Product Clinic for a Pickup Truck Door Hinge

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Germany is a high-cost economy, so ingenuity in product design is necessary to give the customer high value while minimizing both manufacturing cost and life cycle expense. Product Clinic is one methodology for achieving best-in-class design, and many companies now use versions of it. The version used for the truck door hinges is from the Institute of Business Administration: Corporate Management, Logistics, and Production, linked to the Technical University of Munich. In Germany such institutes serve industry and the public interest in various ways.

A Product Clinic begins with market studies to establish cost trade offs by which customers express preference for various functions or features of products (called conjoint analysis by academics). Customer preferences are compared with the best existing design ideas from various competing products to establish the base for a new product design that sets a new benchmark. And the best design ideas come from carefully studied, documented reverse engineering of competitors' products. The complete methodology, which can be rather extensive, is summarized in the box copy. Product Clinic has been applied to the design of engines, laboratory instruments, robots, and many other items, including software. It has not been used for something as complex as the design of a new vehicle, but only major automotive modules.

In the summer of 2003, the Institute found itself suddenly facilitating a fast moving Product Clinic for door hinges on a new pickup truck. Technically, the hinges were relatively simple, but time was short. The OEM had accepted a door hinge design from a supplier that went bankrupt and could not deliver. An alternate supplier could not manufacture the hinges at an acceptable cost, the overall truck design had been "frozen," and preparation for manufacturing ramp up had begun. The OEM needed a quick, ingenious redesign to avoid the anticipated cost overrun.

Product Clinics ordinarily occur before design freeze, not afterward. Likewise most Product Clinics are by one company with minimal involvement of customer or supplier personnel. This was an exception on both counts because of the time pressure. The clinic compared hinges from the Citroen Berlingo, Renault Kangoo, Ford Transit, Mercedes Benz Vito, and VW Transporter.

In Brief

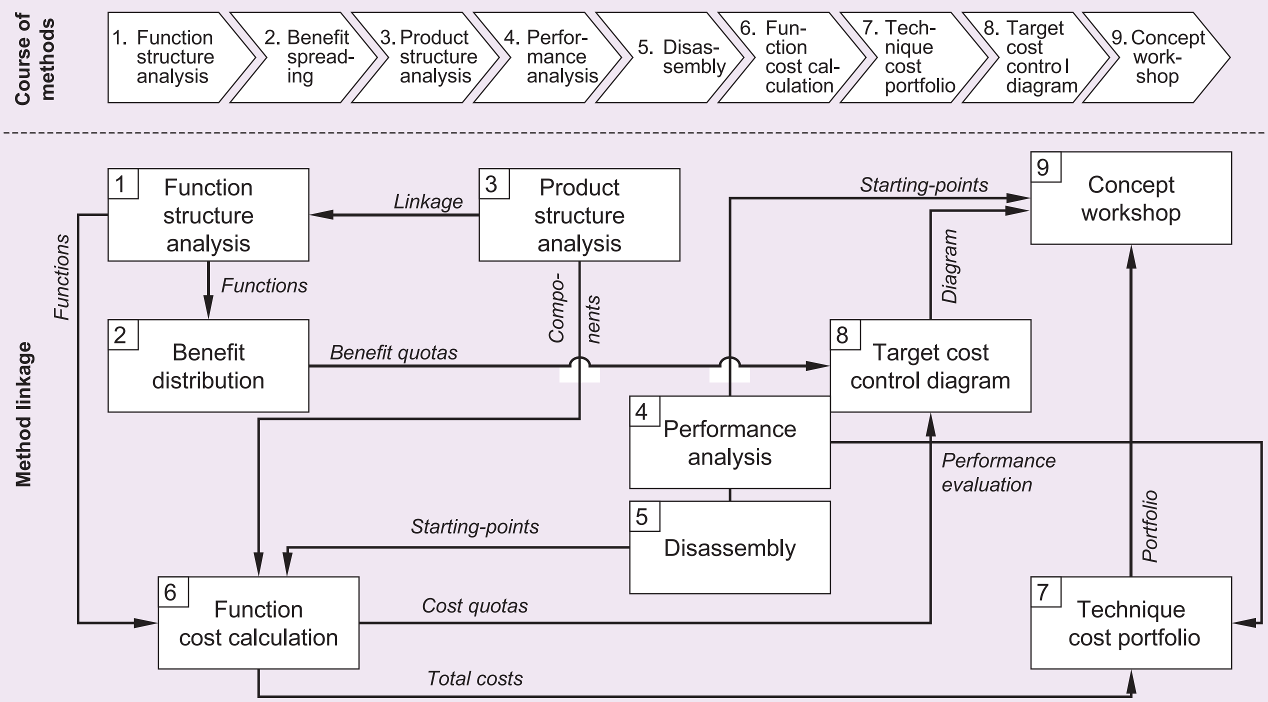
In Germany, Product Clinic is a widely used technique for making major advances in the design of new products. The methodology is illustrated using the example of door hinges for a European pickup truck.

Supplier Design Competitions

Normally German car companies hold design competitions between suppliers as early in the design process as possible. Frequently the lowest cost proposal wins, but not always. If a supplier is dependable and has an obviously better design solution, a cost penalty will be worth it to obtain their service. Some suppliers do hold Product Clinics when making these proposals, and they state their service advantages to be weighed along with costs when submitting them. In this case an apparently successful design turned into a disaster.

Methodology of a Product Clinic

The methodology of all Product Clinics facilitated by the Institute at the Technical University of Munich follows the nine steps across the top of the diagram below. The flow of logic and information follows the nine steps across the top of the flow diagram below. Germany has many institutes attached to universities that provide advice and service to businesses such as manufacturers. Many institutes are highly technical or scientific. This institute concentrates on management of manufacturing and logistics.



1. **Function Structure Analysis:** Establish a basis to compare all competitive parts or products, such as features, performance, price, and cost.

2. **Benefit Distribution:** Define, from the customer's view, the value (or relative importance) of each of the main features or functions of the product.

3. **Product Structure:** Bills of material for each of the competitive products are analyzed to see how components fulfill each of the functions a customer desires from the product.

4. **Performance Analysis:** Comparisons of the functional performance of each competing product.

5. **Disassembly:** During disassembly, each component is analyzed to determine its origin and to estimate its probable cost based on known methods of fabrication.

6. **Function Cost Calculation:** The costs to achieve each feature or function of each competing product are estimated using various methods.

7. **Technique Cost Portfolio:** Estimates of the fraction of total cost for fulfilling each function of the product.

8. **Target Cost Control:** Develop a target cost control diagram and estimate the target cost gap.

9. **Concept Workshop:** Participants work out a common design concept for the ideal new product, blending ideas "cherry picked" from competitors with novel ones.

With the nine steps, a Product Clinic brings to a new product development the ability to synthesize best-practice solutions and go beyond them. Participants in a Product Clinic:

- Work in multi-disciplinary and sometimes cross-company teams
- Learn from the physical products
- Connect with internal and external expertise
- Consider many external needs, beginning with customer needs and preferences
- Adhere to a rigorous methodology
- Measure and quantify the design possibilities observed
- Openly communicate these results throughout the company
- Constructively adopt strange and novel solutions to problems
- Develop demonstrable design targets
- Directly convert results into actions to be taken.

Product Clinic began in Germany at the beginning of the nineties. Several automotive and high tech companies had established a process something like Product Clinic, but focused on Value Engineering, for example, converting metal parts to plastic. They did not incorporate new ideas to fulfill customer requirements, nor attempt analyses to fulfill the right product functions at the right cost/price. In addition the approach went little beyond hands-on, reverse engineering by technical people. The TU Institute began working to convert Product Clinic into something more holistic by embedding well-known ideas, like QFD, and developing a few new ones.

Thus the ancestor of Product Clinic is Value Engineering; its offspring were gradually enhanced with other capabilities. Among the lessons learned: after evaluating QFD the TU Institute decided that it was too complex and time consuming for the results produced. A better method is conjoint analysis; asking the customer or "the voice of the customer" what features they want at what price, which is the vital consideration.

The Value Engineering heritage is retained in an advanced form with the function cost calculation and the target cost diagram. Now the Product Clinic methodology links all the methods according to the input-output flows shown in the diagram. The result is a rigorous, integrated process that views design from every functional viewpoint.

In practice this rigorous approach is frequently watered down. In the past year, several companies described their internal Product Clinics, but it was obvious that they had employed a weak version of the methodology shown here. Nonetheless, rigorous versions of Product Clinic have spread to industrial equipment (elevators), consumer goods (ice cream), and to service companies' processes.

The winning supplier had the low cost design and an established competency in R&D, manufacturing capabilities, and logistics. Then it went bankrupt, and not just into a financial work out; they disbanded and could not fulfill production to the contract.

The OEM turned the winning design over to supplier two for a production quote and discovered that this was no simple shop-the-print design. Despite a good reputation in the business, supplier two reported that they were unable to manufacture the winning design to spec at the cost proposed by the original winning supplier. A few changes enabled production to meet spec, but the cost remained too high — quality performance, but above-premium cost. Neither the OEM's engineers nor those at supplier two could alter the design to deliver the originally promised performance at an acceptable cost.

Reluctantly they decided to start a design from scratch, concentrating on components that could still be changed, and the new design had to be production ready in about ten weeks. Although the product was "only a door hinge," the problem was knotty enough that they decided to assign a team of ten people to work through it using the logic described in the box copy. Two people from the Institute, experienced in Product Clinic, mentored and facilitated the team.

Product Clinic on Pickup Truck Door Hinges

Because a pickup truck hinge must absorb more force than a car hinge, some options available on car designs are excluded from pickup trucks. For example, in a car the "door-holding function" of the hinge can often be met by a stamped sheet metal part, if well designed, but that will not hold up on a pickup. You are pushed into evaluating various materials and geometries of cast or forged metals.

The team was cross-functional. Members represented sales, purchasing, quality assurance, production, and of course, engineering. Not everyone worked full-time with the team for the entire time, but they met for regular sessions with assigned work in between.

Although personnel from the functional departments had frequently collaborated on previous projects, purchasing was initially very reluctant to engage in this one. They thought that they had bought an optimal door hinge at the best price, and that Product Clinic questioned their judgment. Consequently, they refused to buy the competitive door hinges to get started.

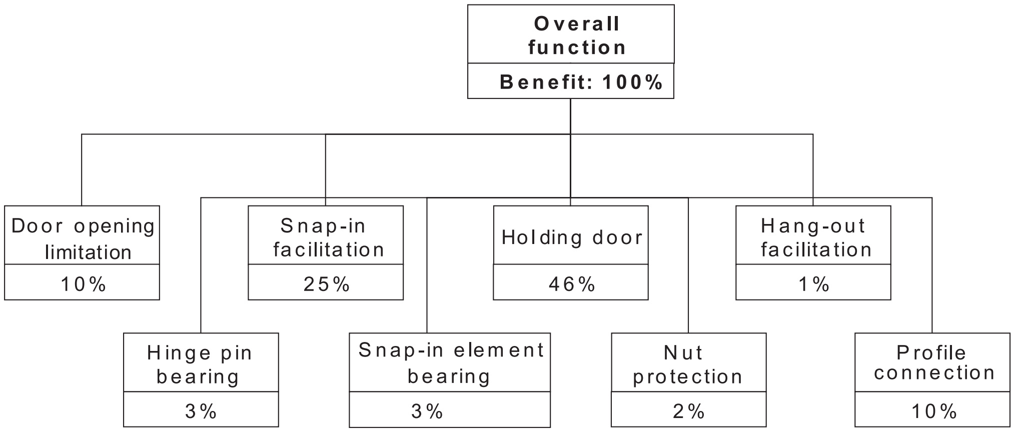
To move forward, the TU Institute facilitators obtained the door hinges from competitive dealers, which encouraged everyone else on the team to get going. Soon the participants from purchasing realized that a team effort was necessary to overcome an unexpected problem; they weren't being criticized; and they began to participate. As might be expected, the design engineers on the team followed the process very methodically, while the sales people tended to jump to conclusions when they saw competitive solutions that were both simpler and better.

The team began work on the first two elements of Product Clinic in the box copy, Function Structure Analysis and Benefit Distribution. That did not take long because several team members had become disgustingly familiar with hinges before they began. In most other cases, teams discover that they know much less detail about customers' real needs than is necessary for further analysis, and there's a long delay for market research.

The function analysis was relatively easy. All vehicle door hinges fulfill the same functions, and from a customer's view no one could think of a function not fulfilled by current hinges. So the only issue was the relative importance of each function to the customer. As can be seen in Figure 1, more than two thirds of the total weight applied to just two functions, holding the door up and facilitating its closure, or snap in.

With competitive door hinges in hand, bills of material were easy to see. However, as can be seen in Figure 2, relating bills of material to the eight functions of the hinge shown in Figure 1 did not reveal anything

Benefit Analysis of the Function Structure of a Door Hinge



First, the team defined the functions that a door hinge should perform. Those are labeled in the lower boxes of the diagram. The percentages represent the weights that a customer would attach to the importance of each function.

Figure 1.

Linking Product Design (BOM) to the Product Function Structure

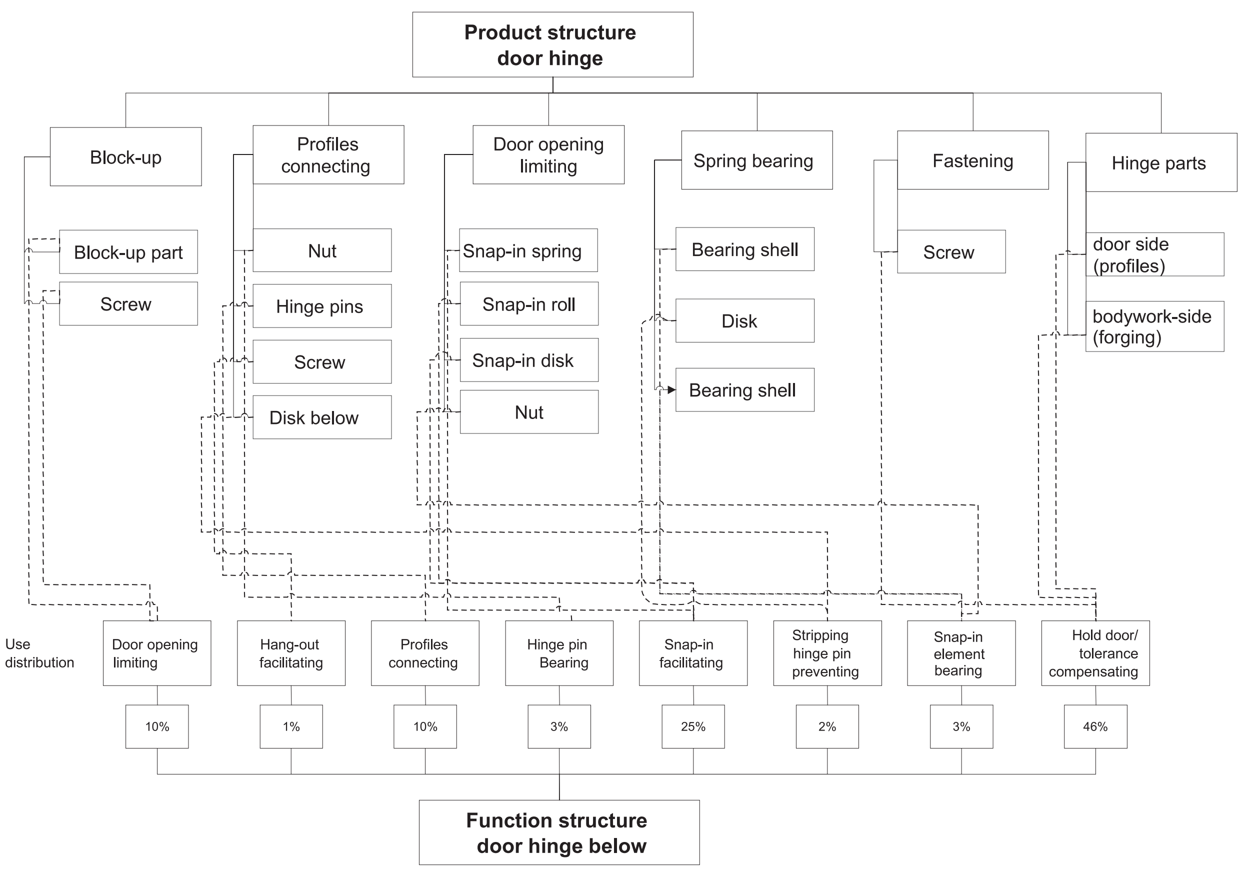


Figure 2.

very interesting. For instance, some designs used an extra component for "snap in;" some did not.

The team went on to Step 4, Performance Analysis, comparing how well each of the hinge designs performed each of the functions important to the customer. For a pickup, that means checking door opening and closing using each of the hinge designs. In this case time was limited for long-term wear testing, so some inferences had to be made, but this step is also where engineers are surprised. A design or material thought inferior may not perform badly, while one that's over-designed doesn't yield performance as superior as expected. However, the output of Step 4, Performance Comparison, was a set of targets for the functional performance that seemed achievable for all eight functions important to the customer.

On to Step 5, Disassembly. The team did not just take the hinges apart and casually look at components. They attempted to further analyze why the components worked together to make the hinges perform overall, and they kept the components of each hinge organized for cost estimating in the next step. The hinge attributes most carefully studied during disassembly were the profiles used, the method of door opening limitation, the block up, the connecting profiles, and the spring bearing. Those interactions are key to making the components add up to more than a sum of the parts.

Step 6 was the estimation of component costs. Each one was determined by estimating its material cost, the cost to fabricate using known methods and hourly machine costs (and considering where it might have been made), and its cost to assemble. Several methodological variations for this cost estimating can be used. In this case, the team kept it simple. The result was a portfolio of components, function design concepts, and costs.

In Step 7, the team analyzed the cost of each design idea to fulfill the functions important to the customer that were identified back in Figure 1. One output from this is shown in Figure 3, which is a cost estimate for a design combination to fulfill each function.

Using tables like Figure 3, the team began detailed comparisons. The hinge considered best offered better function fulfillment than more expensive ones. The current supplier's hinge design was slightly bettered in function fulfillment by a competitor's design that was estimated to cost 31 percent less.

Going through the tables, and still in Step 7, the team began cherry picking the most cost effective design alternatives, inserting them into a benchmark design table, developed like Figure 3. When finished they arrayed their findings from Step 7 into the charts shown in Figure 4.

The benchmark design portfolio met the functional requirements at a cost 76 percent below that of supplier 1's original design. All the estimates were checked by the team's manufacturing engineers to assure that alternatives could actually be made at the cost assigned to them.

Now the team was ready for Step 8, development of target cost control. They went back to the customer weights assigned to the hinge performance functions in Figure 1 and matched them against the cost-design possibilities uncovered in the technique cost portfolios in Step 7. This resulted in the conclusion that designs had greatly overvalued the "holding door" function until it dominated design thinking. This was the place to substitute less costly components from competitive designs, but that could not be done directly because of the differences in door geometry. The team got on with construction of the target cost diagrams shown in Figure 5.

In Step 9, the Concept Workshop, the team used the target cost control diagrams and all the other findings that had accumulated to brainstorm approaches to a new lower-cost design with supplier 2, which would produce the hinge. The supplier had other ideas from their own experience, and the team combined these with their learning to generate a produceable design that could be launched quickly.

Immediate cost savings were only eight percent below those of the original

Product of one's own	components	Functions/ costs	Limiting door opening	Making snap-in possible	Holding door/ compensating for tolerance	Making Hang-out possible	Profiles connect	Hinge pin bearing	Lock element bearing	Redeem hinge pin prevent, Boxtrees offer protection
	Benefit distribution	100%	10%	25%	46%	1%	10%	3%	3%	2%
Hinge parts	Forging on the side of the door	5.98			100					
	Profile on body work side	5.34			100					
Connection elements	Hinge pin, incl. tappets	0.36					100			
	2 nuts	0.16						100		
	Screw	0.04				100				
	Disk below	0.01								100
	Middle disk	0.25								100
Door fastener	Snap-in spring	0.38	20	80						
	Snap-in disk	0.76	20	60					20	
	Snap-in roll	0.37		100						
	Nut at snap-in element	0.09							100	
	Bearing shell teflon-coated	0.18		100						
	Disk teflon coats	0.14		100						
	Nut bearing	0.05		100						
Block-up	Block-up part	0.43	100							
	Screw	0.04	100							
	4 fastening screws	0.16			100					
	TOTAL COSTS	**14.74**	0.70	1.50	11.48	0.04	0.36	0.16	0.24	0.26

The column under "Functions/Costs" itemizes the cost of each component (in Euros). At the bottom, the row to the right of "Total Costs" shows the estimated cost in Euros of each design function of the hinges. For example, the function "lock element bearing," is achieved with two components, the snap-in disk and the "nut at snap-in element," which has no other design function. Then the cost of the function, "lock element bearing" is: [20% of 0.76 EUR plus 100% of 0.09 EUR = 0.24 EUR]. Reducing the cost of the hinge parts for "holding door" was the obvious target to attack.

Figure 3. A table from Step 7, Determining Hinge Function Costs.

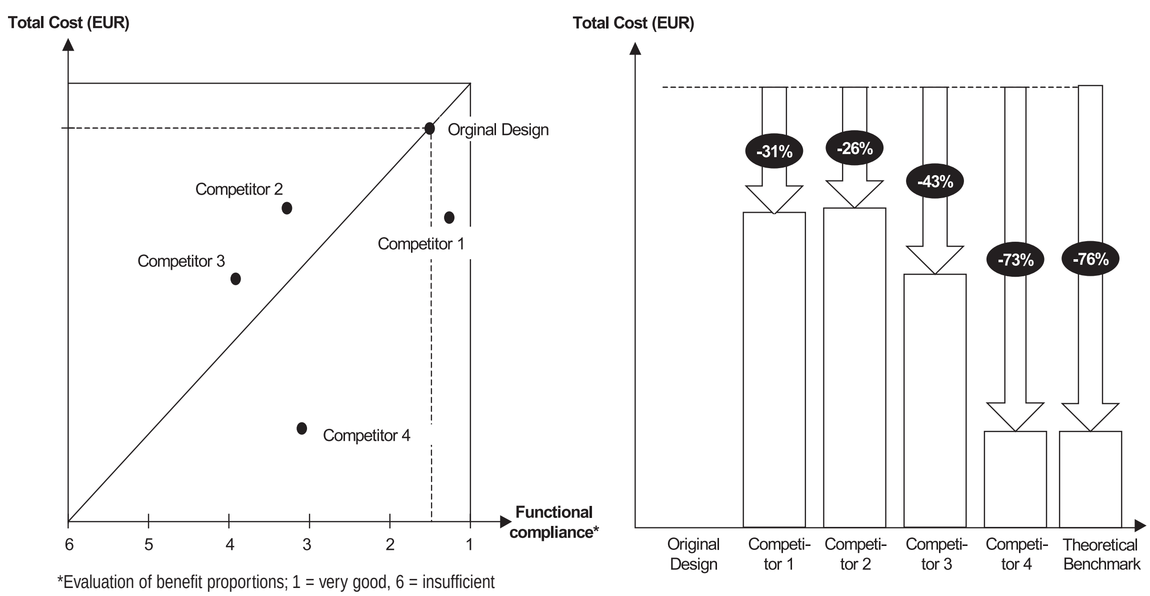
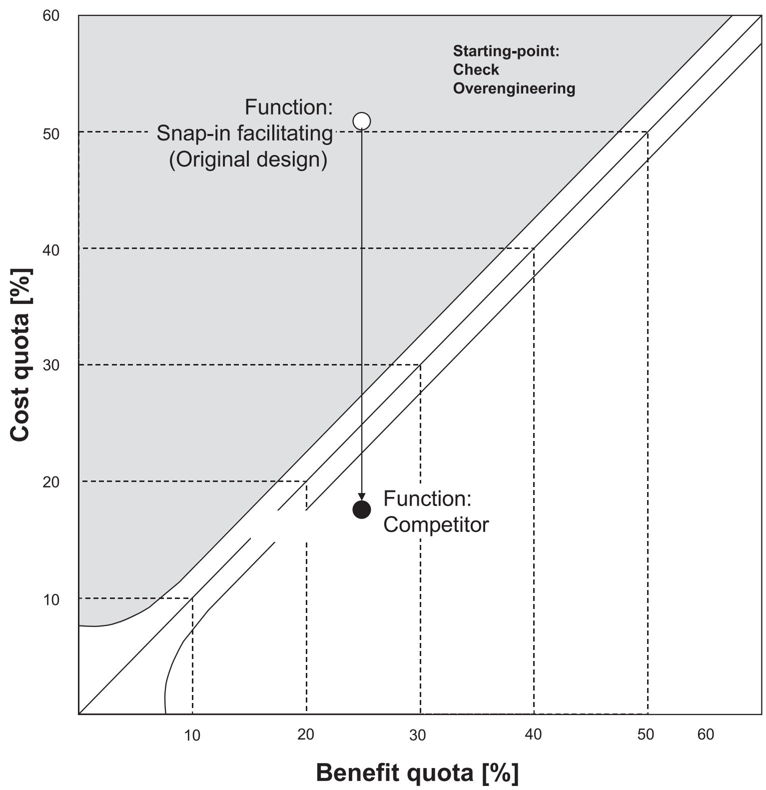


Figure 4. Graphical summaries of the cost technique portfolio, Step 7.



A Target Cost Control Diagram compares the benefit quota (from the benefit distribution) with the cost to achieve each function of the design. Logically, higher costs to achieve greater benefits should fall along the diagonal shown. In the example above, the benefit quota distributed to the function "snap-in facilitating" was 25 percent. The original design was overengineered. A competitor had fulfilled this function equally well at much lower cost. Once into the methodology, Target Cost Control Diagrams for each function of the design can be constructed quickly. When finished, the diagrams prioritize engineering improvement efforts.

Figure 5. Door hinge Target Cost Control Diagram.

hinge design from the bankrupt supplier, but within four weeks, after examining how the hinge would actually be made, the new supplier committed to an additional 14 percent cost reduction to be gained at the next model "facelift" of the truck at the latest.

Long-term savings, but hard to quantify, came from retaining the design knowledge gained from this exercise and classifying it systematically. This became part of the product classification system for vehicle components, very useful when trying to identify identical and carry-over components for use in future designs. This assists the OEM's design policy of "achieving external design uniqueness using internal design standardization," that is, re-using existing proven components in new designs whenever possible. The OEM wants to give the customer more choices while keeping designs and processes simple.

The execution of this project had to jump many hurdles. The three highest were: 1) time demands and distractions imposed on participants simultaneously scrambling to launch a new vehicle in production. 2) communication issues between R&D and purchasing, which mostly cleared up in the joint workshops, and 3) convincing supplier 2 that the purpose of the exercise was not to reduce his margins, which only happened after their representatives gained confidence in the approach being taken. Only by having a very efficient, structured approach could this exercise have been achieved in these conditions.

Lessons Learned

In general, Product Clinics promote the transfer of knowledge between different functional groups, and sometimes between customers and suppliers. Because competitive findings are made available throughout the company, everyone learns in more detail about the strengths and weaknesses of competitors. Analyses of product designs thus become part of best practice databases accessible using a company's system of "knowledge management." Making use of this to synthesize best-practice solutions during new product development is a benefit that accrues over time, with more and more Product Clinics. And not least, Product Clinic methodology is grounded in established research about learning and creativity. Briefly, some key features of Product Clinics are:

- Learning from concrete physical objects
- Working in interdisciplinary combined teams
- Combining internal and external expert knowledge
- Using spatial representations during each project
- Considering more external influences more rigorously
- Proceeding along a line supported by established methodology

- Measuring and quantifying differences discovered
- Openly communicating the results throughout a company (knowledge management)
- Constructively adopting novel, or even counterintuitive concept solutions
- Deriving demonstrable design targets
- Directly converting results into design and performance measures.

Product Clinic began in the German auto industry over ten years ago, and steadily expanded into other industries, notably electric machinery, electronics, and mechanical engineering. Recently Product Clinic has begun to find acceptance in the food industry and in services, such as software. The methodology of Steps 1-6 have existed almost since Product Clinic began. In the last few years, Step 7 technique cost portfolio, and Step 8 target cost control have been added. These have increased the rigor of the method and improved the imagination of outcomes developed. So far the involvement of customers or suppliers has only been observed in a few cases. Of course, some companies have not wanted to go through the steps presented here, and perform standard reverse engineering, learning by serendipity from disassembly and comparative performance analysis, but calling it Product Clinic. However, those who bother to use the full discipline of Product Clinic are helping to preserve the traditional reputation of German design engineering.

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