The Integration of the Japanese Tear-down Method with Design for Assembly and Value Engineering

James A. Rains, Jr. and Yoshihiko Sato

James (Jim) Rains, CVS-Life, FSAVE, PVM has been President of the Advanced Value Group, LLC (AVG) since 2000. AVG specializes in value engineering, tear-down analysis, target costing, Design for Assembly and synchronous process improvements in the factory or office environment. Before Jim launched AVG, he worked at General Motors. Jim has served on the SAVE International Board of Directors in several capacities, including President. Mr. Rains became a Certified Value Specialist in 1988 and is currently a Life - CVS. Jim has presented numerous papers and workshops around the globe. He was elected into the SAVE College of Fellows in 2002. He is a member of the Lawrence D. Miles Value Foundation Board of Directors, Executive Committee and Treasurer.

Yoshihiko Sato, CVS-Life, FSAVE is currently President, VPM Inc. and serves as an Associate Director for the Society for Japanese Value Engineering (SJVE). Upon graduation from Kanagawa Technical High School, he started building his brilliant VE career at Isuzu Motors. While working as a production manager, he developed his unique VE-tinted "Tear Down" process, which has later been widely adopted by not only all Japanese car-makers but also by major electronic and other manufacturers. Winding up his General Manager post at Isuzu, he opened his own consulting firm, VPM Inc. in 1997, with himself becoming its President and a full-fledged independent VE/Tear-down & Management Consultant. His sustaining service to some major manufacturers has made him spend an aggregate total of 1,500 consulting days (up to 2007) away from home. Mr. Sato has published many books, text–books, etc., and presented papers on VE, VM and Tear-Down methodologies. Mr. Sato was elected as a Fellow by SAVE in 1995. SJVE has recognized him twice for his remarkable contribution. He has published many books, manuals, text–books and software on VE/Tear-Down subjects. At the 2006 SAVE International Conference his ambitious book, "VA Tear-down" (co-authored with Mr. J.J. Kaufman and published in USA in 2005), was recognized as the Best Paper of the Year.

逆訳

佐藤嘉彦、CVS-Life, FSAVE，は現職VPM Inc．社長で、日本VE協会のAssociate Director
に就任している。神奈川工専を卒業して、いすゞ自動車に入社して、彼の輝かしいVEキャリアが始まった。そして、在任中に独自のVE色あるテアダウン・プロセスを開発した。コレがその後広く自動車産業界のみならず、電子工業その他の大企業の導入するところとなった。いすずでの幹部職を1997年に辞して、VPM Inc．を立ち上げてその社長となり、
ＶＥ．テアダウン・マネジメントに関する専門独立コンサルタントとなった。それ以来いくつかの主力メーカーでの出張コンサルティング実働日数は、2007年までの通産1500日を超えている。1995年にはSAVE International のフェローに就任した。また、日本ＶＥ
協会からはその貢献を賞して二度表彰された。彼にはVE・テアダウン分野に関する多数の書籍、教材、ソフトなどの著作があり2006SAVE International
大会では、その野心的共著(J.J.カウフマンと)の“ＶＡテアダウン,”2005米国出版、が年度最優秀図書として認められた。

Abstract

While working for Isuzu in the early 1970's, Mr. Yoshihiko Sato first learned of tear-down methods from his association with General Motors (GM). Later Mr. Sato fully developed the tear-down methodology to become much more extensive and encompassing than the original version offered by GM. Since that time Mr. Sato has written several books and has offered training in his tear-down methods. Recently he has taught his methods in the USA and now has a book written in English, which is co-authored by J. Jerry Kaufman. In 2006, Yoshihiko Sato was brought to the USA by Jim Rains to teach and perform a full week tear-down workshop for an automotive supplier.

Based on the experience of working with Yoshihiko Sato, Jim Rains has been able to perform tear-down workshops with other companies. One of the elements of Sato's tear-down method is Dynamic Tear-down. Since working with Sato, Rains has developed a Design for Assembly (DFA) module that he has inserted into Sato's Dynamic Tear-down element. This DFA module has further enhanced the tear-down method. In addition Rains has experience of integrating value engineering with the enhanced tear-down method. The paper will describe the introduction of Japanese Tear-down into the USA and the enhancements that have been made as a result; including the integration of Tear-down/Design for Assembly and Value Engineering.

Description of Japanese tear-down

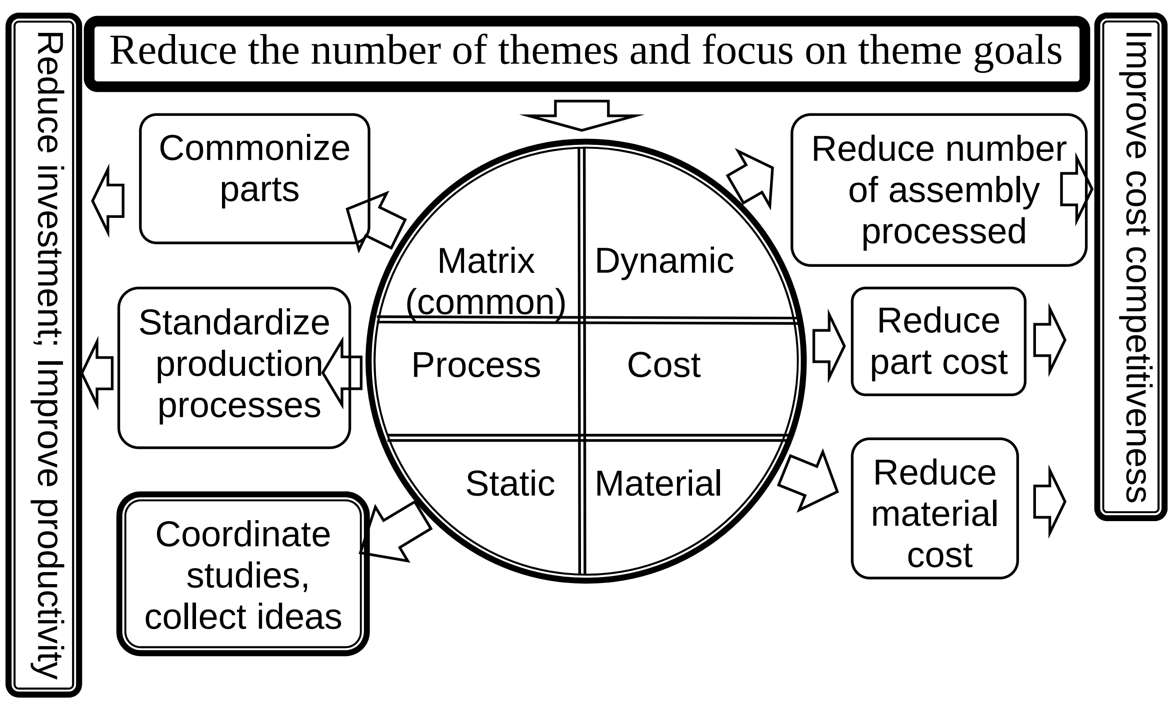
While working for Isuzu in the early 1970's, Mr. Yoshihiko Sato first learned of tear-down methods from his association with General Motors (GM). Later Mr. Sato more fully developed the tear-down methodology to become much more extensive and encompassing than the original version offered by GM. Since that time Mr. Sato has written several books and has offered training in his tear-down methods.

In Sato's book (J.J. Kaufman, co-author) the definition of VA Tear-down is "a method of comparative analysis in which disassembled products, systems, components and data are visually compared; and their functions determined, analyzed and evaluated to improve the value adding characteristics of the project under study."[1]

The elements of the Japanese tear-down method are Dynamic, Cost, Material, Matrix, Process and Static. The relationship of these elements and how they relate to each other are shown in the following figure. The most common tear-down elements are Dynamic, Cost, Material and Static tear-down. It seems that the Matrix and Process tear-down (TD) elements are more suitable for companies that are advanced in these techniques.

Sato notes his opinion of the fundamental difference between US & Japanese Tear-down practices. “I believe that the Tear-down methodologies, as originated earlier in the US are basically of an "overall examination" type approach. This is the way we were impressed when GM brought it to us, in which we started to use any findings from there to be developed into improvement proposals. Meanwhile, the new approach to Tear-down as we developed (at Isuzu) is unique in that it takes a "comparative analysis" to be applied to competitors' products specifically in such terms as Function, Cost, Material, Dynamic, Process and Matrix. We determine what are specific strong-points (worth to be learned) and what are weak-points to be corrected. Finally, all the problematic findings must be shared through Static viewpoints.

Structure of Tear Down



The Tear-Down Elements Detail

All TD elements require upfront planning and preparation. It is recommended that the preparation begins with the 5 Whys and 1 How as described in the Sato/Kaufman book. Once this information is developed then the actual planning of the products, competitor's products and the workshop itself is necessary. This paper will not go into the detail of those upfront planning activities, except as shown in the examples located in the Appendix.

Dynamic TD – Dynamic TD applies the principle of comparative analysis to the assembly process. Essentially the comparisons are focused on the effort and time it takes to assemble and disassemble the products being studied.

Cost TD – The focus of the Cost TD element is to make detailed comparisons of your product components with that of your competitors. Each component part may have many slight differences. Each difference then is noted and a cost estimate for this difference is determined.

Material TD – Material TD focuses on material choices, material surface treatments and altering material chemical properties through various treatments such as heat treating and stress relief. Another sub-element of Material TD is to analyze material offal for metal parts and resin waste for injection molded parts.

Matrix TD – As mentioned earlier only more advanced companies that have already made an effort for part commonization will benefit from this element. Matrix TD will further de-proliferation efforts by reducing part numbers through the utilization of common parts on different products in the same or different product family. The utilization of carry-over designed parts to new product designs is also of benefit.

Process TD – Once part commonization is mastered, process standardization can also be mastered. When common processes can be institutionalized process development time and production rates can be minimized. This results in lower capital and tooling investments and in lower piece part costs. It also results in faster time to market, especially in a high capital intensive business.

Static TD – Static TD represents the original element of tear-down presented to Mr. Sato by General Motors many years ago. Yet as simple as this element seems, Mr. Sato was able to develop many improvements to that shown to him by GM. In Static TD the component parts are appropriately displayed to enable on-going investigation and cost reduction.

Introduction of Japanese tear-down in the United States

Several years ago, Yoshihiko Sato gave J. Jerry Kaufman and Jim Rains an initial draft of his TD book in English. While working simultaneously, Mr. Kaufman was able to secure a publisher and edit the initial draft into a book that was published in the US in 2005. At the SAVE International Annual Conference in 2005, Sato taught the first two-day seminar to many interested people that attended his class. The seminar was followed again at the SAVE Conference in 2006.

In 2006 with the cooperation of Jim Rains, Sato was able to introduce his TD methods to an automotive supplier in the Detroit, Michigan area. To prepare for this workshop Rains reviewed and revised every PowerPoint slide and spreadsheet that was used in the above mentioned SAVE training class. Prior to this date, the materials used, were not completely converted to English text and grammar. The first USA workshop included three teams of approximately 24 people. Three different products were analyzed along with several respective competitor designs. The week long workshop provided training in each of the Japanese TD elements; however, only the Dynamic, Cost, some Material and Static elements were actually performed. This workshop was the first workshop of its kind in the United States. Sato and Rains have recently (June 2008) teamed up again to perform a workshop for a large manufacturing company. Based on the significant results from these workshops, it is safe to say that the Japanese TD methodology is meaningful and exceptional in obtaining competitive cost results for the company that invests in learning and using it.

Design for Assembly

"Dynamic TD is supported by commercially available computer software designed for Design for Assembly (DFA) criteria in that it can assess product designs in the same way". [2] With this in mind and Rains' familiarity with DFA, he decided to essentially integrate this method of DFA in the Dynamic TD element. This DFA method, however, is not a computer software system, but a manual method that obtains the same desired result as the software. There are several design guidelines that come into play when using DFA. Some of these guidelines[3] are:

Simplify the design and reduce the number of parts because for each part, there is an opportunity for a defective part and an assembly error. The probability of a perfect product goes down exponentially as the number of parts increases. As the number of parts goes up, the total cost of fabricating and assembling the product goes up. Automation becomes more difficult and more expensive when more parts are handled and processed. Costs related to purchasing, stocking, and servicing also go down as the number of parts are reduced. Inventory and work-in-process levels will go down with fewer parts. As the product structure and required operations are simplified, fewer fabrication and assembly steps are required, manufacturing processes can be integrated and lead-times further reduced. The designer should go through the assembly part by part and evaluate whether the part can be eliminated, combined with another part, or the function can be performed in another way. To determine the theoretical minimum number of parts, ask the following:

- Does the part move relative to all other moving parts?
- Must the part absolutely be of a different material from the other parts?
- Must the part be different to allow possible disassembly?

Design for parts orientation and handling to minimize non-value-added manual effort and ambiguity in orienting and merging parts. Basic principles to facilitate parts handling and orienting are:

- Parts must be designed to consistently orient themselves when fed into a process.

- Product design must avoid parts which can become tangled, wedged or disoriented. Avoid holes and tabs and designed "closed" parts. This type of design will allow the use of automation in parts handling and assembly such as vibratory bowls, tubes, magazines, etc.
- Part design should incorporate symmetry around both axes of insertion wherever possible. Where parts cannot be symmetrical, the asymmetry should be emphasized to assure correct insertion or easily identifiable feature should be provided.
- With hidden features that require a particular orientation, provide an external feature or guide surface to correctly orient the part.
- Guide surfaces should be provided to facilitate insertion.
- Parts should be designed with surfaces so that they can be easily grasped, placed and fixtured.
- Minimize thin, flat parts that are more difficult to pick up. Avoid very small parts that are difficult to pick-up or require a tool such as a tweezers to pick-up. This will increase handling and orientation time.
- Avoid parts with sharp edges, burrs or points. These parts can injure workers or customers, they require more careful handling, they can damage product finishes, and they may be more susceptible to damage themselves if the sharp edge is an intended feature.
- Avoid parts that can be easily damaged or broken.
- Avoid parts that are sticky or slippery (thin oily plates, oily parts, adhesive backed parts, small plastic parts with smooth surfaces, etc.).
- Avoid heavy parts that will increase worker fatigue, increase risk of worker injury, and slow the assembly process.
- Design the work station area to minimize the distance to access and move a part.
- When purchasing components, consider acquiring materials already oriented in magazines, bands, tape, or strips.

Design for ease of assembly by utilizing simple patterns of movement and minimizing the axes of assembly. Complex orientation and assembly movements in various directions should be avoided. Part features should be provided such as chamfers and tapers. The product's design should enable assembly to begin with a base component with a large relative mass and a low center of gravity upon which other parts are added. Assembly should proceed vertically with other parts added on top and positioned with the aid of gravity. This will minimize the need to re-orient the assembly and reduce the need for temporary fastening and more complex fixturing. A product that is easy to assemble manually will be easily assembled with automation. Assembly that is automated will be more uniform, more reliable, and of a higher quality.

Design for efficient joining and fastening. Threaded fasteners (screws, bolts, nuts and washers) are time-consuming to assemble and difficult to automate. Where they must be used, standardize to minimize variety and use fasteners such as self threading screws and captured washers. Consider the use of integral attachment methods (snap-fit). Evaluate other bonding techniques with adhesives. Match fastening techniques to materials, product functional requirements, and disassembly/servicing requirements.

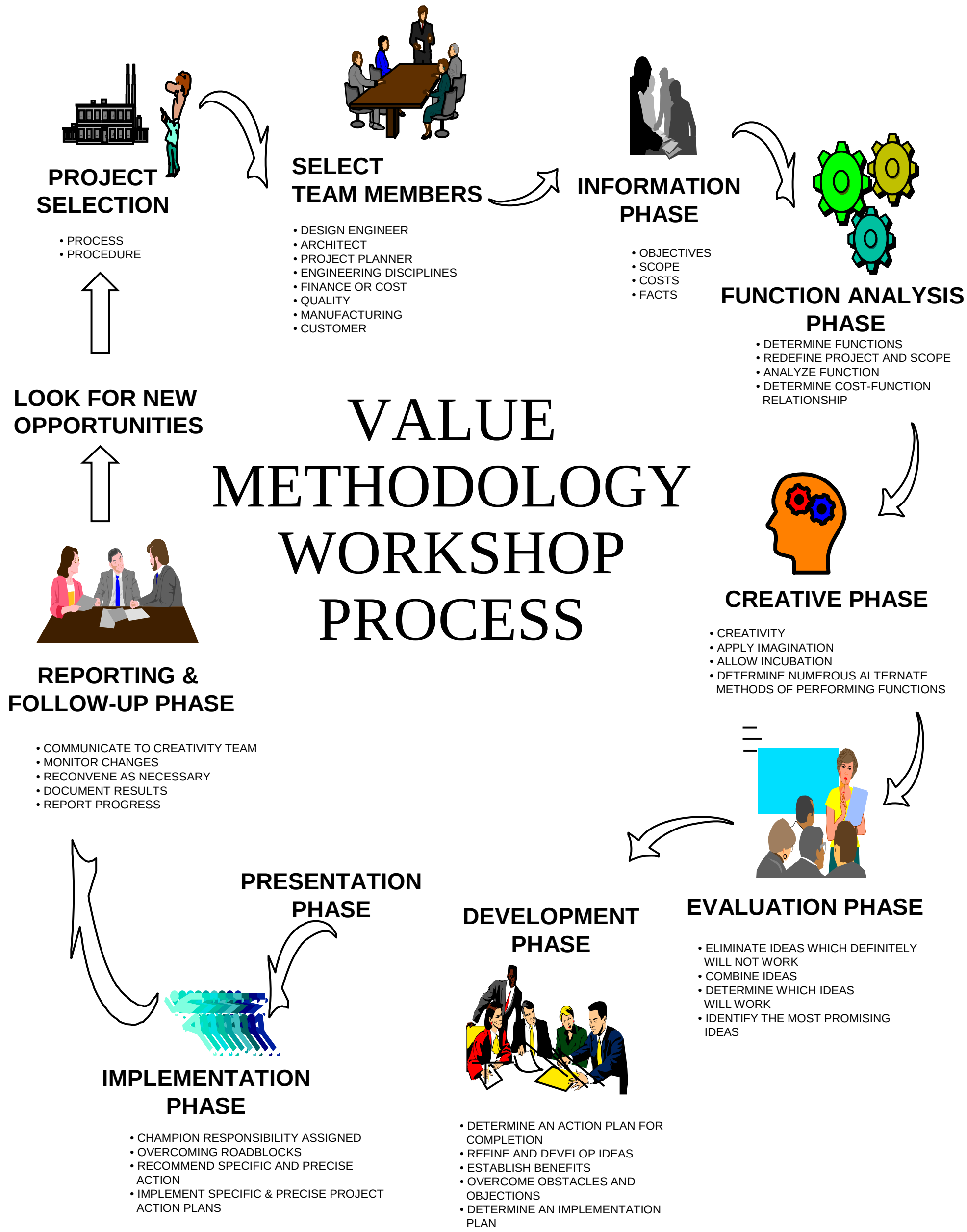
The manual DFA form[4] we use has a scoring system for each of the following categories.

- Part Needed - function can't be consolidated because:
  1. Part must be of a different material
  2. Part must move relative to other parts
  3. Part must be different to allow assembly or disassembly
  4. Part is a purchased vendor catalog item
- Part Fabrication or Subassembly - part is easy to fabricate, adheres to DFM guidelines & has good yields. Geometric features are required & complexity justified by consolidation of multiple functions. Subassembly has minimum of parts and is easy to assemble.
- Part Handling - part can be easily gripped or held from pick-up through insertion. Part is presented or feed without interference with other parts, nesting or tangling. No effort to unpackage, remove protective material, or prepare. Part is not fragile or dangerous to handle.
- Part Orientation - orientation is unambiguous or has a high degree of symmetry that makes orientation easy. If part must be asymmetrical, the features that define the asymmetry are obvious.
- Part Size & Weight - size is neither too small or thin nor too large and heavy to handle manually. Does not require special tools (e.g., tweezers, lift, etc.) nor another person to handle. Part can be picked-up with one hand.
- Assembly Access - top down assembly with a stable base component. No separate fixture required (self-fixturing). No reorientation of the assembly required to get access for installation or assembly. No blind assembly; can be seen and guided by operator or machine.
- Part Insertion - part is easily aligned and inserted with a simple, straight insertion direction, no insertion force & plenty of clearance to operator & tool. Part features (e.g., chamfers, tapers, etc.) facilitate alignment and insertion.
- Joining & Fastening - requires minimal effort. Integral attachment is the ideal with no separate fasteners or joining material. Avoid need for torquing or curing time. When fasteners are required, use common fasteners. Joining & fastening conforms to guidelines.
- Adjust & Finish - assembly step does not require any adjustment. Assembly step/part doesn't require cleaning or finishing. Finish is robust to avoid special handling & wrapping to protect finish. Assembly step/part does not require final cosmetic inspection and retouching.
- Mistake-proof - product or process design features prevent part from being incorrectly assembled and avoid the need for subsequent inspection or checking.

The scoring system used means that high scores are bad and low scores are good. Below is an example of the scoring for the above category of **Part Insertion**. Each component part of every competing design is scored using our DFA system.
0 points - Part is easily aligned and inserted with minimal force
2 points - Part lacks alignment or insertion features or is flexible
4 points - Requires fixture/tool to align/insert; flexible; minimal clearance
5 points - Difficult to insert; high insertion force; lacks clearance

The Integration of Teardown/DFA with VE

The authors strictly follow the value engineering job plan that is offered as the SAVE International standard. The major phases of this job plan are: Information Phase; Function Analysis Phase; Creative Phase; Evaluation Phase; Development Phase; Presentation Phase and Implementation Phase.



This job plan becomes the framework for the integration of the TD methodology and the DFA methodology. The TD and DFA activities are both part of the Information Phase. Once the product to be analyzed has been selected the first workshop is scheduled. This workshop is the Information Phase. All product samples (including the competitor's) are collected. It is best to have more than one unit from each competitor, however, this is not always possible based on cost and size issues. After performance testing, these units are disassembled. Generic checklists are used to insure all data such as cost, drawings, quality detail, sales and marketing information of the company's product is available. Another checklist of tools and materials for the TD/DFA workshop is available. Sample checklists are shown in the Appendix.

The TD workshop starts with presentation materials to get the workers in the correct mindset for design improvements. The Dynamic TD is usually done first. In this case most of the effort to perform the Dynamic TD is using our DFA manual worksheet. We compile detailed data on our own and each competitor's products using our scoring system. Advantages and disadvantages of competitor's products are discussed throughout this process. The next step is to perform the Cost TD. We use the form developed by Mr. Yoshihiko Sato. Our costed-bill-of-materials is listed first. Then a bill-of-materials (not costed) for each competitor design is created. Then part by part design comparisons are made to our design. We note every minute detail that is different. It is common to have many differences for each component part. These need to be listed individually. For each difference, we identify the cost variation from our design to the competitor's design. This step is time consuming, but is extremely valuable in the information that is learned and what can be done to improve our own product. The improvements are only noted at this point. Since we are still in the Information Phase we are not necessarily looking for ideas or solutions, but merely collecting data and facts that will be used in the remainder of the VM job plan. Material TD often requires special equipment and expert analysis. Generally most of this TD method is done at a later date, outside of the workshop environment. There will be, however, opportunities to identify and collect Material TD data and information. The final part of the workshop is to display all of the products components, including the competitors. This is called Static TD. There are proper and improper ways to display these component parts. Special care is to display the parts so that one can view the part from all sides and angles. Specialized board attachment methods have been developed to insure this happens.

Generally we recommend a one to two week lapse before completing the remainder of the VM job plan. With the Information Phase now completed the workshop continues with the Function Analysis Phase. The details of running this part of the workshop is essentially identical to running a VM workshop that does not include tear-down and DFA as part of the Information Phase. The issue is that now that we have so much more information each phase of the job plan takes a bit longer. Depending on the size and scope of the project under study, no less that four days needs to be devoted. An enhancement to this activity would be to perform a FAST diagram and cost-function analysis on each of the competitors designs. Depending on the product complexity and the number of competitor's products analyzed this can add 3 to 6 days to the process.

The remaining VE job plan phases are followed as normal. Special care however, in the Evaluation Phase is necessary to correct any design deficiencies noted in the DFA effort. Also using the Cost TD information, the team must insure that all areas of potential improvement have been addressed.

Examples of Successful Tear-down applications in Japan

Product development phase: The Comparative Analysis is applied as early as the pre-design phase, where materials, product configuration, and what will be product functions are analyzed. The results of the analysis should be reflected in product merchandising plans. These are unique points of our approach, which cannot be found in the western world use of Tear-down. Based on the data collected through the comparative analysis, Tear-down Targets for each Function, Cost and Product weight, respectively, are established. This specific goal data is to be importantly used in the company's overall Target Costing Activity.

Product design phase: It goes without saying that those "strong-points" found in the competitor's products are not to be merely "copied", but are to be used to create "new associated ideas" so that our products can be made superior over those of the competition.

Product verification phase: Tear-down efforts can be extended even in this phase by taking up competitors' newest products to check if our products are still better. Any qualitative targets, so far unclear, are to be cross-examined with competitors' products. The results of such comparison should be used in making company's products marketing/sales strategies more effective.

Other phases:

- Employee training: Tear-down findings such as functions, configurations, materials, fabrication methods, etc. can be utilized in developing company's new-employee training programs.
- Dealer collaboration activities: Collected competitor information can be utilized in such joint activities as teaming up in product development, creating future-oriented strategies for parts suppliers, etc. It is helpful in making them discover what are new hint for solution, what should be taken up for joint product development, etc.
- In-house and other communication: Tear-down information is helpful in promoting communication between top executives and field staffs, inter-departmental exchanges, smoother member-to-member sharing of first-line data, building better communication channels with dealers, etc.

Design for Manufacturability

A future enhancement that is not detailed in this paper is once the final design concept has been determined, it is then very useful to utilize the Design for Manufacturability (DFM) techniques for each and every component part or sub-assembly. The Advanced Value Group, LLC working in conjunction with DRM Associates offer detailed DFM training. Our DFM training modules include:

- Design for Automated and Robotic Assembly
- Design for Electronics
- Design for Machining
- Design for Sheet Metal
- Design for Injection Molding and Composites
- Design for Die Casting

- Design for Forging, and
- Design for Finishing.

Using the appropriate and applicable DFM techniques will insure that the component part is designed to insure the lowest possible manufacturing cost. When designing parts that will be produced for many years and at up to thousands manufactured every day, it is highly prudent to insure that the best design is done upfront in the development process. This will save untold dollars in making expensive changes once the product is in production.

Results

The first full week tear-down workshop in the USA was a huge success. The automotive supplier that hosted the workshop had read the Sato/Kaufman book and were familiar with the concepts in the book. However, by their own admission going through the actual workshop with Rains and Sato and actually putting to use the concepts with the experts, proved to be a significant benefit. Now they are able to continue this effort on their own, knowing that they have not only been taught by the best, but the person who actually invented and developed the methodology. The results were significant for the projects that were worked on during the workshop, but we feel that the knowledge and training that the people received so that they can be self-sufficient in the future is even more valuable.

When Jim Rains was working with a heating component company, he decided to propose to the company that they integrate Sato's TD workshop, DFA as part of the Dynamic TD (DRM Associates process) and value engineering. The integrated workshop took two weeks. The two weeks were separated by one week. The final result of this workshop was just outstanding. Not only did the company make significant improvements to their current product, they developed a new product that did not exist in their product portfolio that would allow them to improve their competitive position in the market place and take business away from their competitors.

We wish that we could discuss these results in more detail, however, due to Confidentially Agreements that is not possible.

Conclusion

Mr. Sato quotes that, "All in all, as developer of Japanese Tear-down approach, I am proud that our methodology is more widely utilized among Japanese industrial circles than in the US." Now that we know that the above statement is true, the next question remains is what is the industrial western world going to do about it. All western world companies that have made progress in utilizing the techniques developed in Japan by Mr. Sato have found them to be beneficial and an important element of their product development strategy. It is not enough to only fully understand your products, including its design strengths and weaknesses, cost detail, performance, functional elements, and selling features. This same information must be known on the competition's products as well. Following the Japanese tear-down methodology with integrity has certainly proven to be necessary in improving corporate profitability.

It must be said, that using this detailed tear-down methodology on any given product line, is not a one-time activity. The best benefits come after many years of comparing competitor's products to our own. A detailed database of previous analyses will allow you to see design change trends in your competitor's designs. You may possibly even develop the skills to predict your competitor's design changes before they actually occur.

In addition, the integration of Design for Assembly into the Dynamic Tear-down element and using the tear-down and DFA information as part of the Information Phase of a structured value engineering activity will definitely offer superior profitable results.

Appendix

The list below helps get the project team prepared for the products that they will be performing the tear-down benchmarking review on. The prep meeting with the team should be about 4 weeks prior to the workshop; or longer if time is needed to secure competitor's products.

	Preparation for Tear-down Workshop Worksheet			
	Workshop Date		*Place*	
	Date of Workshop goes here		Location of workshop goes here	
	Latest Update	XX-XX-XXXX		
#	**Product Information and Parts Required**	**Responsible Person**	**Comments**	**Due Date**
1	Several assembled units of product to be analyzed; internal plus competitors			
2	Complete performance testing prior to workshop			
3	Collect assembled units of similar product functions.			
4	Assembly and detail drawings			
5	Material specifications for all component parts			
6	Test specifications for all assemblies; include engineering test specifications as well as manufacturing floor test specifications.			
7	Cost detail for internal assembly and component parts; include purchasing cost detail for any purchased material, both finished and raw material. Include in-house labor costs (direct labor and variable burden) and any third party processing costs.			
8	Any detailed information of competitors products, such as manufacturing location, level of automation, key suppliers, etc.			
9	Forecasted annual volumes - 2008/2009/2010			
10	Detailed process routing sheets of current production methods. Include time studies of each operation.			
11	Video of current production process			
12	Design for Assembly analysis if available			

The list shown on the following page is a list of tools and equipment that are normally needed to perform the tear-down workshop.

VA TEAR DOWN TRAINING TOOL CHECK LIST

Workshop Date ***Place***

Date of Workshop goes here

#	TOOL DESCRIPTION.	QTY	READY ? NO X	READY ? YES X	COMMENTS
1	Flat Screw Drivers (1/8")	2			
2	Flat Screw Drivers (1/4")	2			
3	Philips Screw Driver (1/8").	2			
4	Philips Screw Driver (1/4")	2			
5	Torx L-Key (T10)	1			
6	Torx L-Key (T20)	1			
7	Square Drive Torx-Bit Socket (T10)	1			
8	Square Drive Torx-Bit Socket (T20)	1			
9	Reversible Ratchet Wrench (small)	1			
10	Reversible Ratchet Wrench (medium)	1			
11	All Purpose pliers set	1			
12	Long nose pliers	2			
13	Side Cutting Pliers	1			
14	Diagonal cutting pliers	1			
15	Vise-Grip pliers	1			
16	Adjustable Wrenches	2			
17	Dremel	1			
18	Power Screw Driver	1			
19	Screw Driver Bit (T10)	1			
20	Screw Driver Bit (T20)	1			
21	Cordless Drill	1			
22	Extension Cord	1			
23	Files (Small, Medium, Round)	1			
24	Hammer	1			
25	Scissors	2			
26	Hacksaw	1			
27	Ruler (millimeters)	1			
28	Caliper	1			
29	Measuring Tape (mm & in)	1			
31	Utility knife	1			
32	C - Clamps	2			
33	Magnifiers	1			
34	Scales - weight	1			
35	Chronometers	3			
36	Stop watches	2			

This final list depicts the office supplies and display board materials required for the workshop.

VA TEAR DOWN TRAINING OFFICE SUPPLIES CHECK LIST					
Workshop Date		*Place*			
Date of workshop goes here					
#	TOOL DESCRIPTION.	QTY	READY ?		COMMENTS
			NO	YES	
			X	X	
1	Markers (4 colors)	8			
2	Chart paper and stand	2			
3	Rubber Bands	100			
4	Zip-lock bags (small)	50			
5	Zip-lock bags (medium)	50			
6	Zip-lock bags (tall)	50			
7	ID Tags	250			
8	Digital Camera	1			
9	Video Camera and Monitor	1			
10	Tape	2			
11	Post its (Small, Medium, Large)	50			
12	Boxes (for storage of parts & material)	10			
13	Wire ties	?			
14	Peg boards	?			

[1] Value Analysis Tear-down: A New Process for Product Development and Innovation by Yoshihiko Sato and J. Jerry Kaufman; Industrial Press Inc.; 2005; page 1
[2] Ibid page 103
[3] Website of DRM Associates; author Ken Crow; http://www.npd-solutions.com/dfmguidelines.html
[4] Form developed by Ken Crow of DRM Associates