2016 International Forum on DFMA Boothroyd Dewhurst

The Design Engineer's Guide for Total Product Cost Using DFA

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DFMA and Value Engineering Manager

Topics

- Product Cost Breakdown
- DFA Analysis
- Finance Basics and Overhead
- Total Cost of Ownership
- DFA Examples

Product Cost

- DFMA Experience – Where is your company?
  - Initial interest in DFMA
  - Completed an introductory DFMA workshop
  - Restarting the initiative
  - DFMA is established, fully implemented
- Product Simplification and Cost Improvement

Overhead 24%

Labor 4%

Materials 72%
(Piece Part Costs)
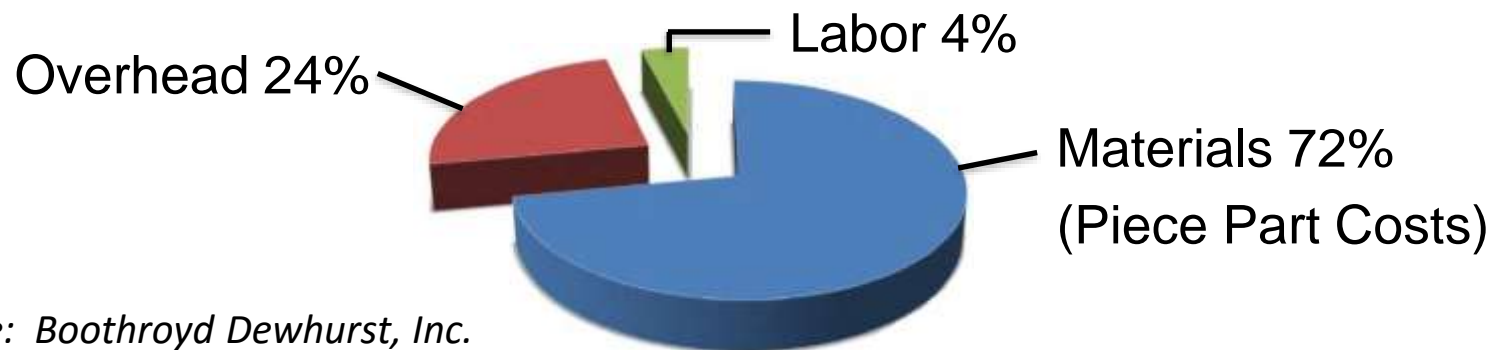
Source: Boothroyd Dewhurst, Inc.

Understand how to apply DFA towards materials, labor, and overhead costs

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DFA Applications

Product   DFA Analysis   Design Data

- Theoretical Min. Part Count
- Total part count
- DFM part & tooling costs
- Assembly time
- Assembly operations
- DFA Index
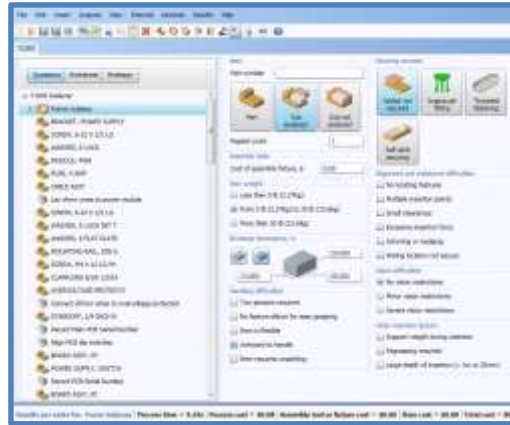- Total product cost
- Total production life cost
- Suggestions for redesign

Product state

- New Concepts/Next Gen – initial CAD layout, before launch
- Existing Product – baseline the assembly
- Cost Reduction – sustain existing product
- Benchmarking – understand the competition's design/cost

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Design Data from DFA

Example Summary

Let's walk through an example:

Product	
Materials	$700
Labor	$50
Overhead	$250
	$1000

Product Cost Breakdown

Example Product

Materials $700   (70%)

- Parts
- DFM should-costs
- Tooling (Amortized)
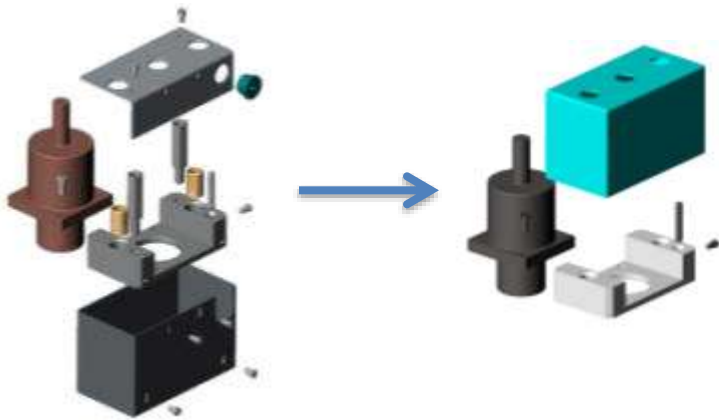- Supplier quotes
- Known off the shelf costs

Labor $50   (5%)

- Direct Labor Rate
- Average salary of the workers who touch the parts
- For this example: 2.00 hour assy routing @ $25/hr

Overhead $250   (25%)

- Overhead rate at the site where the product is manufactured
- Typically shown as a percentage
- For this example: 500%
- (Overhead Labor Rate = $150/hr)

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DFA – Materials (Parts)

Materials $700
- DFA – Minimum Part Criteria
- Ideation – Category 1's
- DFM – Mfg. Alternatives
- Impact to Total Cost

Materials
$700

Item function

Item has no function except to:
- ○ Fasten or secure other items
- ○ Connect other items   **Category 2**
- ◉ Item has other function

Minimum part criteria

Item must be separate from all other items assembled, because:
- ○ Base part (usually only the first)
- ○ Moves relative to all other items
- ○ Must be a different material
- ○ Separate to allow assembly
- ◉ No fundamental reason exists   **Category 1**

Suggestions for redesign

Category 1
- ◉ Candidates for elimination other than fasteners and connectors

Category 2
- ○ Fasteners
- ○ Connectors
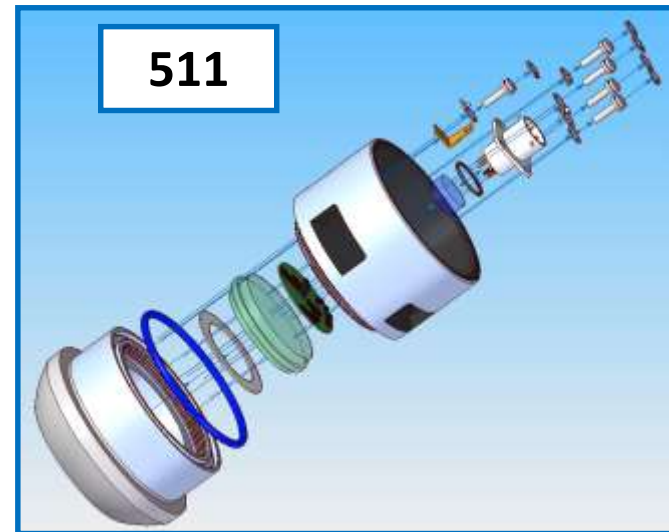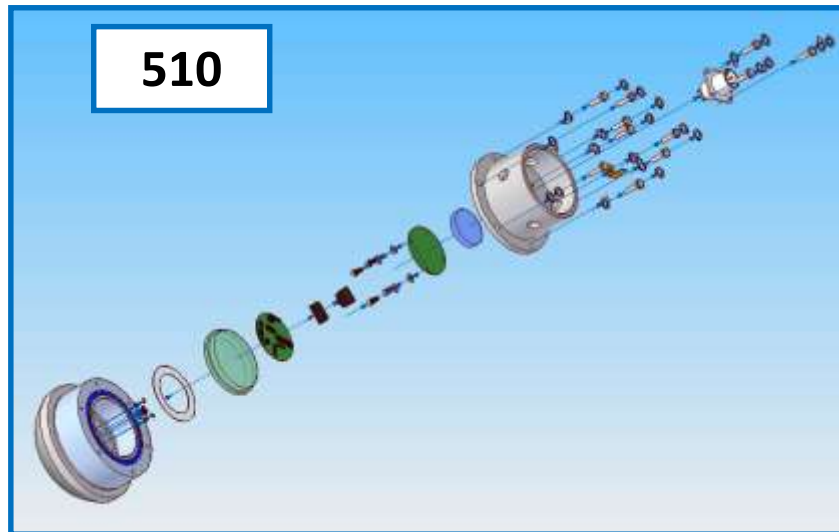- ○ Separate operations

Category 3
- ○ Handling or insertion difficulties

Source: Boothroyd Dewhurst, Inc.

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Pressure Transducer Assembly

510

511

	510	511
• DFA Index	7.0	9.6
• Part Count	102	66
• Fasteners	82	46
• PCBs	2	1

Reductions to:

Part Count
Total Mfg. Cost
Labor Time

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DFA – Labor (Assembly Time)

Suggestions for redesign

Category 1
- Candidates for elimination other than fasteners and connectors

Category 2
- Fasteners
- Connectors
- Separate operations

Category 3
- Handling or insertion difficulties

Category 2 example →

Reduce Labor Costs by understanding detailed assembly time with DFA

Labor $50   2.0 hrs
- Assembly time = "Touch Time"
- Category 2 & 3 parts

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Questions	Worksheet	Redesign	Repeat count	Total count	Process time per product, s
SCREW, 6-32 X 1/2 LG			2	2	36.05
WASHER, 6 LOCK			2	2	13.65
MODULE, PWR			1	1	10.80
FUSE, 4 AMP			2	2	13.17
CABLE ASSY			1	1	24.34
Lay xfrmr wires to power module			4	4	9.04
SCREW, 6-32 X 1/2 LG			4	4	58.47
WASHER, 6 LOCK INT T			4	4	20.87
WASHER, 6 FLAT PLATE			4	4	20.87
MOUNTING RAIL, DIN U			1	1	14.54
SCREW, M4 X 12 LG PH			2	2	36.05
CLAMP,END E/UK 12014			2	2	33.78
OVERVOLTAGE PROTECTO			1	1	10.04
Connect xfrmer wires to overvoltage p			5	5	82.50
STANDOFF, 1/4 INCH N			13	13	510.36

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Finance Basics and Overhead

Operating Profit = Revenue – COGS – SG&A

~~SG&A (Selling, General & Admin) – costs of selling, engineering, finance, IT, HR and admin. (salaries)~~

> **The Design Engineer can disregard SG&A for analysis purposes**

Product Gross Margin = Revenue – COGS

Cost of Goods Sold (COGS) – direct costs attributable to the production of the goods sold or delivery of services provided by a company.

- **Materials, Labor, Overhead**

  - Overhead – rent, utilities, maintenance/repair/operations (MRO), shipping/freight, bin/bulk items (fasteners/hardware)
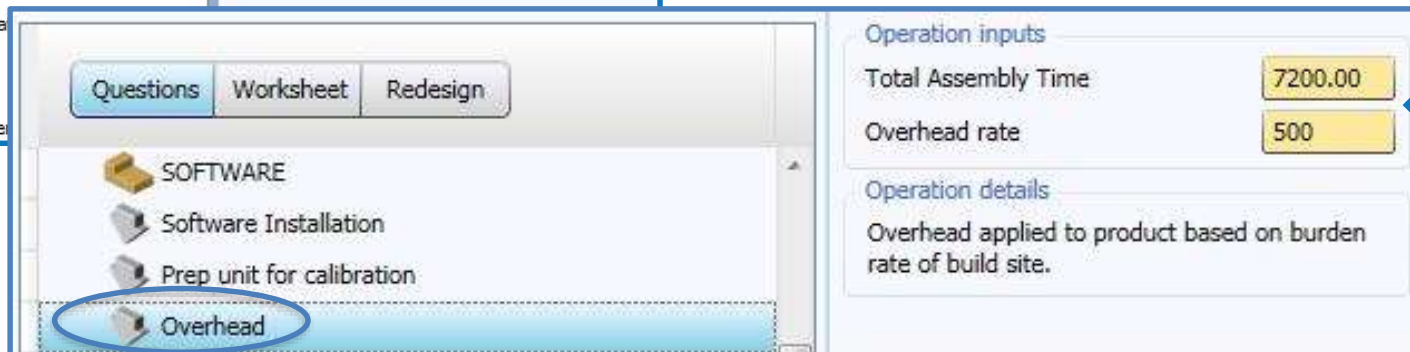
DFA – Overhead

DFA Operation Library
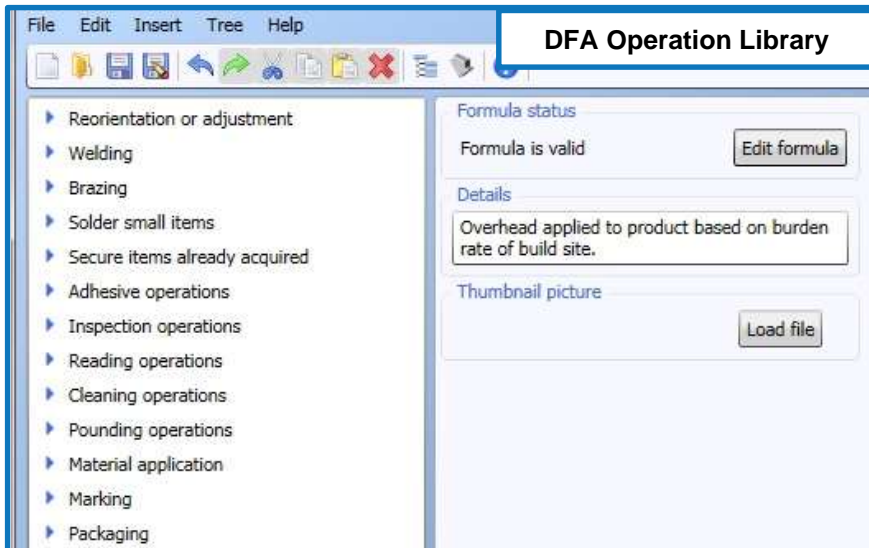
Overhead $250

- Custom Operation in DFA

Applied Overhead to Product =

Assy Time x Direct Labor Rate x Overhead Rate

7200s x $25 x 500% = $250

Results per entry for: Overhead | Process time = 0.00s | Process cost = $250.00 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost = $250.00

Product Cost Summary

Example Product - Before   After - DFA Application

Materials	$700	→	Materials	$350	
Labor	$50	2.0 hrs →	Labor	$25	1.0 hr
Overhead	$250	500% →	Overhead	$125	500%
	$1000			$500	

- New Concepts/Next Gen Designs – set standard Gross Margin at launch

- Existing Product/Cost reduction
  - Materials reduction – reduced cost, improved Gross Margin
  - Labor/Overhead reduction – create opportunity, increase capacity

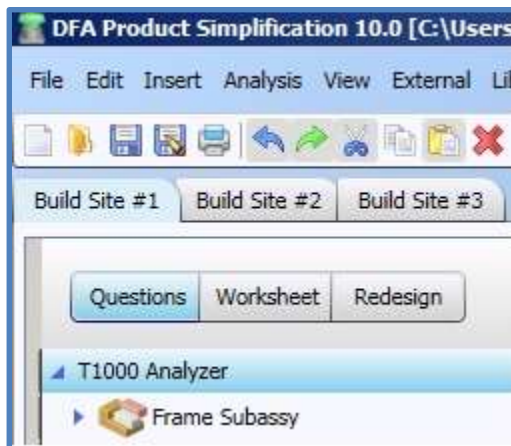- Benchmarking – full cost & Gross Margin estimate
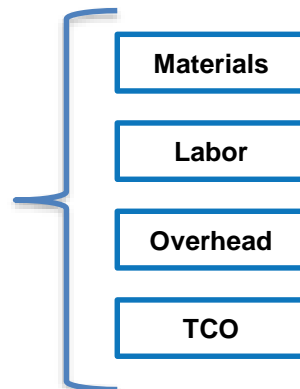
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Total Cost of Ownership

Total Cost of Ownership

TCO

- Strategic sourcing decisions
- Where to build the product
  - Custom DFA Operation
  - Compare site locations

Costs in DFA

TCO Inputs

- Risk factors
- Product volume
- Lead time
- Material, Labor, Overhead
- Transportation costs
- Cost of Poor Quality
- Build site profit
- Inventory carrying costs
- Recurring Costs
- Transition & setup costs

What do you get?

- 1-year snapshot of TCO costs
- Revise inputs for additional years
- Chart costs (i.e. Years 1 thru 5)

TCO Inputs into DFA Custom Operation

- Enter remaining TCO Inputs

Product Data	
Yearly Volume	300
Lead Time, wks	4
Total Product Cost, $	2484.27

Total Landed Cost	
Transportation Cost, $	175.00

Total Cost of Ownership	
Cost of Poor Quality, %	1
Cost of Poor Quality per unit, $	26.59
Profit at Build Site, %	0
Profit at Build Site per unit, $	0.00
Inventory Carrying Cost, %	10
Inventory Carrying Cost per unit, $	20.66
Recurring Cost, $	0.00
Recurring Cost per unit, $	0.00
One Time/Transition Cost, $	0.00
One Time Cost per unit, $	0.00
Risk Factor, %	1.6
Risk Unit, $	43.86
TCO per unit, $	266.115

USA

- Risk factors per build site
  - Rank risk factors with a 1 thru 17 weight
  - Probability of occurrence 0-100%

Risk Factor - Weight (1-17) and Probability	
Inflation, weight, #	17
Inflation, probability, %	10
Labor, weight, #	16
Labor, probability, %	10
Energy/Fuel, weight, #	15
Energy/Fuel, probability, %	10
Business Continuity, weight, #	14
Business Continuity, probability, %	10
Health/Pandemic, weight, #	6
Health/Pandemic, probability, %	10
Infrastructure, weight, #	13
Infrastructure, probability, %	10
Quality (recipe loss), weight, #	7
Quality (recipe loss), probability, %	10
Customer Perception, weight, #	10
Customer Perception, probability, %	50

Currency, weight, #	11
Currency, probability, %	25
IP Transfer, weight, #	1
IP Transfer, probability, %	25
People, weight, #	2
People, probability, %	25
Culture, weight, #	3
Culture, probability, %	25
Language, weight, #	4
Language, probability, %	25
Skill, weight, #	5
Skill, probability, %	25
Financial & Legal, weight, #	9
Financial & Legal, probabiltiy, %	25
Service Level, weight, #	12
Service Level, probability, %	25
Trust/Corruption, weight, #	8
Trust/Corruption, probability, %	25

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TCO Inputs into DFA Custom Operation

- Enter remaining TCO Inputs

Product Data	
Yearly Volume	300
Lead Time, wks	12
Total Product Cost, $	2165.88
Total Landed Cost	
Transportation Cost, $	500.00
Total Cost of Ownership	
Cost of Poor Quality, %	10
Cost of Poor Quality per unit, $	266.59
Profit at Build Site, %	10
Profit at Build Site per unit, $	293.25
Inventory Carrying Cost, %	10
Inventory Carrying Cost per unit, $	74.44
Recurring Cost, $	20000.00
Recurring Cost per unit, $	66.67
One Time/Transition Cost, $	5000.00
One Time Cost per unit, $	16.67
Risk Factor, %	8.3
Risk Unit, $	280.53
TCO per unit, $	1498.139

China

- Risk factors per build site
  - Rank risk factors with a 1 thru 17 weight
  - Probability of occurrence 0-100%

Risk Factor - Weight (1-17) and Probability

Inflation, weight, #	17
Inflation, probability, %	10
Labor, weight, #	16
Labor, probability, %	10
Energy/Fuel, weight, #	15
Energy/Fuel, probability, %	10
Business Continuity, weight, #	14
Business Continuity, probability, %	10
Health/Pandemic, weight, #	6
Health/Pandemic, probability, %	10
Infrastructure, weight, #	13
Infrastructure, probability, %	10
Quality (recipe loss), weight, #	7
Quality (recipe loss), probability, %	10
Customer Perception, weight, #	10
Customer Perception, probability, %	50

Currency, weight, #	11
Currency, probability, %	25
IP Transfer, weight, #	1
IP Transfer, probability, %	25
People, weight, #	2
People, probability, %	25
Culture, weight, #	3
Culture, probability, %	25
Language, weight, #	4
Language, probability, %	25
Skill, weight, #	5
Skill, probability, %	25
Financial & Legal, weight, #	9
Financial & Legal, probabiltiy, %	25
Service Level, weight, #	12
Service Level, probability, %	25
Trust/Corruption, weight, #	8
Trust/Corruption, probability, %	25

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TCO Inputs into DFA Custom Operation

- Full screen capture of TCO operation in DFA looks like this…

Compare TCO Costs between Build Sites

Product & Site Inputs

Risk Factors

Results per entry for: TCO | Process time = 0.00s | Process cost = $1498.14 | Assembly tool or fixture cost = $0.00 | Item cost = $0.00 | Total cost = $1498.14

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Real-World Examples

DFA – Product Design Example

DFMA® - Boothroyd Dewhurst, Inc.
### Analysis Totals for Design for Assembly (DFA)

Monday, March 28, 2016

DFMA
BOOTHROYD DEWHURST

Example-1.dfax

Entries including repeats	CONCEPT 1	CONCEPT 2	CONCEPT 3
Parts meet minimum part criteria	17	12	15
Parts are candidates for elimination	47	44	37
Analyzed subassemblies	3	1	5
Separate assembly operations	11	11	10
Total entries	78	68	67

Assembly labor time, s			
Parts meet minimum part criteria	123.79	84.51	74.63
Parts are candidates for elimination	1054.78	871.65	534.46
Insertion of analyzed subassemblies	20.67	11.44	43.54
Separate assembly operations	181.69	88.00	74.93
Total assembly labor time	1380.93	1055.60	727.56

Design efficiency			
DFA Index	4.49	4.12	7.50

Assembly labor time, s
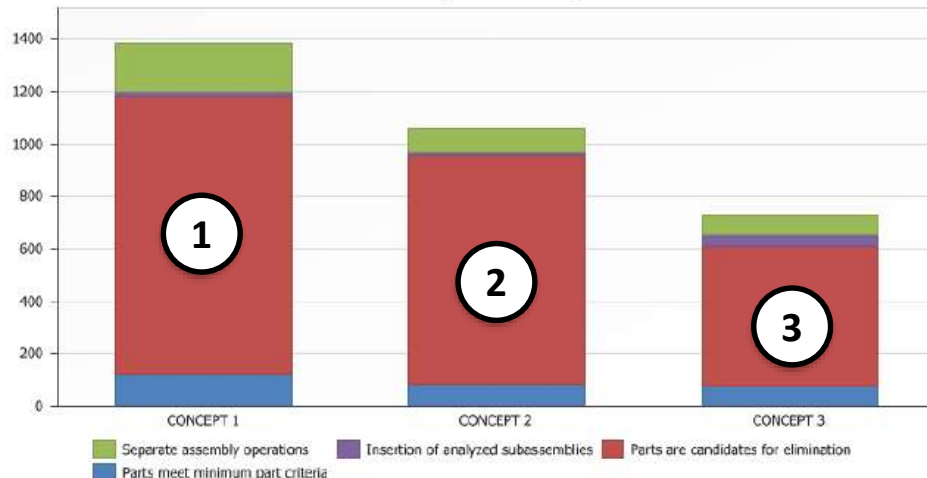
① Concept 1

② Concept 2

③ Concept 3

- New Concept/Next Gen Design
- DFMA used to quantify part count, labor time, and total cost
- Concept 1 & 2 ideas combined resulted in the Concept 3 design
- From 1 to 3:
  - Labor time   -47%
  - Total estimated cost   -32%

Applied early, DFA reduces total product cost before launch to production
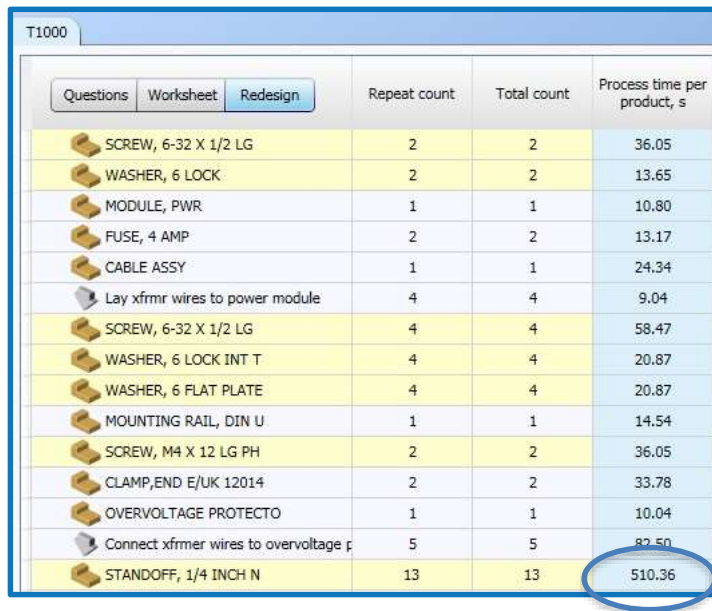
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DFA Labor Time vs. Time Study

Example Product:
Conducted time study	1.48 hrs / 89 min.
DFA assembly time	1.35 hrs / 81 min.
DFA vs. Time Study	-9%

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Questions Worksheet Redesign	Repeat count	Total count	Process time per product, s
SCREW, 6-32 X 1/2 LG	2	2	36.05
WASHER, 6 LOCK	2	2	13.65
MODULE, PWR	1	1	10.80
FUSE, 4 AMP	2	2	13.17
CABLE ASSY	1	1	24.34
Lay xfrmr wires to power module	4	4	9.04
SCREW, 6-32 X 1/2 LG	4	4	58.47
WASHER, 6 LOCK INT T	4	4	20.87
WASHER, 6 FLAT PLATE	4	4	20.87
MOUNTING RAIL, DIN U	1	1	14.54
SCREW, M4 X 12 LG PH	2	2	36.05
CLAMP,END E/UK 12014	2	2	33.78
OVERVOLTAGE PROTECTO	1	1	10.04
Connect xfrmer wires to overvoltage p	5	5	82.50
STANDOFF, 1/4 INCH N	13	13	510.36

- 81 min. / 4854.52s in DFA
- Category 2
  - 13 nylon standoffs
  - Threaded, 510.36s
  - 8 minutes of Labor!
  - Move to snap-in supports

Identify the "pain-points" in assembly with DFA and improve

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DFMA and TCO Analysis

- Analysis request to VAVE Group
  - Full DFMA & TCO analysis on an existing US built product
  - Determine if manufacturing site should change
  - Most cost effective decision

- Analysis
  - DFA on product assembly
  - DFM on 50+ parts
  - Labor/Overhead Comparison
  - Total Cost of Ownership

Cost Summary	US Existing	China	Asia
Labor Rate	$33.00		
Overhead Rate	503%		
Labor Hours	18		
Materials, $	$X		
Labor, $	$594		
Overhead, $	$2,988		
Total Product Cost	$X	?	?
TCO Cost	$X	?	?

Total Cost of Ownership in DFA

Analysis Steps

- First, determine total cost for each site
  - Materials, Labor, Overhead

Cost Summary	US Existing	China	Asia
Labor Rate	$33.00	$4.56	$2.04
Overhead Rate	503%	600%	1020%
Labor Hours	18	18	18
Materials, $	$X	$X	$X
Labor, $	$594	$82	$37
Overhead, $	$2,988	$410	$375
Total Cost	$X	**-23%**	**-24%**
After TCO	$X	?	?

- Second, run TCO analysis

TCO Inputs – Custom DFA Operation

- Overall risk factor per build site
- Product volume
- Lead time
- Material, Labor, Overhead Costs
- Transportation costs
- Cost of Poor Quality
- Build site profit
- Inventory carrying costs
- Recurring Costs
- Transition & setup costs

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DFMA and TCO Analysis

- Analysis request to VAVE Group
  - Full DFMA & TCO analysis on an existing US built product
  - Determine if manufacturing site should change
  - Most cost effective decision

- **Decision:**
  - Minimal savings if moved
  - Stay with existing mfg site
  - Cost reduction of the product through sustaining activities

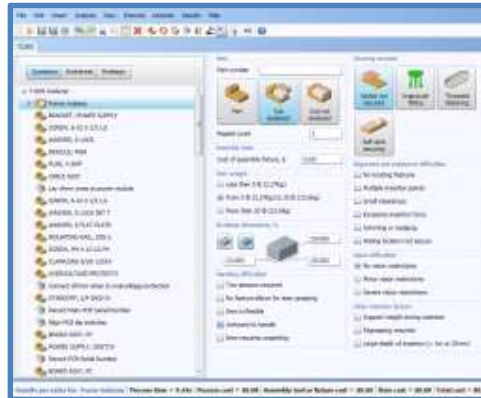| Cost Summary	US Existing	China	Asia
Labor Rate	$33.00	$4.56	$2.04
Overhead Rate	503%	600%	1020%
Labor Hours	18	18	18
Materials, $	$X	$X	$X
Labor, $	$594	$82	$37
Overhead, $	$2,988	$410	$375
Total Product Cost	$X	**-23%**	**-24%**
TCO Cost	$X	**-2%**	**-9%**

(Year 1 Cost Comparison)

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Total Product Cost Using DFA

Products

DFA Analysis

- DFA and the Product State
- Total Product Cost
  - Materials
  - Labor
  - Overhead
  - TCO
- Real-World Application Examples
- Design Decisions

DFA provides the critical data for product simplification and cost to guide the Design Engineer

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Thank you!

Questions?