into more cost effective solutions. These solutions include: selecting less expensive temporary fasteners: the fasteners currently used satisfy far higher technical specifications than is necessary. These fasteners have a limited use since they need to support a static load rather than fatigue loads.

Reusing the temporary fasteners: while the temporary fasteners cannot be reused in service, they can be refurbished and then reused as temporary fasteners. With this solution, The Boeing Company would contract a 3rd party to refurbish the fasteners and then would ship the fasteners back to FH I to be used on future airplanes

Both of these solutions would provide significant savings to FH I and to The Boeing Comp ny. If The Boeing Company and FHI had addressed this temporary fastener issue upfront during program development, they might have been able to produce a more cost effective solution than those described above. This cost issue was not addressed during program development because the Boeing design team was not aware of the difference in cost between fasteners.

4.3 Material Selection

Early in the 787 Program, Boeing engineers changed the material for two large parts of the fuselage from aluminum to an alloy. This change was intended to reduce the weight of each airplane. The design team assumed that the alloy was comparable in price to the aluminum. The Value Engineering organization has since discovered that the alloy is many times more expensive than the aluminum because it is in less plentiful supply

than the aluminum and because it is more difficult to work with (i.e., more difficult to machine).

The Boeing Company has since changed the material for these parts back to the original aluminum. While this change reintroduces the weight saved by the original change, the cost reduction more than offsets the increase in weight.

The original design team responsible for the first change would not have initiated the change if they had a good understanding of the real material costs. Instead, they generated a change that would have to be reversed later.

5. Methodologies

The following Sections will analyze The Boeing Company's readiness for Target Costing through these four lenses.

5.1 Organizational Involvement

Successful Target Costing relies on cross-functional coordination throughout product development. Best practices recommend the following organizations be involved: Engineering, Finance, Manufacturing, Marketing, and Supplier Management. All organizations should be involved during every phase of product development. Additionally, suppliers should be treated as an organization within the company and should be involved in every phase of product development once they are brought on.

In The Boeing Company's case, CAS should be involved in product development as well. The CAS organization maintains constant communication with the customers through the maintenance, spares, modifications, and training services it provides to The Boeing Company's customers. Since CAS interacts with customers while they are using the product, they have unique insight into technical problems faced by customers (often avoidable with design changes upfront) and they receive feedback that would be valuable to determining features and functionality to include on future airplanes.

The Boeing Company's cross- functional coordination contributed to decreased change, error, and rework, and decreased program cost [14]. More recently, the 787 Value Engineering organization involved in this study demonstrated the benefits of cross-functional coordination. In this group, design engineers have been collocated with Finance, Supplier Management, and with Boeing Partners. Through this collocation, the engineers have been able to quickly coordinate with the other groups to identify efficiencies that have significantly reduced the cost to produce the 787.

The case studies suggest that The Boeing Company's development teams need more coordination. In the temporary fastener case study, if Finance and Supplier Management had been involved earlier in the process, they might have highlighted the large cost of the temporary fasteners and the design team might have paid attention to removing this cost. In the material selection case study, the engineers who made the decision to switch materials did not understand the cost of the material they were switching to. If there had been more coordination with the Finance and Supplier Management organizations, they may have better understood the

financial impact of the design change and chosen not to pursue it.

Best practices emphasize that all organizations should be involved throughout the development process. For The Boeing Company, the standards tool pilot indicated that cost targets were not being flowed down to the engineer level. Engineers interviewed believed that part of the reason this was happening was because the Engineering organization did not feel involved in the process of setting those targets. Engineering, Manufacturing, and Supplier Management should all be involved in the Target Costing process upfront because they have valuable subject matter expertise that could inform whether cost targets are realistic. Since these organizations will also be held accountable to those cost targets, they should be involved in setting them.

5.2 Process

As described in Section 2.3, The Boeing Company follows a fairly standard product development process with review gates at the end of each phase of design. This process is well set up to align with Target Costing. The Boeing Company needs to infuse cost into the development process by dictating that product cost is one of the criteria reviewed during each review gate. Boeing managers currently review a standard list of criteria (e.g., strength, weight, corrosion) during each review gate, so product cost simply needs to be added to the list. By requiring that individual engineers report out on product cost, Engineering will have to coordinate with other organizations such as Finance to determine those costs. If cost had been a review criterion for the temporary fasteners case study, the cost of those fasteners would have been highlighted and the overly expensive design / manufacturing methods would not have been approved.

Since weight, schedule, and cost will be reviewed during each review gate, The Boeing Company can expect that tradeoffs between the three may have to occur. The Boeing Company should set tradeoff values between the three metrics. In the grip length case study, if the design team had been armed with these kinds of tradeoff rules, they would have selected more cost efficient grip lengths.

Additionally, since process dictates who performs the work, the product development process should include CAS, Marketing, Finance, Engineering, Manufacturing, Supplier Management, and suppliers throughout. Successful Target Costing relies on the coordination of these organizations throughout the development process.

5.3 Tools

As The Boeing Company moves into conceptual design, it will be able to improve on initial estimates with parametric estimates. As described in Section 3.4, these parametric estimates rely on CERs to provide cost estimates. These estimates are only as good as the CERs, so The Boeing Company should constantly review and revise its CERs to ensure it is getting the most accurate estimates possible. The Boeing Company could also use neural networks 5 and fuzzy logic6 to improve on those parametric estimates.

As the development team moves into detailed design, feature-based cost tables can be used. This study observed that The Boeing Company has multiple home-grown feature-based tools that can provide accurate cost estimates, but these are not widely used. If the design team had access to these tools to estimate the cost of the

initial material change in the material selection case study, they might have better understood the cost implication of that design decision. The Boeing Company should standardize financial estimating processes to include tools like these so that design teams have the best information available to them when making cost-based decisions.

Once the design has been drawn in CAD systems, The Boeing Company could make use of feature- based CAD software available. This software would enable design teams to determine the expected cost of a part in very little time. This kind of cost estimate should be shared with Supplier Management since it provides them with a "should cost" or a baseline cost with which to negotiate with suppliers.

Finally, The Boeing Company's cost estimates will become more accurate when supplier quotes and actual costs begin to be reported. Best practices suggest this cost information should be tracked to the individual design team level since it will provide the basis of cost estimates for future products and will provide the company with visibility into cost drivers.

These tools are critical to Target Costing because they provide the ability to estimate the cost of the product. The Boeing Company should leverage existing tools and identify gaps in cost estimating capabilities. If the design teams in the bolt grip length and the temporary fastener case studies had access to existing cost tools (such as the standards tool piloted as part of this study), they might have been able to release a more cost effective design upfront.

When determining gaps, The Boeing Company must ensure it has the ability to estimate total lifecycle costs. Design and manufacturing are not the only areas where there is opportunity to reduce cost. All cost elements must be reflected in cost estimates so that product development teams can properly assess the tradeoffs.

The Target Costing toolset is not limited to cost estimating tools, but also includes standard frameworks and techniques that help teams identify and remove costs. In addition to cost estimating tools, The Boeing Company should employ the techniques for cost reduction. This study observed that The Boeing Company has made significant investments in continuous improvement, so the tools employed should mirror those already being used for continuous improvement. QFD should be used both to inform tradeoff decisions and to help allocate costs down to the individual design team level.

5.4 Market

The Boeing Company positions itself against Airbus through product differentiation. While Airbus can offer lower price tags to airlines, The Boeing Company sells airplanes based on the difference in their value (e.g., more fuel efficient, less maintenance required). The Boeing Company proved with the 777 program that the company has the customer in mind and can value the functionality its airplanes provide. The Boeing Company should emphasize this customer focus throughout the product development process into detailed design.

The Boeing Company faces a challenge estimating the cost of future airplanes. Since new programs are typically the result of new technologies that improve airplane performance, those new technologies will make

new airplanes difficult to cost. Additionally, The Boeing Company does not release new airplanes frequently, adding to the cost estimating challenge. Because of this challenge, The Boeing Company should leverage all cost estimating tools available to them to improve the accuracy of cost estimates. The Boeing Company should also report uncertainty in cost estimates so that decision makers understand the risk.

6. Conclusion and Next Steps

Target Costing is not easy to implement. It requires a large upfront investment and a lot of commitment to be successful. Companies that have successfully implemented Target Costing have seen the benefits not just through lowered lifecycle costs, but also through improved quality and reduced production timelines.

Based on this study, The Boeing Company has the right infrastructure i n place, but needs to focus more on cost. With potential new entrants to the market, this is The Boeing Company's opportunity to get ahead of the competition by implementing Target Costing.

In order to successfully implement Target Costing, The Boeing Company should focus more on creating cross-functional teams and ensure all organizations (CAS, Engineering, Finance, Manufacturing, Marketing, and Supplier Management) are involved in every phase of product development. More emphasis on process is pivotal to include product cost as a review gate criterion. Dictate the organizations that should be involved in each phase of product development.

Besides, regularly update and improve CERs used for parametric estimates and evaluate new tools available. Use continuous improvement techniques to identify and remove cost. Improve accuracy of cost estimates to the extent possible and report uncertainty in cost estimates.

References

[1] M. M. Helms, L. P. Ettkin, J. T. Baxter and M. W. Gordon, "Managerial Implications of Target Costing," Competitiveness Review 15.1, pp. 49-56, 2005.

[2] C. K. Rajkumar Roy, "Cost Engineeri ng: why, what and how?," Cranfield University, Cranfield, 2003.

[3] J. Roskam, Airplane cost estimation: design, development, man ufacturi ng and operating, DARcorporation, 2006.

[4] M. Kaufma nn, Cost/ Weight Optimization of Aircraft Structures, Stockholm: KTH School of Engineeri ng Sciences, 2008.

[5] P. Belobaba, A. Odoni and C. Barnhart, The Global Airline Wiley & Sons, Ltd, 2009.

[6] T. Guardian, "Airbus claims to have overtaken rival Boeing after record sales in 2013," Guardian News and Media Limited, 13 January 2014. [Online]. Available: http://www.theguardian.com/business/201

4/jan/1 3/airbus-record-sales-201 3-ahead- boeing. [Accessed 17 February 2014].

[7] T. B. Company, "Boeing 2013 lOK Report," 112 2013. [Online]. Available: http://services.corporate-ir.net/SEC/Document.Service?id=P3VybDlhSFiwYORvdkwyRndhUzUwWlclcmQybDZZWEprTG10dmJTOWtiM2R1Ykc5aFpDNXdhSEEvWVdOMGFXOXVQVkJFUmlacGNHRm5aVDAOTnpBNE5UWXhKbk4xWW50cFpEMDFOdz09JnR5cGU9MiZmbj1UaGVCb2VpbmdDb21wYW55 XzEwS18yMDEzM DixMS5wZG. [Accessed 9 2 2014].

[8] W. B. C. Robin Cooper, "Control Tomorrow's Costs Through Today's Designs," H arvard Business Review, pp. 88-97, January-February 1996.

[9] L. M. Ellram, "The Implementation of Target Costing in the U nited States: Theory Versus Practice," Journal of Supply Chain M anagement, no. 42, pp. 13-26, 2006.

[10] Shahid L. Ansari, Target Costing: The Next Frontier in Strategic Cost Management, Irwin Professional Pub, 1997.

[11] R. Kee, "The sufficiency of target costing for evaluating prod uction-related decisions," International Journal of Production Economics, no. 126, pp. 204-211, 2010.

[12] R. G. Schaad and J. M. Hopper, "The Customer Influence i n 777 Design," in A/AA Aerospace Design Conference, Irvine, CA, 1993.

[13] R. Cooper and R. Slagmulder, "Develop Profitable New Products with Target Costing," MIT Sloan M anagement Review, vol. 40, no. 4, pp. 23-35, 1999.

[14] J. W. Burns, "Aircraft Cost Estimation Methodology and Value of a Pound Derivation for Preliminary Design Develo pment Applications," in Society of Allied Weight Engineers, Long Beach, CA, 1994.