The Use of Design for Manufacturing and Assembly with Value Engineering to Optimize Customer Value

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by Jim Bolton, PE, CVS-Life, PVM, FSAVE

Introduction and Background

- Many manufacturing organizations today have tried the '*Lean*' journey, the '*Six Sigma*' journey, the '*DFMA*' journey, the '*Value Engr*.' journey, and the '*TRIZ*' journey, but few have succeeded in *combining* these for a '*winning*' approach to optimize the design of products.

- Many of these manufacturing organizations will have some *early success* with one of these 'journeys', but then after some period of time will '*throw it aside*', for the *next more 'promising journey*' they have heard about, and then after a few years, *repeat the cycle*.

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Understanding What Customers Want

- Customers of manufactured products *expect* the very best *value* for their *hard earned money*.
- True *value* may be *measured* in terms of a formula as illustrated below:

$$\text{Value} = \frac{\text{Performance of Required Funtion}}{\text{Cost to Acquire Function}}$$

where a *required function* is any 'work' or 'sell' function (as described on the next slide) and where cost is the '*overall cost*' or the '*life cycle cost*' of that manufactured product.

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What are Functions

- **Work or Use Function – an action verb followed by a measurable noun that provides a '*quantifiable objective*' expression of something that is to be accomplished.**
- **Sell or Aesthetic Function – a passive verb followed by a non-measurable noun that provides a '*qualitative subjective*' expression of something that is to be achieved.**
- **Manufactured products consist of both '*work and sell functions*' and therefore, both are 'required functions' per the previous formula.**

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For Manufactured Products

- **Life Cycle Cost** – consists of *initial* costs and *post-production* costs as follows:

- **Initial Cost** includes such items as:
  - All required direct and indirect *materials*
  - *Development and engineering* costs including design, prototypes, validation, trail runs, etc.
  - Packaging, inventory, handling (logistics/transport)
  - Duty, taxes, *finance costs* (borrowed money), etc.
  - *Maintenance*, plant related overhead and expense
  - Supplier and/or internal *tooling and/or re-tooling*
  - *Equipment capital* (either new or refurbished)

- **Post-Production Cost** includes such items as:
  - *Warranty claims, shipment damage, energy, trade agreements, service calls, recalls, etc.*

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VALUE may be *Improved* by:

- *Reducing* Cost while *improving* Function, F C
- *Reducing* Cost while *maintaining* Function, F C
- *Improving* Function while *maintaining* Cost, F C
- *Improving* Function while *increasing* Cost by a proportionally *smaller* amount (will only work if customer will pay increase), *or* F C
- *Reducing* Function while *reducing* Cost by a proportionally *greater* amount F C

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When is Value Measured?

- Managers of manufactured products need to understand that today's customers don't only measure value *at the time of the sale*, but they also consider value *for the total life cycle of the product*.
- Due to the availability of internet information today, *customers educate themselves on the reliability and quality of products* before purchase.
- Manufacturing organizations need to realize that customers care about '*life cycle value*' before they make their final purchase and *must design products accordingly*.

Integrating DFMA with Value Methodology

- DFMA can be used to develop the *value of the competitor's products* which can help design teams to improve their own products.
- Many times the *customer requirements* and *functions* are the same for competitor's and your own manufactured products.
- By utilizing the *Value Engineering tools* of the *FAST Diagram* and the *Cost Function Worksheet* of the competitor's vs. your own products helps to identify *value opportunities*. See *Figures 1*and *2* on the following slides.

FAST Diagram

PROJECT: TOASTER OVEN **Date:** 29JN09

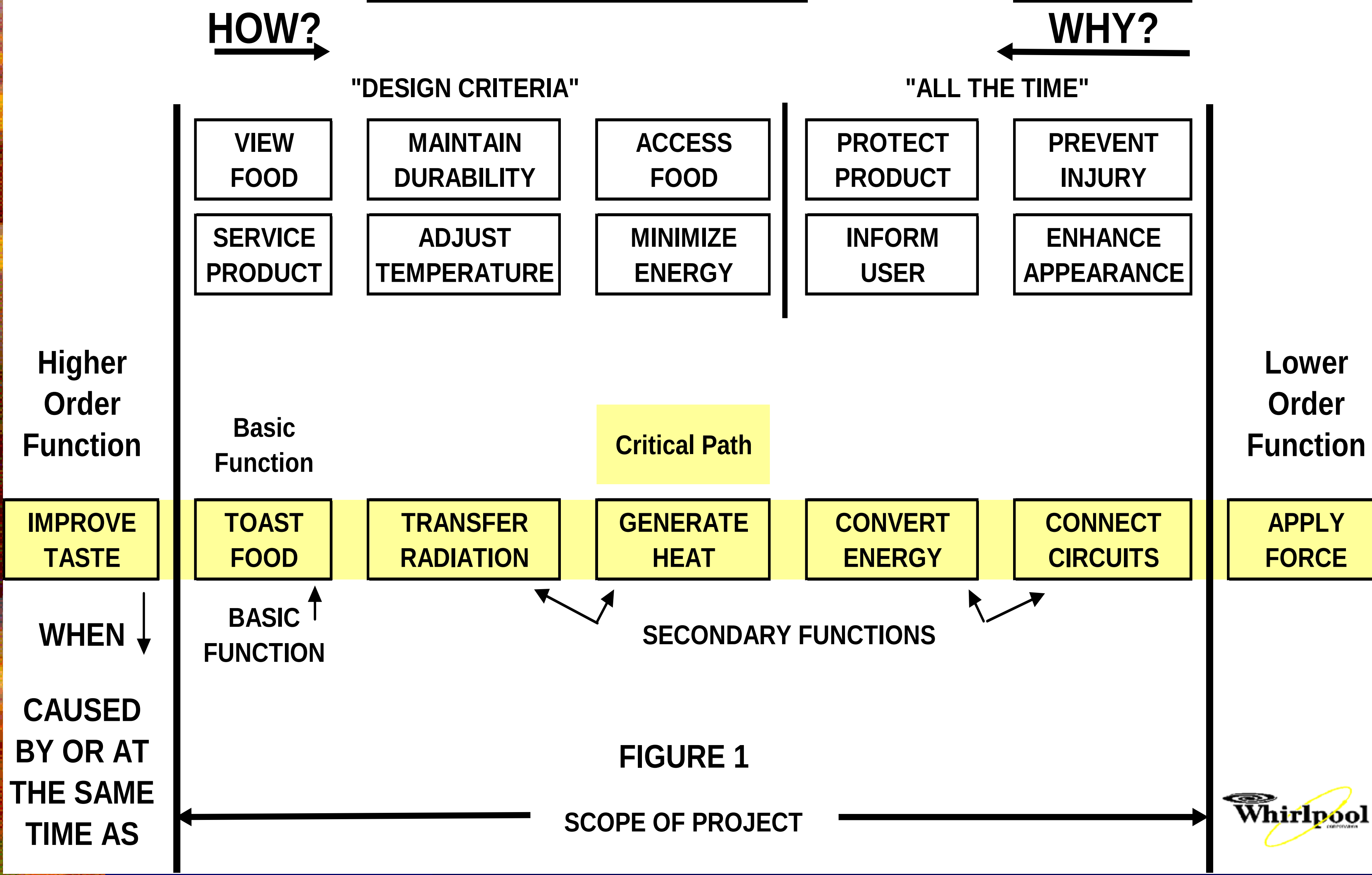

FIGURE 1

COST / FUNCTION WORKSHEET

FIGURE 2

DATE: 29-Jun-09
FACILITATOR: JIM BOLTON
TEAM: VALUE IMPROVEMENT
PROJECT: TOASTER OVEN

			FUNCTION (ACTIVE VERB / MEASUREABLE NOUN)									
PART or OPERATION:	Cost	Check sum	TRANSFER RADIATION	GENERATE HEAT	CONVERT ENERGY	CONNECT CIRCUITS	VIEW FOOD	MINIMIZE ENERGY	ADJUST TEMPERAT.	ENHANCE APPEARAN.	PROTECT PRODUCT	ACCESS FOOD
RADIANT COILS	8.5000	100%	2.975 35%	2.550 30%	1.700 20%	1.275 15%						
CABINET	12.7000	100%	6.350 50%					1.270 10%		1.270 10%	3.810 30%	
DOOR AND HINGE ASSEMBLY	4.9500	100%	0.248 5%							0.743 15%		3.713 75%
DOOR GLASS	3.1000	100%	0.155 5%				2.325 75%			0.620 20%		
TEMPERATURE CONTROL UNIT	6.7200	100%			0.336 5%	0.336 5%		0.672 10%	4.368 65%	0.672 10%		
SHELVES	3.7000	100%					1.110 30%					2.590 70%
INSULATION	1.8500	100%						0.925 50%				
PACKAGING	1.5200	100%									1.520 100%	
LABELS	0.2300	100%										
INSTRUCTION MANUAL	0.1100	100%										
FUNCTIONAL TOTAL	$ 43.38		9.73	2.55	2.036	1.61	3.44	2.87	4.37	3.30	5.33	6.30
FUNCTIONAL RANKING:			1	8	9	10	5	7	4	6	3	2
			TRANSFER RADIATION	GENERATE HEAT	CONVERT ENERGY	CONNECT CIRCUITS	VIEW FOOD	MINIMIZE ENERGY	ADJUST TEMPERAT.	ENHANCE APPEARAN.	PROTECT PRODUCT	ACCESS FOOD

Integrate Lean & DFMA to Add Value

- By integrating *Lean* principles with *DFMA*, additional *value* may be generated.
- Spend a considerable amount of *time on the assembly line* with a trained Lean or Value practitioner to *identify waste* and *areas for improvement* in relationship to DFMA goals.
- Utilize the *DFMA notes section* of the software to capture where *waste is created* (see Figure 3) and *generate improvement opportunities* per the DFMA re-design per Figure 4 below.

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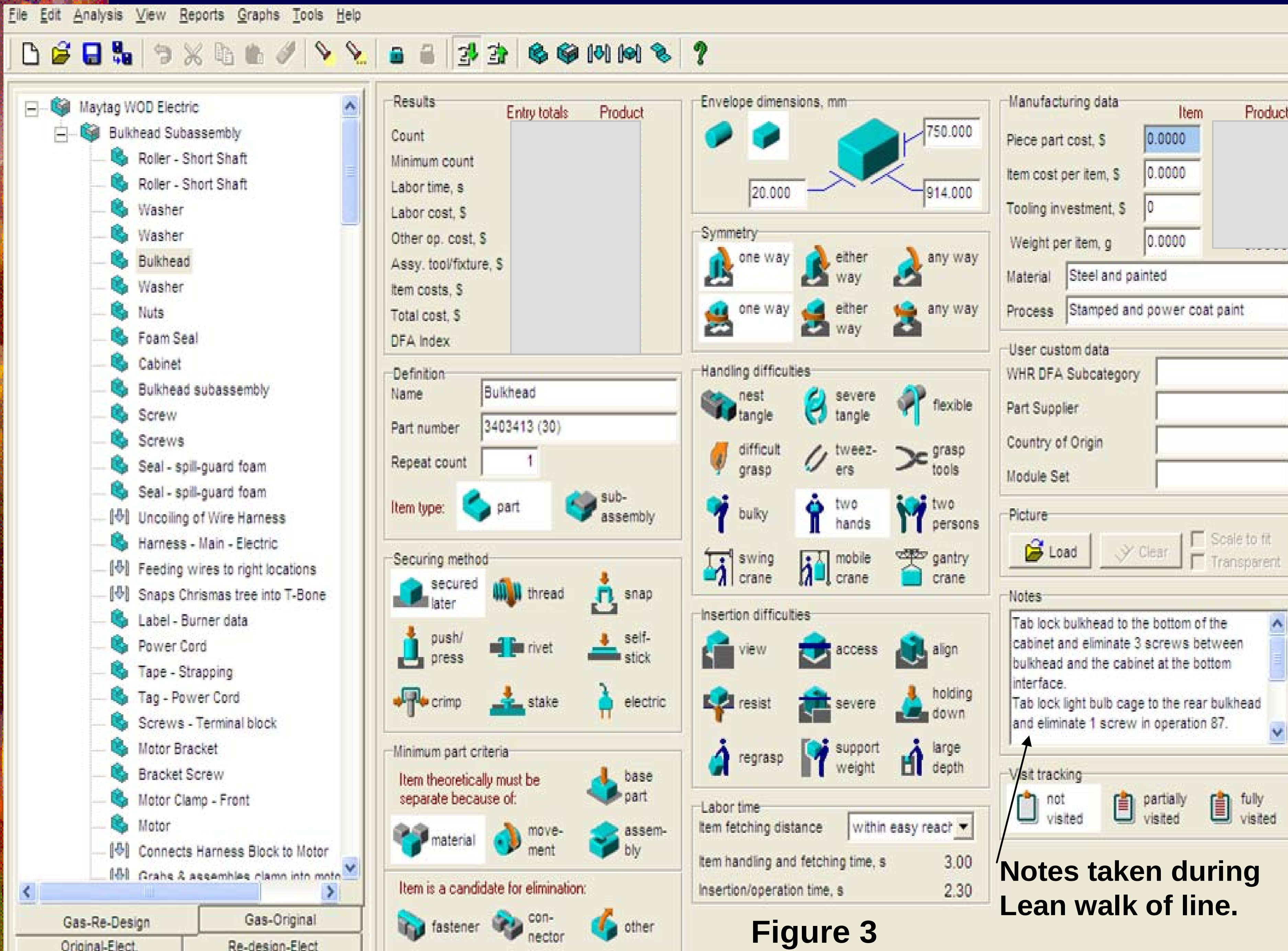

Notes taken during Lean walk of line.

Figure 3

Front Frame

Tab lock hinge receiver into mating front frame and use only one screw on each side - saves 2 screws and labor.

Tab lock door latch into front frame and use only one door latch screw.

Deliver front frames right side up

Eliminate bandaid clip with front cover re-design by inetgrating this function into the frame or hinge receiver.

Incorporate foot forward slope into front frame to commonize range foot (eliminates P/N).

Door Seal

Use returnable containers for door seal

Cut door seal at angle to remove extra seal and save material.

Investigate assembly sequence of assembly sequence to eliminate interference during hinge received operation.

Hinge Receiver

Present hinge receivers to operator in bulk tub with bottom drop and chute rather than have supply person re-package in tote bins and supply onto roller conveyors.

Find local supplier rather than purchase hinge receivers from Italy with duty and freight added.

Tab lock hinge receiver into mating front frame and use only one screw on each side - saves 2 screws and labor.

Elimninate bandaid clip with front cover re-design.

Eliminate bandaid clip with front cover re-design by inetgrating this function into the frame or hinge receiver.

Investigate manufacturing hinge receivers in-house at Tulsa.

Clip

Eliminate bandaid clip with front frame re-design by inetgrating this function into the frame or hinge receiver.

Screw

Eliminate one screw by tab locking hinge receiver into front frame.

Value enhancement opportunities by team from Lean Line Walk:

- Re-design opportunities
- Labor savings ideas
- Lean opportunities
- Procurement ideas
- Logistic ideas
- Returnable packaging ideas

This is just one page of the 14 pages of notes taken by the team during the actual workshop.

Figure 4

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DFA & DFMA Executive Summaries

- Review the notes and *suggestions for re-design generated by the DFMA software* (Fig. 5), a new optimized designed is developed.

- The *DFA Executive Summary* (Fig. 6) shows labor improvement and *design optimization*.

- The *DFMA Executive Summary* shows the Design Efficiency (DFA) Index and the *total product cost improvement* (Figure 7).

- Finally, if *traditional brainstorming* doesn't generate breakthrough results, *TRIZ* can help.

Design for Assembly: Suggestions for Redesign

Boothroyd Dewhurst, Inc.

These ideas are generated by the software after loading in the original design

Thursday, May 07, 2009 9:28 PM
FRS - Pyro Ceran - Electric

Tulsa_Original Rev 1.dfa
Product: Original

This is just 1 page of a 12 page report

Combine connected items or attempt to rearrange the structure of the product in order to eliminate the following items whose function is solely to make connections.

Parent assembly	Name	Part number	Quantity	Time savings, s	Percentage reduction
FRS - Pyro Ceran - Electric	Latch Rod	W10078380 (mainback station 7)	1	5.73	0.44
FRS - Pyro Ceran - Electric	Door Switch Rod	9757239 (Side Panel station 2)	1	7.65	0.59
FRS - Pyro Ceran - Electric	Wire Harness (Sensor)	W10084660 (Side Panel station 2)	1	8.36	0.65
FRS - Pyro Ceran - Electric	Left Cooktop Wire Harness	W10174423 (cooktop station 5)	1	1.69	0.13
FRS - Pyro Ceran - Electric	Right Cooktop Wire Harness	W10174422 (cooktop station 5)	1	1.69	0.13
FRS - Pyro Ceran - Electric	Main Wire Harness	W10226062	1	5.26	0.41
Console Assembly	Spring Clips (console)	3196200 (console station 1)	2	4.00	0.31
Totals				34.38	2.66

Reduce the number of items in the assembly by combining with others or eliminating the following parts or subassemblies. Note that combining an item with another may eliminate further items such as fasteners or operations, resulting in much larger time reductions than those indicated.

Parent assembly	Name	Part number	Quantity	Time savings, s	Percentage reduction
FRS - Pyro Ceran - Electric	Motor Latch Screws	3196178 (mainback station 7)	1	1.50	0.12

The DFA software will not redesign the product but just give ideas to think about on how to redesign the product along with the labor time and percentage reduction if that item can be eliminated.

Figure 5

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Per Product data		Original	Re-design
Entries (including repeats)	Component parts	290	239
	Subassemblies partially or fully analyzed	7	7
	Subassemblies not to be analyzed (excluded)	0	0
	Standard and library operations	103	103
	Total Entries	**400**	**349**
Labor Time, s	Component parts	881.44	734.83
	Subassemblies partially or fully analyzed	13.85	13.85
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	398.58	398.58
	Total Assembly Time	**1293.87**	**1147.26**
Labor Cost, $	Component parts	5.62	4.68
	Subassemblies partially or fully analyzed	0.09	0.09
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	2.54	2.54
	Total Assembly Cost	**8.25**	**7.31**

Reduced # of entries by 51 or 12.75%

Labor Time Improved by 146.4 seconds or 11.33%

Labor Cost Improved by $0.94 or 11.39% per Product

The chart shows a breakdown of time per product

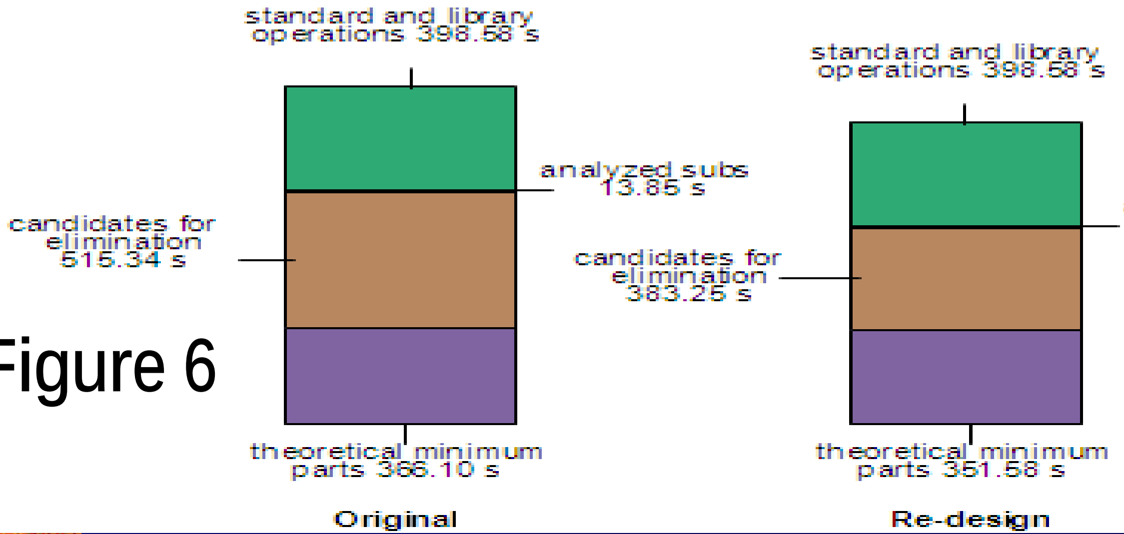

Figure 6

DFA Executive Summary Report

	Original	Re-design
Product life volume	820,000	820,000
Number of entries (including repeats)	400	349
Number of different entries	220	200
Theoretical minimum number of items	125	118
DFA Index	23.8	25.8
Total weight, kg	* 0.0000	* 0.0000
Total assembly labor time, s	1293.8700	1147.2600
Total cost for manufactured items (including tooling), $	** 222.1447	** 217.6460
Total assembly labor cost, $	8.2452	7.3110
Other operation cost per product, $	0.0000	0.0000
Total manufacturing piece part cost, $	222.1447	217.6460
Total cost per product without tooling, $	230.3900	224.9570
Assembly tool or fixture cost per product, $	0.0000	0.0000
Manufacturing tooling cost per product, $	0.0000	0.0000
Total cost per product, $	230.3900	224.9570

Note: Item weight not given for some items. Total weight may be incomplete.

***Note: Manufacturing piece part costs not given for some items. Total cost may be incomplete.*

Reduced PNC by 20 items or 9.1%

DFA Index Improved by 2 or 8.4%

Improved Cost of 2.25% or $5.43 per unit

The chart shows a breakdown of cost per product

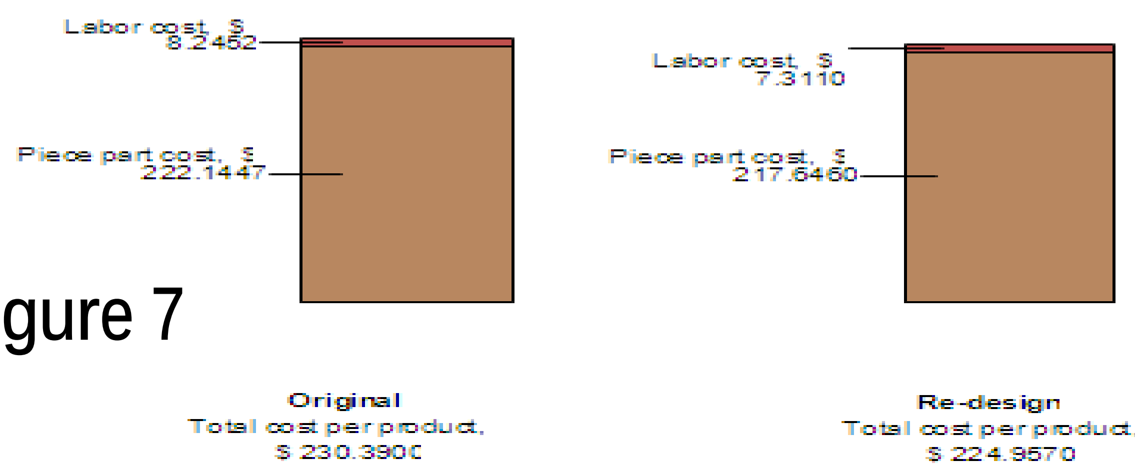

Figure 7

Potential Annual Saving Opportunity = $3.75M

DFMA Executive Summary Report

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How Whirlpool Uses DFMA with VE

- Whirlpool ***combines Value Engineering with Lean, DFMA, and TRIZ*** **to optimize the designs of their products to remain competitive by applying these tools:**
  - **In *New Product Introductions* (NPI) projects**
  - **In *Existing Products Improvements* (EPI) projects.**
- **Whirlpool has established an internal global *Design for Value* team to *apply these various Value Enhancement tools* five years ago in all regions where Whirlpool operates per the following page.**

Design for Value (DFV) Global Organization

James Bolton
Global Leader

Regional Manager India

Jagathesh Manickam

- Food Stream Solution
- Food Preparation
- Fabric Care
- Air Treatment

Regional Manager EMEA

Stefan Wohnhas

- Food Stream Solution
- Food Preparation
- Fabric Care
- Cleaning

Regional Manager LAR

Claudia Tridapalli

- Food Stream Solution
- Food Preparation
- Fabric Care
- Cleaning
- Air Treatment

Regional Manager China

Min Zhan

- Food Stream Solution
- Fabric Care
- Food Preparation
- Finished Goods

Regional Manager NAR-USA

Michelle Shatrau

- Food Stream Solution
- Food Preparation
- Fabric Care
- Cleaning
- Portables

Regional Manager NAR-Mexico

Julian Cantu

- Food Stream Solution
- Food Preparation
- Fabric Care

2012 DFV Project Tracking Status

	2012 Projects TOTAL Business Cases - Risk Wt./Ranked ideas Annual Saving (USD)	2012 Tracked, Business Cases - Risk Wt./Ranked ideas Annual Saving (USD)	Actual Annual Savings (USD) Implemented from Projects started in 2012	Actual Annual Savings (USD) Implemented from Projects Started prior to 2012	% of 2012 BC Annual Savings Tracked in ISC/PDTS	% of Annual Savings Implemented from Projects started in 2012
Continous Improvement Support	$ 85,041,181	$ 60,600,319	$ 10,417,234	$ 35,662,442	71.3%	17.2%
Mega Project Support	$ 13,912,610	$ 13,912,610	n/a	n/a	n/a	n/a
Supplier Workshop Support	$ 14,173,343	$ 561,365	$ -		4.0%	0.0%
DFV 2012 Summary	$ 113,127,134	$ 75,074,294	$ 10,417,234	$ 35,662,442	Total Implementated Saving $ 46,079,675	

2012 DFV Deliverables-BC Risk Weighted Annual Savings Opportunities by Region and Workshop Type

	Continous Improvement (EPI)	TC Mega Project	Supplier Workshops	TOTAL	% of 2012 BC Risk Weighted Annual Savings from EPI Projects	% of 2012 BC Risk Weighted Annual Savings from Supplier Workshops
Asia	$ 6,031,855	$ -	$ -	$ 6,031,855		
EMEA	$ 11,552,046	$ 3,953,606	$ -	$ 15,505,652		
LAR	$ 19,697,787	$ 442,564	$ 1,160,135	$ 21,300,486		
NAR-USA	$ 37,604,273	$ 9,516,440	$ 8,435,643	$ 55,556,356		
NAR-MX	$ 10,155,220	$ -	$ 4,577,565	$ 14,732,785		
	$ 85,041,181	$ 13,912,610	$ 14,173,343	$ 113,127,134	75.2%	12.5%

Summary and Conclusion

- Manufacturing organizations today must use a ***combination of Value Enhancing tools*** to optimize their designs to remain competitive.
- These Value Enhancing tools should include:
  - The use of ***Lean*** principles
  - The use of ***Six Sigma*** principles
  - The use of ***DFMA*** principles
  - The use of ***Value Engineering*** principles
  - The use of ***TRIZ*** principles
- If these various ***Value Enhancing tools*** are used within manufacturing organizations with trained practitioners, ***manufacturing can have a major comeback within NA.***

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