DFA Implementation in Whirlpool Europe: Experience and Results

Stefan Wohnhas

Whirlpool Europe
Bauknecht Hausgeräte GmbH
Central Process Engineering

Gottlob Bauknechtstr. 1-11
73614 Schorndorf, Germany

stefan_wohnhas@email.whirlpool.com

Abstract

Whirlpool Corporation, the world's leading home appliance manufacturer decided to improve the product engineering process in Europe by using DFMA. The main goals are to support the concurrent engineering approach, to reduce the number of parts, to lower manufacturing costs and to improve product quality.
Whirlpool Europe decided to use a practical approach for the introduction with workshops and a focus on strong follow-up afterwards.
This paper describes the implementation in the different product engineering centers and factories all over Europe with examples from various product groups.
Also, other aspects of the DFA software, like benchmarking and assembly line balancing, are discussed.

Introduction

Whirlpool Corporation is the world's leading manufacturer and marketer of major home appliances. Its home is in Benton Harbor, Michigan. There are over 45,000 people in the Whirlpool family who manufacture fine appliances in 13 countries and market them under 11 major brand names in more than 140 countries around the world.

Whirlpool Europe is number three in the difficult European market, where the market leaders in Europe are Electrolux and the Bosch Siemens group.
The Company's Appliance net sales for 1997 were US$ 2.03 billion with an operational profit of US$ 0.49 billion.
Whirlpool owns ten factories in Europe: One in Sweden (Microwave ovens), three in Germany (Refrigerators, Dishwashers, Front loader washers and Washer/Dryers), one in France (Top loader washers and Dryers), four in Italy (Front loader washers, Cooking products, Freezers and Refrigerators) and one in Slovakia for low range toploaders.

Whirlpool products are sold in Europe under the brand of Bauknecht, Whirlpool, Ignis and Laden.

Having a difficult economic situation in Europe with a high level of regional unemployment, people who are buying home appliances often tend to buy simpler products with fewer features, that have correspondingly smaller profit margins.
Raising productivity and reducing cost are thus remaining prevalent priorities in the European business.
Among other improvement programs Whirlpool Europe decided to improve the product engineering and manufacturing process by using DFMA. Main goals are to reduce assembly cost, to improve quality and to speed-up the design process.

History of DFMA in Whirlpool Europe and Consequences for a new Startup

Reports with encouraging results were found in literature, and our own benchmarks showed competitive weaknesses of our products from a DFA point of view. By the end of 1996, Whirlpool Europe began it's DFMA activities.
Also, there was some existing knowledge about potentials of DFMA from experienced colleagues, that had been in touch with the methodology about 12 years previously.
At that time the European factories were owned by Philips from the Netherlands.

However, an analysis of the history showed, that the introduction of the methodology by Philips in 1985 failed for five main reasons:

- The introduction was done in theoretical seminars without any follow up or further support
- The results were not monitored
- The methodology was used only in a manual workbook way, primarily because the software was not seen as useful at that time.
- People were not convinced of the worth of the methodology
- Philip's Management didn't ask for results from DFMA

It was important for us to avoid these failures and develop an implementation strategy with the target, to set-up DFMA as a standard tool in the product development process. DFMA should be used in day-to-day activities and should be recognised as a 'value creating' methodology.

The DFA activities in Whirlpool Europe were started in co-operation with "Central Process Engineering (CPE)" and "Organization and Efficiency (O&E)". O&E is responsible for the planning of the activities and the co-ordination with other improvement or training programs like "Six Sigma". CPE is responsible for the implementation, for the correct application and for the monitoring of results.

After having studied the literature it was decided, that it is essential to get involved in a running project in order to get more experienced with the methodology and the behaviour of people in the application of DFA.

Cornerstones for DFMA Introduction

The base for the new start of DFMA introduction was an approach with the following cornerstones:

Use a practical approach for the introduction.

- *Involve people in the decision of how to start with DFA in their organisational unit*
  In different development situations, people in product engineering departments and factories have different requirements. The approach taken, was to enter the factories and product engineering centers, to show people how the methodology could help them.
  Some people had assembly problems (capacity, cost, quality), others needed a concept evaluation, again others a competitor's benchmark.
- *Organise workshops with cross functional teams*
  To spread the basic know-how of DFA we decided to organise workshops with an audience from different departments. The first day's focus is on the theory of DFA, the impact on design efficiency, and use of the methodology, with examples defined by the workshop leader. Also, the basic use of the DFA software from Boothroyd & Dewhurst is taught.
  During the second day of the workshop, the audience is split up in to groups and has to analyse assemblies from their environment.
  The intention is to create practical results that are visible for everyone in the workshop.

Convince people, don't force them

- *Define a 'Key User' in every organisational unit.*
  This Key User is the principal interface of the DFA trainer in the follow up phase. The Key User of the methodology is familiar with the development

environment and is able to drive the implementation process in the local unit. They must have good communication skills and a general overview over present development projects.

- *Buy DFA Software*
  It is not our intention to force Product Engineering or the factories to use DFA. It is our policy to convince the users during the workshop and let them ask the management to buy the software. (The software is not paid from central budget). For organizational reasons and to guarantee a unique software environment, the maintenance of the software is in central budget.

Create results a soon as possible. This is the best way to verify DFA

- *Define projects that involve cross functional teams*
  It is essential to start well defined projects, together with the management, and encourage people to use DFA. These Projects should be chosen in order to create value and convince the users that DFA gets results, that otherwise would not arise. These projects are carefully monitored by the workshop trainer, who keeps in touch with his clients. It is essential, that the users have a strong support from the Key User of the organisational unit as well as from the workshop leader.
  Our policy is to support the Product Engineering centers and cross functional development teams according to their requirements.

What have we achieved until now?

The management of CPE and O&E decided to create and demonstrate the efficiency and effectiveness of the DFA methodology by getting involved, in a running project, where significant results are likely. The project we have chosen at that time, was in the concept phase near the concept evaluation tollgate. Design changes are still possible in that phase. After a presentation of the results of other companies, we started with the support of the project manager. The following activities were agreed upon:

- Start with a 2 day workshop held by a representative of Boothroyd & Dewhurst (Design IV)
- Select a Key User in the project group
- Make a DFA analysis of the newest design proposals of the project
- Benchmark it with a product from the same range, that is presently in production
- Present the results and start day by day support for the project team.

During our support for the project team we also organised benchmarks of our main competitors in the market. Also, support for detailed design work was done.
Results are shown later in this paper.

After very encouraging results from the prototype project and good acceptance from both, the project management and the users in Product Engineering and Industrial Engineering, we decided to proceed with minor changes in our implementation concept.

During the first 15 months of the introductory phase activities followed in several business units

- Homelaundry (prototype project and general "Product Engineering Dep.")
- Dishwashing
- Microwave
- Cooking

We have completed 10 workshops and have trained about 120 engineers from different departments, that included

- Product engineering (70 %)
- Industrial engineering (20 %)
- Procurement (5 %)
- Controlling, Quality and others (5%)

Prior to the workshops it was necessary to convince the local PE and Factory management. This was normally done through a presentation of the potential and the results that had been achieved.
In general, it was not a problem to receive a strong support from the management.

Results from DFA Work

Prototype Project

The results of the DFA Benchmark with competitors and our products, that were still in production are shown in figure 1.

The results of the benchmark have been:

- Whirlpool Products sold at that time were best in class from an assembly point of view.
- Requirements for the new product regarding assembly efficiency and complexity reduction have not been reached, primarily due to marketing requirements. The estimated assembly time was about 20% higher than our old product.
- Our new product had good improvement potential
- Split up in "Low Range" and "Mid/High Range" of the product with high volume on "Low Range" would increase factory efficiency.

- Main areas for DFA improvement and results are:
    - Cabinet --> Clinch rear panel instead of screwing. Reduce fasteners.
    - Water System Intergrate pump in tub. Save hoses and fasteners
    - Damper fixation --> Integrate damper with fixation. Save screw/washer and several operations.

Over all the assembly efficiency is now 15% better compared with the first prototype.

A very important result was, that the assembly times estimated with the DFA software are quite close to the assembly times found with the MTM methodology. The difference was less than 10%. This is a general experience also found in other projects. Industrial Engineering Departments reported that the preparation of a DFA study it requires about 10% in comparison to the time of a MTM/Work Factor evaluation. This allows cost

estimations to be made in an early state of development, and can deliver input data for the evaluation of different possibilities of assembly line scheduling.

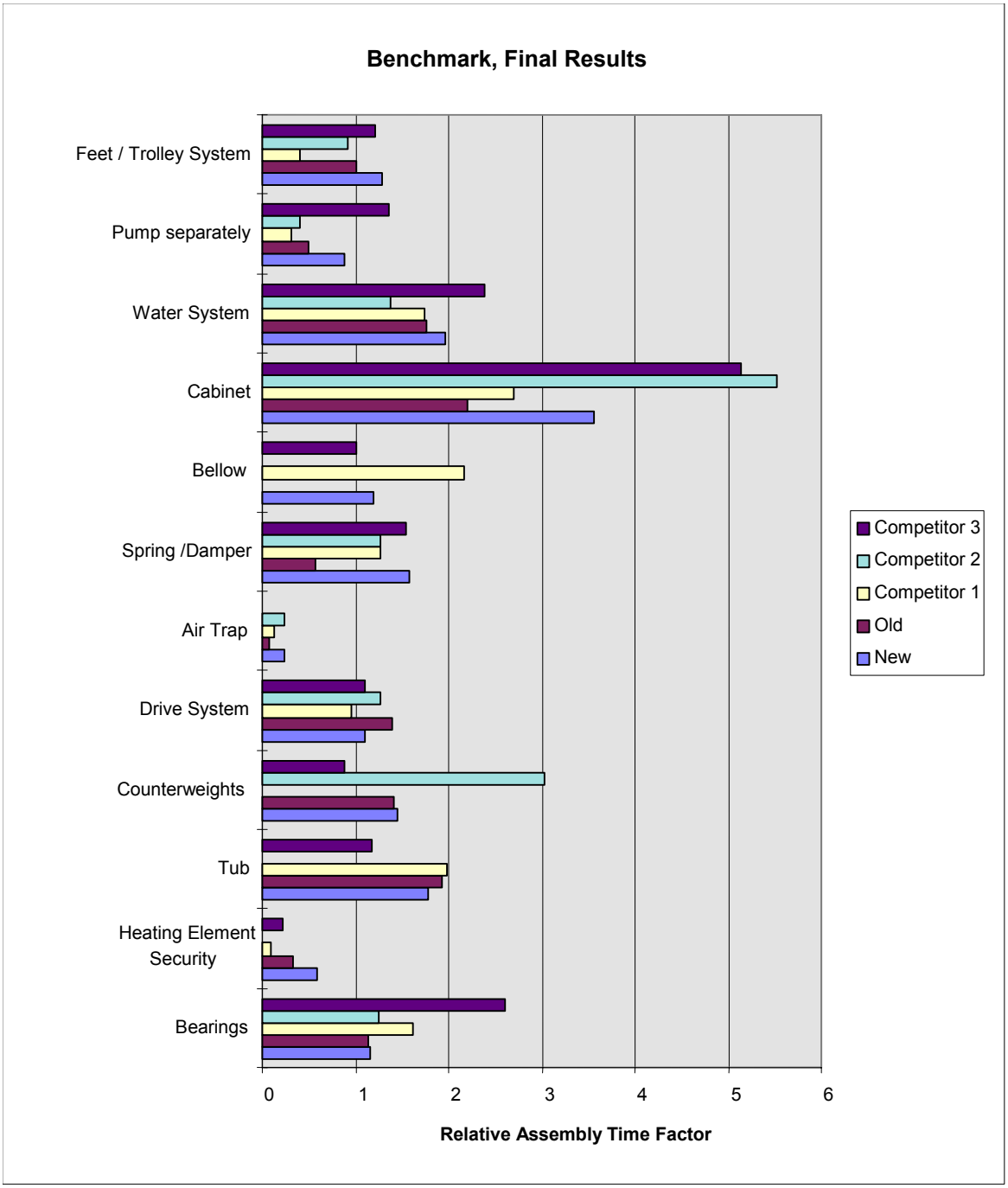

Figure 1: *Benchmark Results per Subassembly Group*

Microwave Factory Norrköping, Sweden

In Norrköping, the DFA activities have been started for two reasons. The first, was to train a concept project team for a new product in the DFA methodology, the other was to find potential savings in the present product range.

During two workshops, the present product was analysed and compared to a design study for a new microwave oven. New ideas have been generated and new proposals for improvements have been made.

The following table shows the evaluation of the present product and the design study:

	Pres. Prod	**Design Study**	**Difference**
Number of Fasteners:	59	39	- 20 (34%)
Total Ass. Time:	100 %	77 %	- 23 %
Ass. Time Fasteners:	100 %	74 %	- 26%
% Fasteners of Total:	26%		
Ass. Time Cables:	100 %	74 %	- 26 %
% Cables of Total:	36%		

Figure 2*: Analysis of a Product vs. a Design Study*

Key results are the assembly time for cabling and the assembly time for fasteners.

After a verification of the results from the product study, the following projects have been introduced:

- Force the reduction and standardisation of cables and cabinets of different product ranges. This led us to a reduction of cabling costs (parts & assembly) and general assembly costs of about 1M US$. Payback time for the project was 0.5 years.

- Set up a project team to better understand DFA and general assembly problems in microwave ovens.

  This cross functional group analysed the present assembly problems with video and assembly diagrams. At each workplace DFA problems have been identified and communicated to the management and other project groups. The methodology is shown in figure 3.

  This gave an additional push from the Product Engineering and Factory management and clearly showed, that most of the assembly problems shown in the video are based on an insufficient product design according to DFA rules.

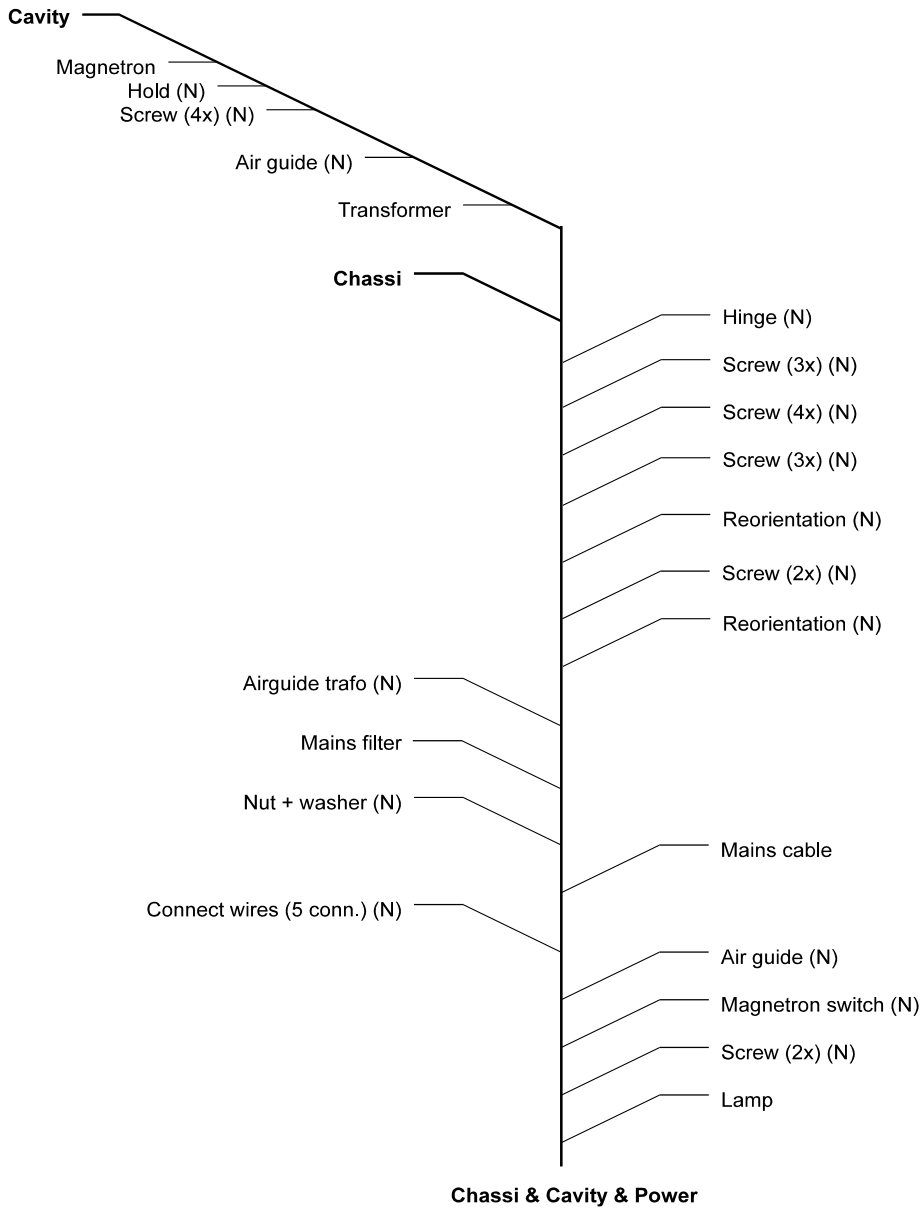

Figure 3: Assembly flow chart with not necessary parts (N)

Not necessary operations:

Hold and screw the Magnetron; Screw the Transformer, Re-orientations;
Fix the Mains Filter with nut and washer
Make five connections to the Mains Filter; Screw the Magnetron-thermostat

For every workstation a DFA performance matrix (figure 4) was prepared, that served as a reference, where DFA rules have not been respected. In addition the video was a very impressive instrument to convince people about the potentials of DFA and the effects on other assembly problems arising subsequently in the assembly line.

Workstation no: 1	DFA guidelines not fullfilled					
No. of different screws/nuts: 4	Reduce parts	Use modular	Don't fight	Reduce processing	Process in the open	Reduce fastener
No. of different screwdrivers: 4	*Necessary*	design	gravity	surface	*Visability*	*Reduce variation*
	Multifunctional	*Form sub-*	*Top-down*	*No re-orientation*	*No restricted acess*	*fasteners*
	Part implusion	*assemblies*				*Reduce fasteners*
Remarks						*Reduce connec*
Feet breaks						
PF foot hard to mount						
" not unclear assymmetric						
" restricted wiev						
Chassis re-oriented and moved				×		
" hard to place on pallet						
Align diode and holder when screwing						
Mains filter screwed/connected from side			×	×		
" earth connection not aligned						
" hold when screwed						
Capacitor holder nests						
Long mains cable and cable tree						
Transformer two-hand handling			×	×		
" hard to mount				×		

Figure 4: *DFA Performance Matrix*

A study was done how a modular design could be implemented in a microwave oven and compared with the state-of-the-art product structure. The main modules, that have been identified are:

- Chassis, Power and Ventilation
- Cavity, Auto
- Panel & Electronics, Doorlock system, Main cable, Main filter
- Door
- Grill
- Forced air convection
- Wrapping
- Accessories

All modules have been defined on a functional analysis with mechanical, electrical and geometrical interfaces.
Afterwards, DFA analyses for each module have been prepared as a basis for discussion. In addition brainstorming sessions, with the background of assembly costs and quality problems gave the teams new ideas; and with DFA an exceptional tool to compare them.

Furthermore, based on DFA analysis of our old product the following targets have been set:

- Modular design with standard interfaces wherever possible. This will enlarge the flexibility and offer the possibility for standardisation
- 30% parts reduction on basis of the old product
- 50% less unique components
- 50% less assembly time

Experience from the Use of DFA

Methodology

Until now, we had concentrated on the DFA, because it is the core of the DFMA methodology. We realised, that there are no problems with the methodology itself. It is working in the expected way.

The theory of the methodology is easy to understand for people with a technical background and the results are fact based and reliable and reproducible. In some cases, people expected more proposals for improvement, but the most important factor in applying the methodology is to give excellent input and basis for discussions.

Consequently we found, that DFA can give support in the following areas:

- Development of new products
- Re-engineering of existing products
- Benchmarking of competitors
- Cost estimations of external suppliers
- Time estimations done with the DFA methodology are good enough to do early cost estimations (management support).

Potentials

The results reported in case studies of 30 - 70 % of parts reduction and 50 - 80 % of assembly time reduction should be seen as potentials savings. Particularly when trying to improve products in an existing assembly line it is very difficult to realise these results, because e.g. line balancing and other problems can not be solved. The estimated potential, however is useful for further developments.

One of the biggest benefits of DFA is the facilitation of communication within cross functional teams. DFA provides fact based data, that is easy to understand and to verify, for everyone.

DFA was also used with success for benchmarking of competitive products. It was found, that estimated assembly times are in a range of 10% of the later calculated MTM times. This was very helpful data in an early state of development for upper management decisions.

The software worked without bigger problems. Maintenance and support by Design IV and Boothroyd Dewhurst are excellent.

Critical Points for the introduction of DFMA

- **Management Support**
  It is essential to have the management support during the implementation of DFA. The management has to support all activities and care about the continuing application of the methodology. The management level has to understand how DFA works and set the necessary targets for future applications. These targets should be fact based and e.g. include a DFA benchmarking session with the competitors products.
  During the application of DFA the management has to ask for results and opportunities. It is also important, that the management regards DFMA as an essential tool in a wider framework of concurrent engineering.
  The management is also responsible for the kick-off of a prototype project and the team building for it.

- **Convince Users**
  During the workshop it is very easy to convince the users about the advantages to work with DFA. To do this, it is necessary to demonstrate the effectiveness of DFA during the workshop with practical examples from the environment of the workshop's participants. This has never been a problem. However, it can be difficult to point out, that users have to use it at the right time in a project and use it as a day by day approach for their future work. Development engineers often have to change their way

of working and their approach about the necessity of "easy to assemble".
To convince people it is necessary to involve them in the way "how to introduce DFA". This could be a small sample problem to be solved or to be checked, whether a supplier has calculated the right assembly cost or perhaps a benchmark.
The person, that is responsible for the introduction should drive the process, but the participants in the workshop should see him more as a facilitator.
Another important point is that people in development departments heard a lot about methodologies or new improvement projects during the last years. It is essential to give people the feeling, that DFA is not another tool for presentation or a "Flavour of the Month" of upper management. There must be a clear link to other programs (like "Six Sigma" or "Robust Design").
DFA results are easily measurable. This factor should also be used to convince design engineers. They often have good ideas, that are lost, only because assembly cost and assembly quality was not measurable.

- **Create Results**
  With only a methodology at hand it is very difficult to convince cross functional teams and the management for a longer period of time about the effectiveness of the methodology.
  DFA is a tool that creates numbers and figures that are instantly understandable for everybody with a technical background. The best way promote the application of DFMA is to create the first results during a workshop and also present them to the development and factory management during the workshop. As soon as possible after the workshop, a prototype project should be introduced. This project should have a good improvement potential and should be carefully monitored.

- **Effective Team Building**
  To use DFA in the most effective way, it is necessary to use cross functional teams. The team members should not only be selected from not only following the technical requirements. A DFA team should be a mixture of both, young and experienced engineers from different departments. In addition also e.g. external suppliers or

consultants could be involved. The most important skill these teams should have is the ability to communicate with other people or teams. The teams should be able to use creative methodologies like brainstorming.
Furthermore, the teams should be able to make decisions under their own responsibility.
For larger projects it is possible to set up a core team for DFA with subteams and/or part time representatives.

- **Follow up**
  It is essential to follow up DFA activities in an organisational unit. A major experience during the implementation of DFA, was, that the use of DFA has been very strong at the beginning and disappeared over the time. This could easily happen, if people are not used in applying scientific-based methodologies or if targets change during the development process. From a certain point in a project it is possible, that time-to-market gets much more important than "Design for Assembly". Despite DFA could also help in this case, people feel a pressure to speed-up product development. In this case they then loose the focus of DFA. A follow-up of the methodology and a re-discussion of the targets as well as the achieved results can help in these cases.
  Moreover, it is also important that the workshop leader is still available as a reference point to the key users as well as also to the general users.
  It is a good practice, to follow up activities after 3 months and again after 6 months after the workshop.

As seen above, the critical points are not related to the methodology itself. Critical points have to do with the application of the methodology after the workshop and has mainly to do with team building and the organization of the teams.