



# Functional Analysis and Risk Management in New Product Development

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McGill University

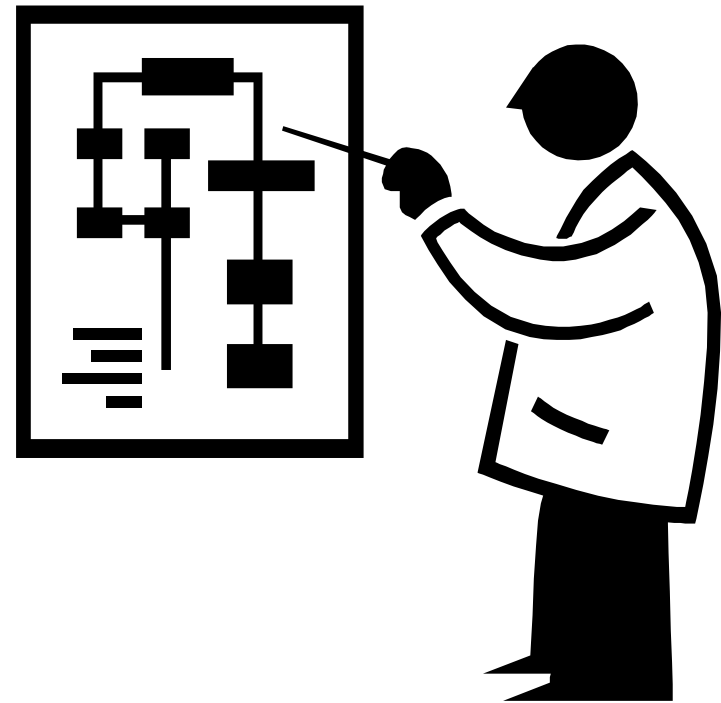
Department of Mechanical Engineering



# Presentation Outline

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- Motivation
- Objectives
- Cost and Risk Analysis Method (CRAM)
- Thermo-flask example
- Benefits of the method
- Conclusion
- Future work



# Motivation

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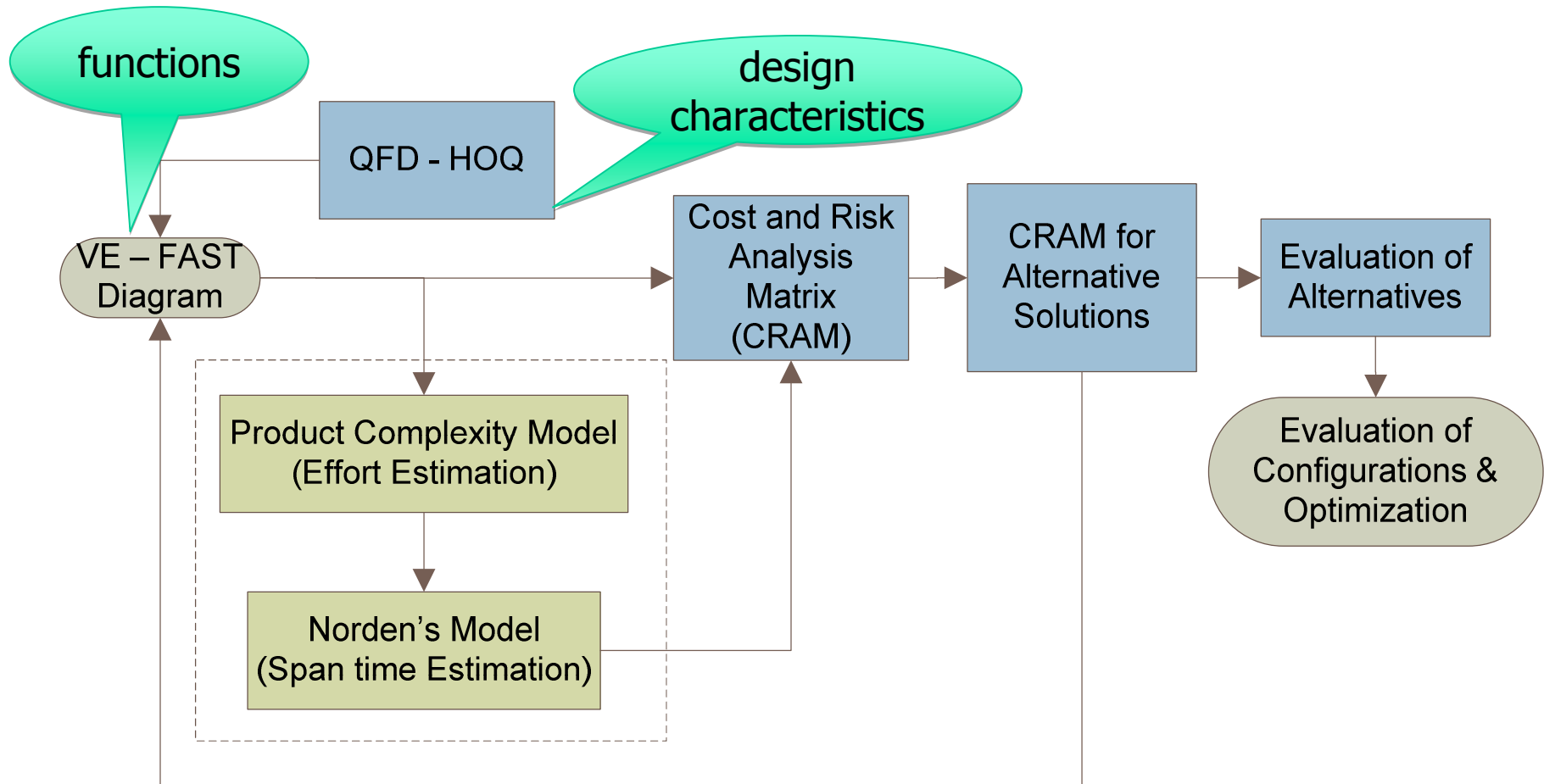
- To assess the impact of engineering change as early as possible during the product life cycle.
- In new product development (NPD) projects, it is important
  - to gain product knowledge as early as possible
  - to meet quality and customer requirements
  - to avoid cost and span time overruns.
- To develop a tool to help managers and designers with their decision-making during the design process.

# Objectives

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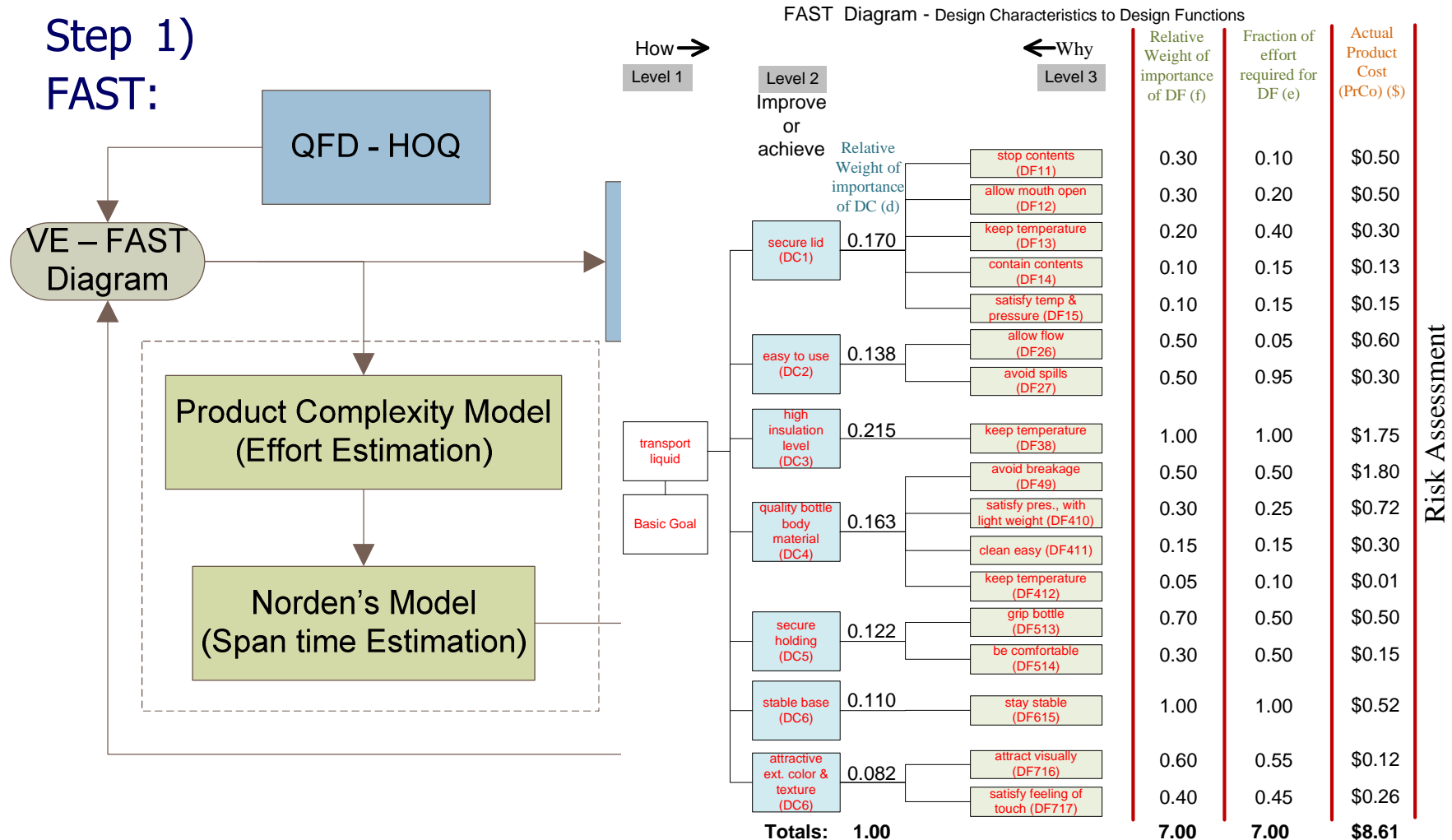
- To develop a tool which can assist project managers:
  - to quantitatively express product cost, development cost, development time and development risk,
  - to allow comparison among design alternatives,
  - to allow the tracking of cost and risk as change occurs in product design,
- through
  - increased product knowledge during the early stages of design
  - a quantitative, data approach.

# Overview of the Framework



# Details of the Framework: Thermo-Flask

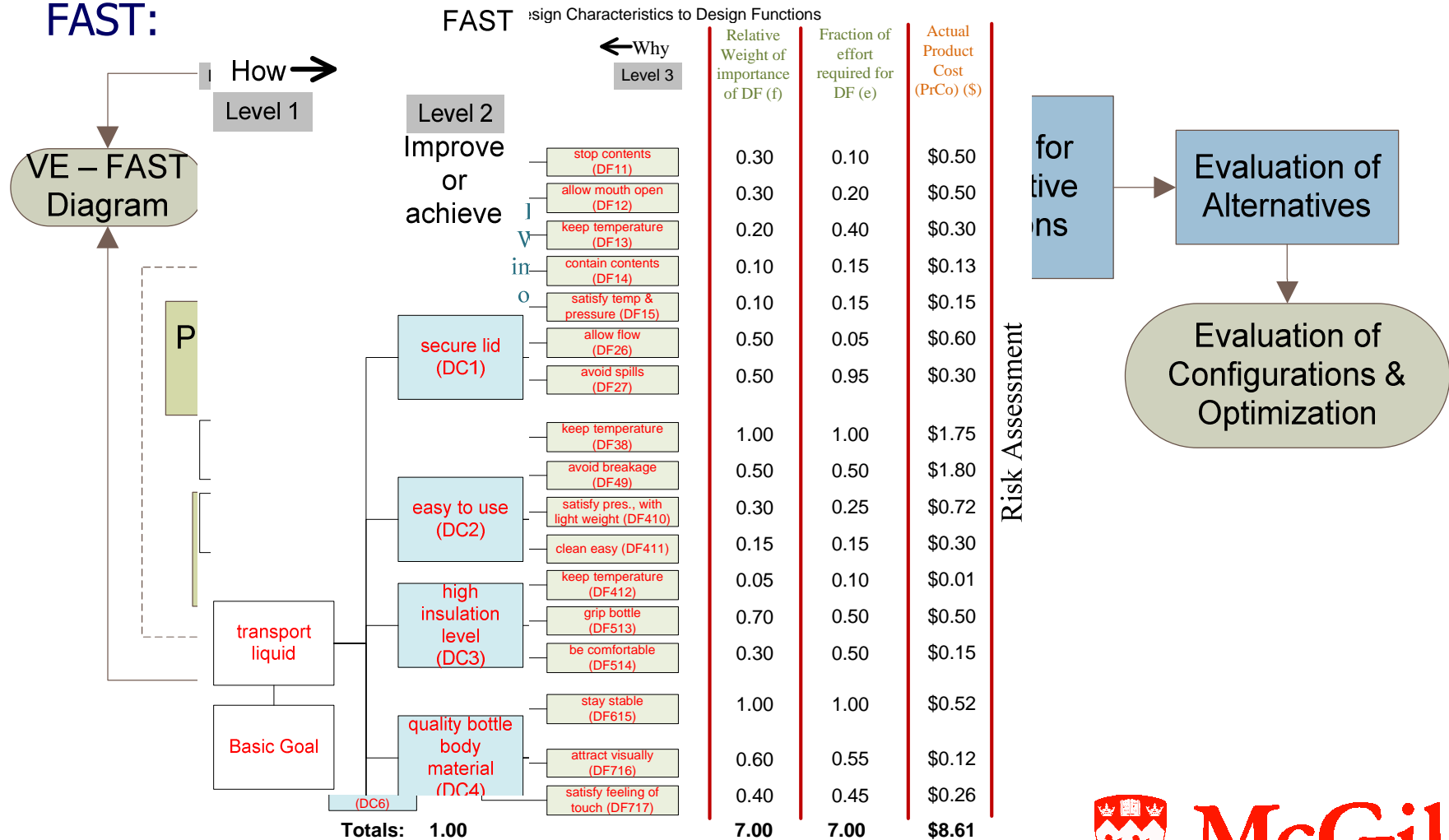
Step 1)  
FAST:



# Details of the Framework: Thermo-Flask

Step 1)

FAST:



# Details of the Framework: Thermo-Flask

Step 1)

FAST:

FAST Design Characteristics to Design Functions

← Why | Relative Weight of | Fraction of effort | Actual Product

1	2	3	4	5	6	7	8	9	
HOQ - Customer Requirements to Design Characteristics									
1	Customer Requirements (CR <sub>i</sub> )	Relative Weight of Importance of CR (c <sub>i</sub> )	Design Characteristics (DC <sub>i</sub> )						
			<i>secure lid (DC1)</i>	<i>ease to use (DC2)</i>	<i>high insulation level (DC3)</i>	<i>quality body material (DC4)</i>	<i>secure holding (DC5)</i>	<i>stable base (DC6)</i>	<i>attractive Ext. color &amp; texture (DC7)</i>
2	<i>Good Insulation to keep hot</i>	0.35	3	1	10	2	1	1	
3	<i>Durability (unbreakable)</i>	0.15	3	1	1	10	3	2	
4	<i>Easy to fill and serve</i>	0.10	3	10	1	1	2	3	
5	<i>Easy to open</i>	0.09	8	4	1	1	2	1	
6	<i>Comfortable to handle</i>	0.08	1	1	1	2	10	1	
7	<i>Stable base</i>	0.08	1	1	1	1	10	1	
8	<i>Does not spill</i>	0.06	7	7	1	1	1	1	
9	<i>Nice look (appearance)</i>	0.05	2	2	1	2	3	2	
10	<i>Easy to clean</i>	0.04	2	3	1	9	2	1	
11	<i>Weight of importance of DC (D<sub>j</sub>)</i>		3.28	2.66	4.15	3.15	2.35	2.1	1.57
12	<i>Relative Weight of importance of DC (d<sub>j</sub>)</i>		0.17	0.14	0.22	0.16	0.12	0.11	0.08

(DC6) | satisfy feeling or touch (DF717) | 0.40 | 0.45 | \$0.26 |  
 Totals: 1.00 | 7.00 | 7.00 | \$8.61

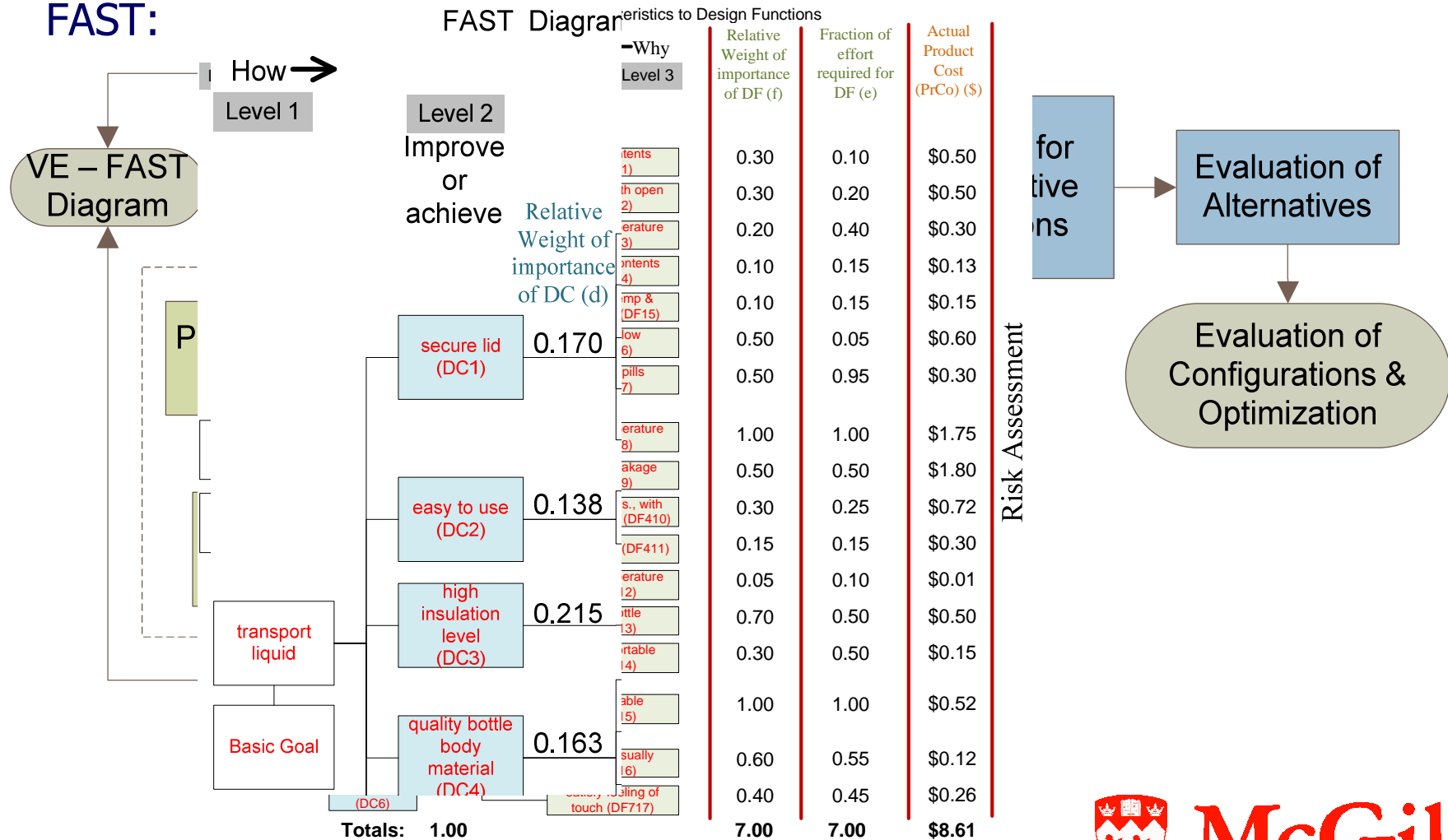


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# Details of the Framework: Thermo-Flask

Step 1)

FAST:

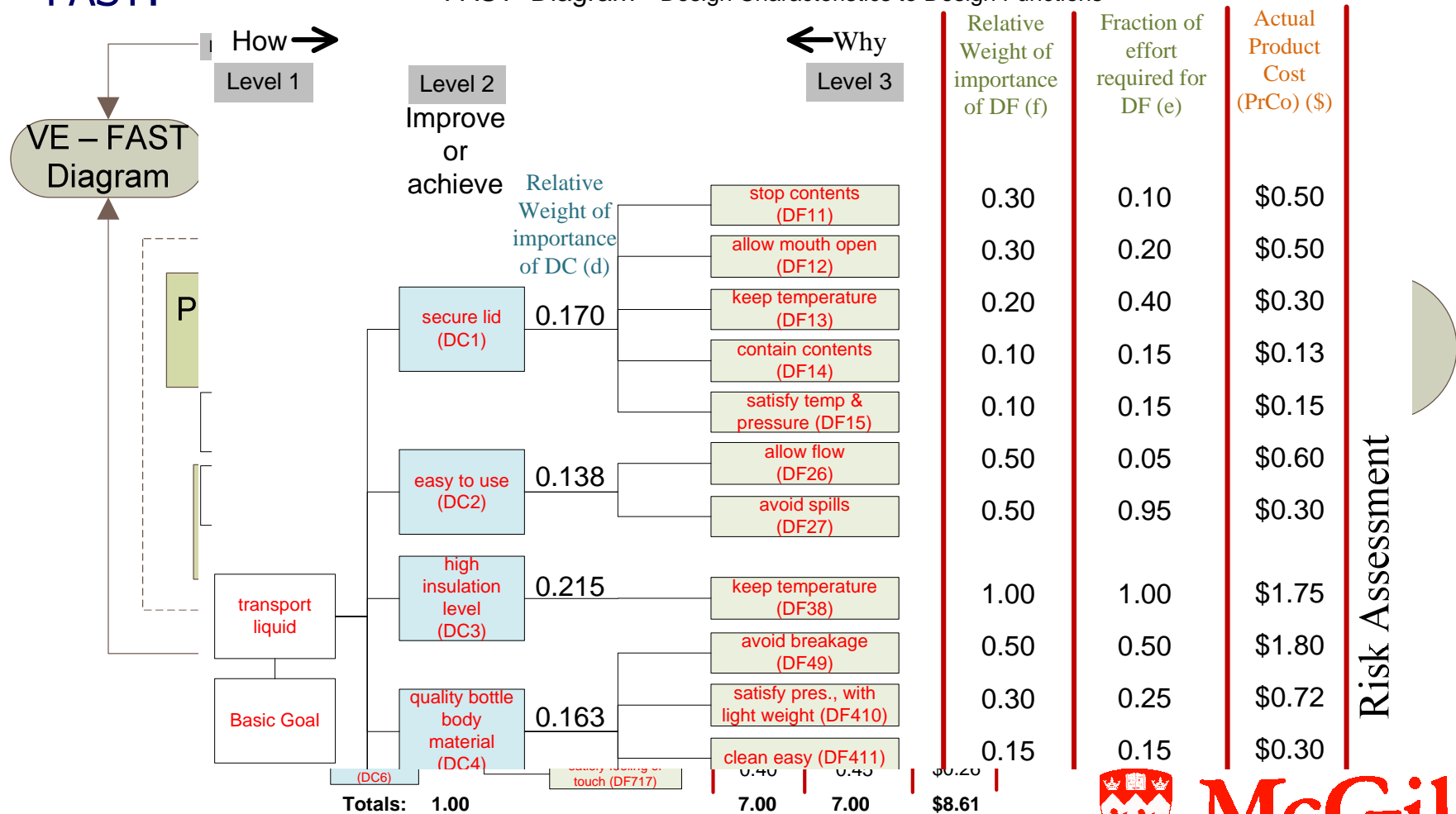


# Details of the Framework: Thermo-Flask

Step 1)

FAST:

FAST Diagram - Design Characteristics to Design Functions



Risk Assessment



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# Details of the Framework: Thermo-Flask

## Step 2) Cost and Risk Analysis Matrix

Cost and Risk Analysis Matrix (CRAM) - Basic Design - Glass Bottle																
Design Characteristics		Functional Analysis			Cost Analysis				Risk Analysis			Monetized Risk Analysis - Worst Case Scenario				
Design Characteristics (DC <sub>i</sub> )	Relative Weight of importance of DC (d <sub>i</sub> )	Design Functions (DF <sub>jk</sub> )	Relative Weight of importance of DF (f <sub>jk</sub> )	Fraction of effort required for DF	Design Cost (DCo <sub>jk</sub> ) (\$)	Actual Product Cost of DF (PrCo <sub>jk</sub> ) (\$)	Target Cost of DF (TCF <sub>jk</sub> ) (\$)	(DCo <sub>jk</sub> +PrCo <sub>jk</sub> )/TCF <sub>jk</sub> (PCI <sub>jk</sub> )	Relative weight of importance of RA (wRA <sub>jk</sub> )			Monetized Risk (\$/year)			Monetized Risk level for DF (MFP <sub>jk</sub> )	Monetized Risk Level for DC (MDP <sub>i</sub> )
									0.4	0.3	0.3	Development	Technical	Timeliness		
									Risk Attributes (RA)							
								Development Cost	Technical	Timeliness	Development	Technical	Timeliness			
secure lid (DC1)	0.170	stop contents	0.30	0.10	\$147.87	\$0.50	\$0.41	1.23	0.60	0.55	0.11	\$35.49	\$16,500.00	\$1,224.90	\$17,760.39	\$65,267.06
		allow mouth open	0.30	0.20	\$295.74	\$0.50	\$0.41	1.23	0.85	0.70	0.14	\$100.55	\$21,000.00	\$3,062.24	\$24,162.79	
		keep temperature	0.20	0.40	\$591.48	\$0.30	\$0.27	1.11	0.50	0.60	0.10	\$118.30	\$10,800.00	\$4,287.14	\$15,205.43	
		contain contents	0.10	0.15	\$221.81	\$0.13	\$0.14	0.96	0.20	0.25	0.07	\$17.74	\$1,950.00	\$1,148.34	\$3,116.08	
ease to use (DC2)	0.138	satisfy temp. & press	0.10	0.15	\$221.81	\$0.15	\$0.14	1.11	0.50	0.40	0.08	\$44.36	\$3,600.00	\$1,378.01	\$5,022.37	\$31,803.97
		allow flow	0.50	0.05	\$59.96	\$0.60	\$0.55	1.09	0.30	0.30	0.08	\$7.20	\$10,800.00	\$372.51	\$11,179.71	
avoid spill	0.50	0.95	\$1,139.23	\$0.30	\$0.55	0.55	0.85	0.60	0.11	\$387.34	\$10,800.00	\$9,436.93	\$20,624.27			
high insulation level (DC3)	0.215	keep temperature	1.00	1.00	\$1,870.92	\$1.75	\$1.72	1.02	0.75	0.45	0.08	\$561.28	\$47,250.00	\$11,623.44	\$59,434.72	\$59,434.72
quality body material (DC4)	0.163	avoid breakage	0.50	0.50	\$710.05	\$1.80	\$0.65	2.76	0.70	0.80	0.22	\$198.81	\$86,400.00	\$11,763.49	\$98,362.30	\$127,616.40
		satisfy pres., with light weight	0.30	0.25	\$355.02	\$0.72	\$0.39	1.84	0.60	0.30	0.08	\$85.21	\$12,960.00	\$2,205.65	\$15,250.86	
		clean easily	0.15	0.15	\$213.01	\$0.30	\$0.20	1.54	0.50	0.60	0.11	\$42.60	\$10,800.00	\$1,764.52	\$12,607.13	
keep temperature	0.05	0.10	\$142.01	\$0.01	\$0.07	0.16	0.70	0.30	0.11	\$39.76	\$180.00	\$1,176.35	\$1,396.11			
secure holding (DC5)	0.122	grip bottle	0.70	0.50	\$529.72	\$0.50	\$0.68	0.74	0.40	0.40	0.11	\$84.75	\$12,000.00	\$4,387.97	\$16,472.72	\$23,709.01
		be comfortable	0.30	0.50	\$529.72	\$0.15	\$0.29	0.52	0.70	0.30	0.11	\$148.32	\$2,700.00	\$4,387.97	\$7,236.29	
stable base (DC6)	0.110	stay stable	1.00	1.00	\$955.75	\$0.52	\$0.88	0.60	0.60	0.25	0.08	\$229.38	\$7,800.00	\$5,937.76	\$13,967.14	\$13,967.14
attractive Ext. color & texture	0.081	attract visually	0.60	0.55	\$389.29	\$0.12	\$0.39	0.31	0.70	0.60	0.05	\$109.00	\$4,320.00	\$1,612.34	\$6,041.34	\$12,751.09
		satisfy feeling of touch	0.40	0.45	\$318.51	\$0.26	\$0.26	1.00	0.40	0.30	0.08	\$50.96	\$4,680.00	\$1,978.79	\$6,709.75	
		<b>Color Coding</b>			<b>DCo<sub>t</sub></b>			PCI <sub>t</sub> cut off= 0.15				<b>Risk Drivers</b>			<b>worst case scenar</b>	
Totals:	1.000	Change Ripple	n	n	\$8,691.89	PrCo <sub>t</sub>	TCF <sub>t</sub>	PCI <sub>t</sub>				Dco	PrCo	Market Share	MR <sub>t</sub>	
		Change Blossom			<b>SP<sub>t</sub></b>											
	1.000	Change Avalanche	7.00	7.00	250	\$8.61	\$8.00	1.08				\$2,261.05	\$264,540.00	\$67,748.34	\$334,549.394	



# Details of the Framework: Thermo-Flask

## Step 2) Cost and Risk Analysis Matrix

	1	2	3	4	5	8	9	10	11	12	13	14	15	16	17		
	Design Characteristics		Functional Analysis			Cost and Risk Analysis											
	Design Characteristics (DC <sub>j</sub> )	Relative Weight of importance of DC (d <sub>j</sub> )	Design Functions (DF <sub>jk</sub> )	Relative Weight of importance of DF (f <sub>jk</sub> )	Fraction of effort required for DF	Target Cost of DF (TCF <sub>jk</sub> ) (\$)										Risk Drivers	worst case scenario
1																	
2	secure lid (DC1)	0.170	stop contents	0.30	0.10												
3			allow mouth open	0.30	0.20												
4			keep temperature	0.20	0.40		\$0.41										
5			contain contents	0.10	0.15		\$0.41										
6			satisfy temp. & press	0.10	0.15		\$0.27										
7	ease to use (DC2)	0.138	allow flow	0.50	0.05		\$0.14										
8			avoid spill	0.50	0.95		\$0.14										
9	high insulation level (DC3)	0.215	keep temperature	1.00	1.00		\$0.55										
10	quality body material (DC4)	0.163	avoid breakage	0.50	0.50		\$1.72										
11			satisfy pres., with light weight	0.30	0.25		\$0.65										
12			clean easily	0.15	0.15		\$0.39										
13			keep temperature	0.05	0.10		\$0.20										
14	secure holding (DC5)	0.122	grip bottle	0.70	0.50		\$0.07										
15			be comfortable	0.30	0.50		\$0.68										
16	stable base (DC6)	0.110	stay stable	1.00	1.00		\$0.88										
17	attractive Ext. color & texture	0.081	attract visually	0.60	0.55		\$0.39	0.08	0.08	\$50.96	\$4,680.00	\$1,978.79	\$6,709.75	\$12,751.09			
18			satisfy feeling of touch	0.40	0.45		\$0.26	1.00	0.40	0.30	0.08	\$50.96	\$4,680.00	\$1,978.79	\$6,709.75		
19			<b>Color Coding</b>														
20	Totals:	1.000	Change Ripple	n	n												
21			Change Blossom														
22			Change Avalanche	7.00	7.00		\$8.00	1.08				\$2,261.05	\$264,540.00	\$67,748.34	\$334,549.394		

- Column 1: design experts (from FAST)
- Column 2: design experts (from HOQ via FAST)
- Column 3 and 4: design experts (from FAST)
- Column 5: design experts (from FAST)

# Details of the Framework: Thermo-Flask

## Step 2) Cost and Risk Analysis Matrix

QFD			6	7	
			Cost and Risk Analysis		
			Cost Analysis		
1	2	3	Design Cost (DC <sub>jk</sub> ) (\$)	Actual Product Cost of DF (PrCo <sub>jk</sub> ) (\$)	Target Cost of DF
Design Characteristics		Functional Analysis			
Design Characteristics (DC <sub>j</sub> )	Relative Weight of importance of DC (d <sub>j</sub> )	Design Functions (DF <sub>jk</sub> )			
secure lid (DC1)	0.170	stop contents	\$147.87	\$0.50	\$0
		allow mouth open	\$295.74	\$0.50	\$0
		keep temperature	\$591.48	\$0.30	\$0
ease to use (DC2)	0.138	contain contents	\$221.81	\$0.13	\$0
		satisfy temp. & press	\$221.81	\$0.15	\$0
		allow flow	\$59.96	\$0.60	\$0
high insulation level (DC3)	0.215	avoid spill	\$1,139.23	\$0.30	\$0
		keep temperature	\$1,870.92	\$1.75	\$0
quality body material (DC4)	0.163	keep temperature	\$710.05	\$1.80	\$0
		avoid breakage	\$355.02	\$0.72	\$0
secure holding (DC5)	0.122	satisfy pres., with light weight	\$213.01	\$0.30	\$0
		clean easily	\$142.01	\$0.01	\$0
		keep temperature	\$529.72	\$0.50	\$0
stable base (DC6)	0.110	grip bottle	\$529.72	\$0.15	\$0
		be comfortable	\$955.75	\$0.52	\$0
attractive Ext. color & texture	0.081	stay stable	\$389.29	\$0.12	\$0
		attract visually	\$318.51	\$0.26	\$0
		satisfy feeling of touch	Color Coding		
Totals:	1.000	Change Ripple	DC <sub>t</sub>		PCI <sub>t</sub>
	1.000	Change Blossom	\$8,691.89	PrCo <sub>t</sub>	T
		Change Avalanche	SP <sub>t</sub>		
			250	\$8.61	\$8

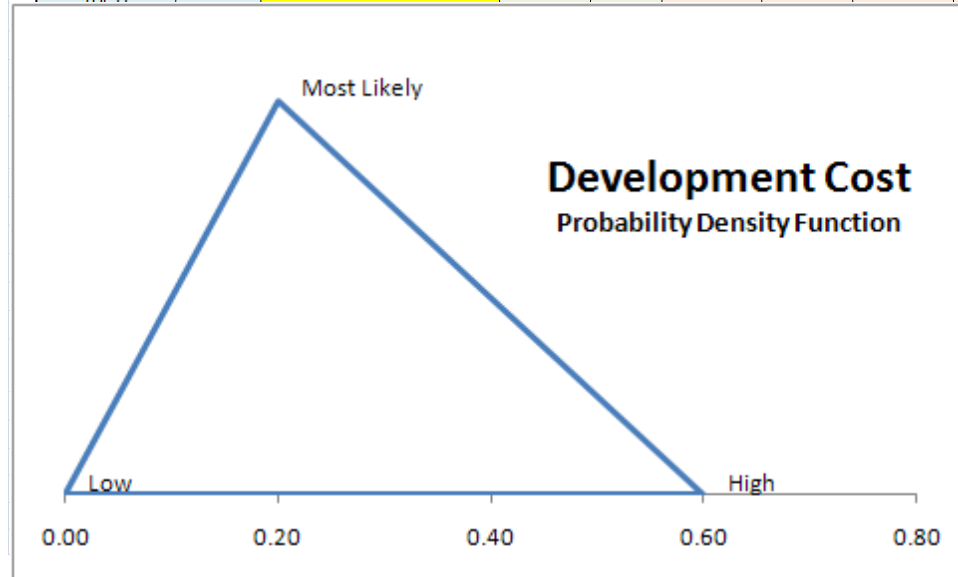
- Column 6: Total Effort required to achieve DF
  - total effort : Product Complexity Model
  - span time: Norden's Model
- Column 7: Actual Cost of DF (from FAST)
- Column 8: Target Cost of DF
- Column 9: [(Design+Product)/Target] Costs
  - if > 1, opportunity for cost improvement
  - if < 1 opportunity for performance improvement

# Details of the Framework: Thermo-Flask

## Step 2) Cost and Risk Analysis Matrix

QFD - HOQ

Cost and Risk Analysis Mat							
Design Characteristics		Functional Analysis			Cost Analysis		
Design Characteristics (DC <sub>j</sub> )	Relative Weight of importance of DC (d <sub>j</sub> )	Design Functions (DF <sub>ik</sub> )	Relative Weight of importance of DF (f <sub>ik</sub> )	Fraction of effort required for DF	Design Cost (DCo <sub>ik</sub> ) (\$)	Actual Product Cost of DF (PrCo <sub>ik</sub> ) (\$)	Target Cost of DF (TCF <sub>ik</sub> ) (\$)
secure lid (DC1)	0.170	stop contents	0.30	0.10	\$147.87	\$0.50	\$0.41
		allow mouth open	0.30	0.20	\$295.74	\$0.50	\$0.41
		keep temperature	0.20	0.40	\$591.48	\$0.30	\$0.27



M) - Basic Design - Glass Bottle

### Column 10-12: Risk Attributes

- Product Specific
  - Development cost risk
  - Technical risk
  - Timeliness risk, etc...
- Triangular distribution

10	11	12	Risk Drivers			17
DCo	PrCo	Market Share	worst case scenar			MR <sub>t</sub>
42.60	\$10,800.00	\$1,764.52	\$12,607.13			616.40
39.76	\$180.00	\$1,176.35	\$1,396.11			
84.75	\$12,000.00	\$4,387.97	\$16,472.72			23,709.01
148.32	\$2,700.00	\$4,387.97	\$7,236.29			
229.38	\$7,800.00	\$5,937.76	\$13,967.14			\$13,967.14
109.00	\$4,320.00	\$1,612.34	\$6,041.34			\$12,751.09
50.96	\$4,680.00	\$1,978.79	\$6,709.75			
40.00	0.30	0.08				
Risk Drivers			worst case scenar			
DCo	PrCo	Market Share	MR <sub>t</sub>			
261.05	\$264,540.00	\$67,748.34	\$334,549.394			



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# Details of the Framework: Thermo-Flask

## Step 2) Cost and Risk Analysis Matrix

QFD - HOQ

Cost and Risk Analysis Matrix								
Design Characteristics		Functional Analysis			Cost Analysis			
Design Characteristics (DC)	Relative Weight of importance of DC (d <sub>j</sub> )	Design Functions (DF <sub>jk</sub> )	Relative Weight of importance of DF (f <sub>jk</sub> )	Fraction of effort required for DF	Design Cost (DCo <sub>jk</sub> ) (\$)	Actual Product Cost of DF (PrCo <sub>jk</sub> ) (\$)	Target Cost of DF (TCF <sub>jk</sub> ) (\$)	(DCo <sub>jk</sub> +PrCo <sub>jk</sub> )/TCF <sub>jk</sub> (P)
secure lid (DC1)	0.170	stop contents	0.30	0.10	\$147.87	\$0.50	\$0.41	1.2
		allow mouth open	0.30	0.20	\$295.74	\$0.50	\$0.41	1.2
		keep temperature	0.20	0.40	\$591.48	\$0.30	\$0.27	1.1
ease (DC2)		avoid spill	0.50	0.50	\$1,159.25	\$0.30	\$0.55	0.5
high insulation level (DC3)	0.215	keep temperature	1.00	1.00	\$1,870.92	\$1.75	\$1.72	1.0
quality body material (DC4)	0.163	avoid breakage	0.50	0.50	\$710.05	\$1.80	\$0.65	2.7
		satisfy pres., with light weight	0.30	0.25	\$355.02	\$0.72	\$0.39	1.8
		clean easily	0.15	0.15	\$213.01	\$0.30	\$0.20	1.5
secure holding (DC5)	0.122	keep temperature	0.05	0.10	\$142.01	\$0.01	\$0.07	0.1
		grip bottle	0.70	0.50	\$529.72	\$0.50	\$0.68	0.7
stable base (DC6)	0.110	be comfortable	0.30	0.50	\$529.72	\$0.15	\$0.29	0.5
		stay stable	1.00	1.00	\$955.75	\$0.52	\$0.88	0.6
attractive Ext. color & texture	0.081	attract visually	0.60	0.55	\$389.29	\$0.12	\$0.39	0.3
		satisfy feeling of touch	0.40	0.45	\$318.51	\$0.26	\$0.26	1.0
		<b>Color Coding</b>			<b>DCo<sub>t</sub></b>		PCI <sub>t</sub> cut off=	0.15
<b>Totals:</b>	1.000	Change Ripple	n	n	\$8,691.89	PrCo <sub>t</sub>	TCF <sub>t</sub>	PCI
		Change Blossom			<b>SP<sub>t</sub></b>			
	1.000	Change Avalanche	7.00	7.00	250	\$8.61	\$8.00	1.0

## Step 3) Repeat Steps 1 to 2 for alternative solutions

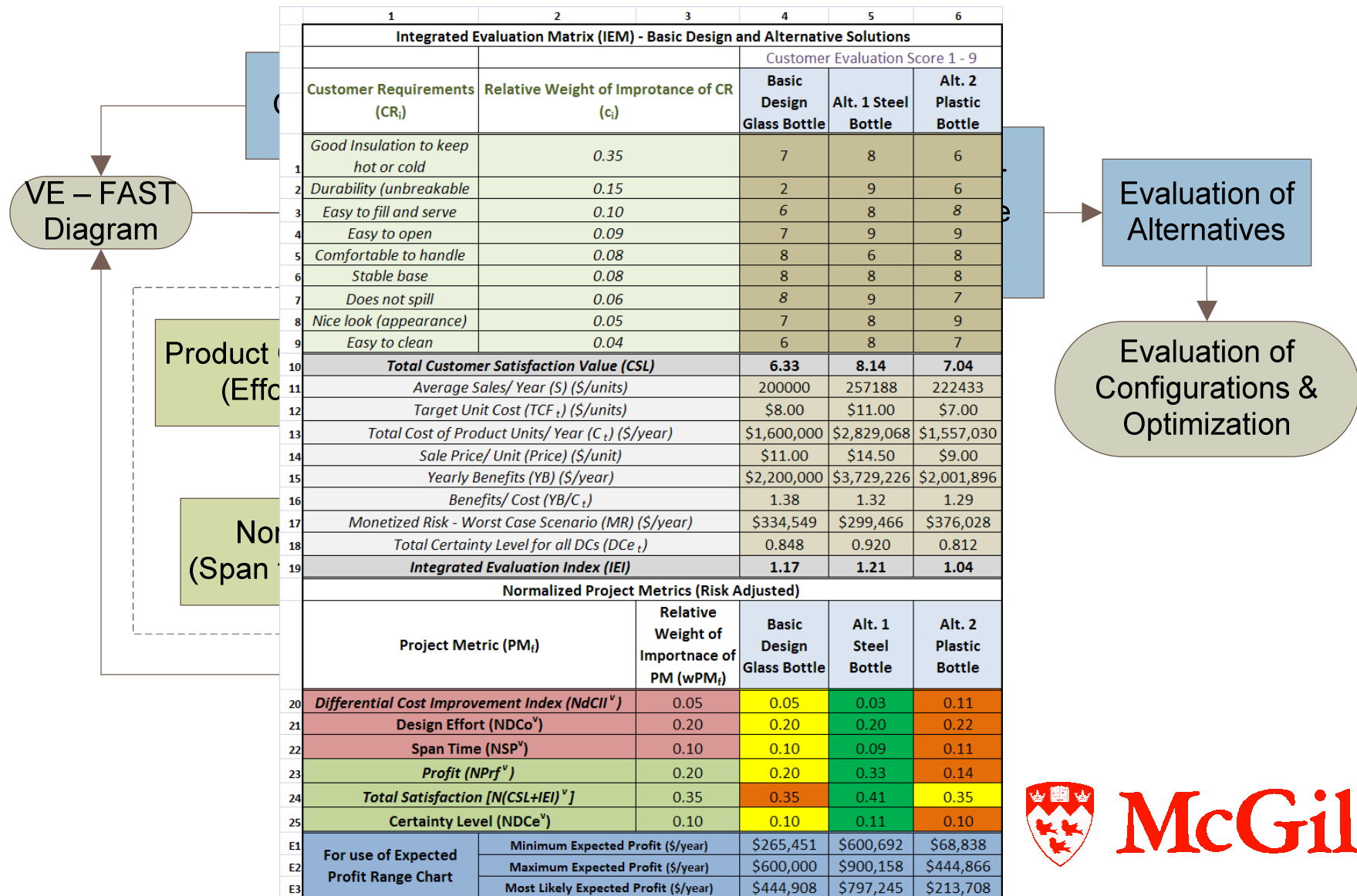
### Column 13-17: Monetized Risk

- Worst Case Scenario
- Column 13:
  - Development cost risk
  - Development cost
- Technical risk
- Actual product cost per unit
- Sales volume in PLC
- Column 15:
  - Timeliness risk
  - Effort requirement
  - Revenue in PLC



# Details of the Framework: Thermo-Flask

## Step 4) Integrated Evaluation Matrix - Current Design and alternatives



# Details of the Framework: Thermo-Flask

## Step 4) Integrated Evaluation Matrix - Current Design and alternatives

CSL<sup>v</sup> = weighted average of the customer evaluation values wrt. the importance of customer requirements

IEI<sup>v</sup> (Company satisfaction level) = Design certainty multiplied by benefits over costs for the product life cycle

	1	2	3	4	5	6
Integrated Evaluation Matrix (IEM) - Basic Design and Alternative Solutions						
Customer Evaluation Score 1 - 9						
Design						
					Alt. 1 Steel	Alt. 2 Plastic

Value Profit Diagram

3	Easy to fill and serve	
4	Easy to open	
5	Comfortable to handle	
6	Stable base	0.08
7	Does not spill	0.06

10	<b>Total Customer Satisfaction Value (CSL)</b>	<b>6.33</b>	<b>8.14</b>	<b>7.04</b>
11	Average Sales/ Year (S) (\$/units)	200000	257188	222433
12	Target Unit Cost (TCF <sub>t</sub> ) (\$/units)	\$8.00	\$11.00	\$7.00
13	Total Cost of Product Units/ Year (C <sub>t</sub> ) (\$/year)	\$1,600,000	\$2,829,068	\$1,557,030
14	Sale Price/ Unit (Price) (\$/unit)	\$11.00	\$14.50	\$9.00
15	Yearly Benefits (YB) (\$/year)	\$2,200,000	\$3,729,226	\$2,001,896
16	Benefits/ Cost (YB/C <sub>t</sub> )	1.38	1.32	1.29
17	Monetized Risk - Worst Case Scenario (MR) (\$/year)	\$334,549	\$299,466	\$376,028
18	Total Certainty Level for all DCs (DCe <sub>t</sub> )	0.848	0.920	0.812
19	<b>Integrated Evaluation Index (IEI)</b>	<b>1.17</b>	<b>1.21</b>	<b>1.04</b>

21	Design Effort (NDCe <sup>v</sup> )	0.20	0.20	0.20	0.22
22	Span Time (NSP <sup>v</sup> )	0.10	0.10	0.09	0.11
23	Profit (NPrf <sup>v</sup> )	0.20	0.20	0.33	0.14
24	Total Satisfaction [N(CSL+IEI) <sup>v</sup> ]	0.35	0.35	0.41	0.35
25	Certainty Level (NDCe <sup>v</sup> )	0.10	0.10	0.11	0.10
E1	For use of Expected Profit Range Chart	Minimum Expected Profit (\$/year)	\$265,451	\$600,692	\$68,838
E2		Maximum Expected Profit (\$/year)	\$600,000	\$900,158	\$444,866
E3		Most Likely Expected Profit (\$/year)	\$444,908	\$797,245	\$213,708



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# Details of the Framework: Thermo-Flask

## Step 4) Integrated Evaluation Matrix - Current Design and alternatives

### Resources

- Worst case scenario

### Benefits

- Worst case scenario
- Normalized to original design

Integrated Evaluation Matrix (IEM) - Basic Design and Alternative Solutions					
Normalized Project Metrics (Risk Adjusted)					
Project Metric (PM <sub>i</sub> )	Relative Weight of Importance of PM (wPM <sub>i</sub> )	Basic Design Glass Bottle	Alt. 1 Steel Bottle	Alt. 2 Plastic Bottle	
Differential Cost Improvement Index (NdCII <sup>v</sup> )	0.05	0.05	0.03	0.11	
Design Effort (NDCo <sup>v</sup> )	0.20	0.20	0.20	0.22	
Span Time (NSP <sup>v</sup> )	0.10	0.10	0.09	0.11	
Profit (NPrf <sup>v</sup> )	0.20	0.20	0.33	0.14	
Total Satisfaction [N(CSL+IEI) <sup>v</sup> ]	0.35	0.35	0.41	0.35	
Certainty Level (NDCe <sup>v</sup> )	0.10	0.10	0.11	0.10	
For use of Expected Profit Range Chart	Minimum Expected Profit (\$/year)	\$265,451	\$600,692	\$68,838	
	Maximum Expected Profit (\$/year)	\$600,000	\$900,158	\$444,866	
	Most Likely Expected Profit (\$/year)	\$444,908	\$797,245	\$213,708	
Benefits/ Cost (YB/C <sub>t</sub> )					
	1.38	1.32	1.29		
Monetized Risk - Worst Case Scenario (MR) (\$/year)					
	\$334,549	\$299,466	\$376,028		
Total Certainty Level for all DCs (DCe <sub>t</sub> )					
	0.848	0.920	0.812		
Integrated Evaluation Index (IEI)					
	1.17	1.21	1.04		
Normalized Project Metrics (Risk Adjusted)					
Project Metric (PM <sub>i</sub> )	Relative Weight of Importance of PM (wPM <sub>i</sub> )	Basic Design Glass Bottle	Alt. 1 Steel Bottle	Alt. 2 Plastic Bottle	
Differential Cost Improvement Index (NdCII <sup>v</sup> )	0.05	0.05	0.03	0.11	
Design Effort (NDCo <sup>v</sup> )	0.20	0.20	0.20	0.22	
Span Time (NSP <sup>v</sup> )	0.10	0.10	0.09	0.11	
Profit (NPrf <sup>v</sup> )	0.20	0.20	0.33	0.14	
Total Satisfaction [N(CSL+IEI) <sup>v</sup> ]	0.35	0.35	0.41	0.35	
Certainty Level (NDCe <sup>v</sup> )	0.10	0.10	0.11	0.10	
For use of Expected Profit Range Chart	Minimum Expected Profit (\$/year)	\$265,451	\$600,692	\$68,838	
	Maximum Expected Profit (\$/year)	\$600,000	\$900,158	\$444,866	
	Most Likely Expected Profit (\$/year)	\$444,908	\$797,245	\$213,708	

Norder time

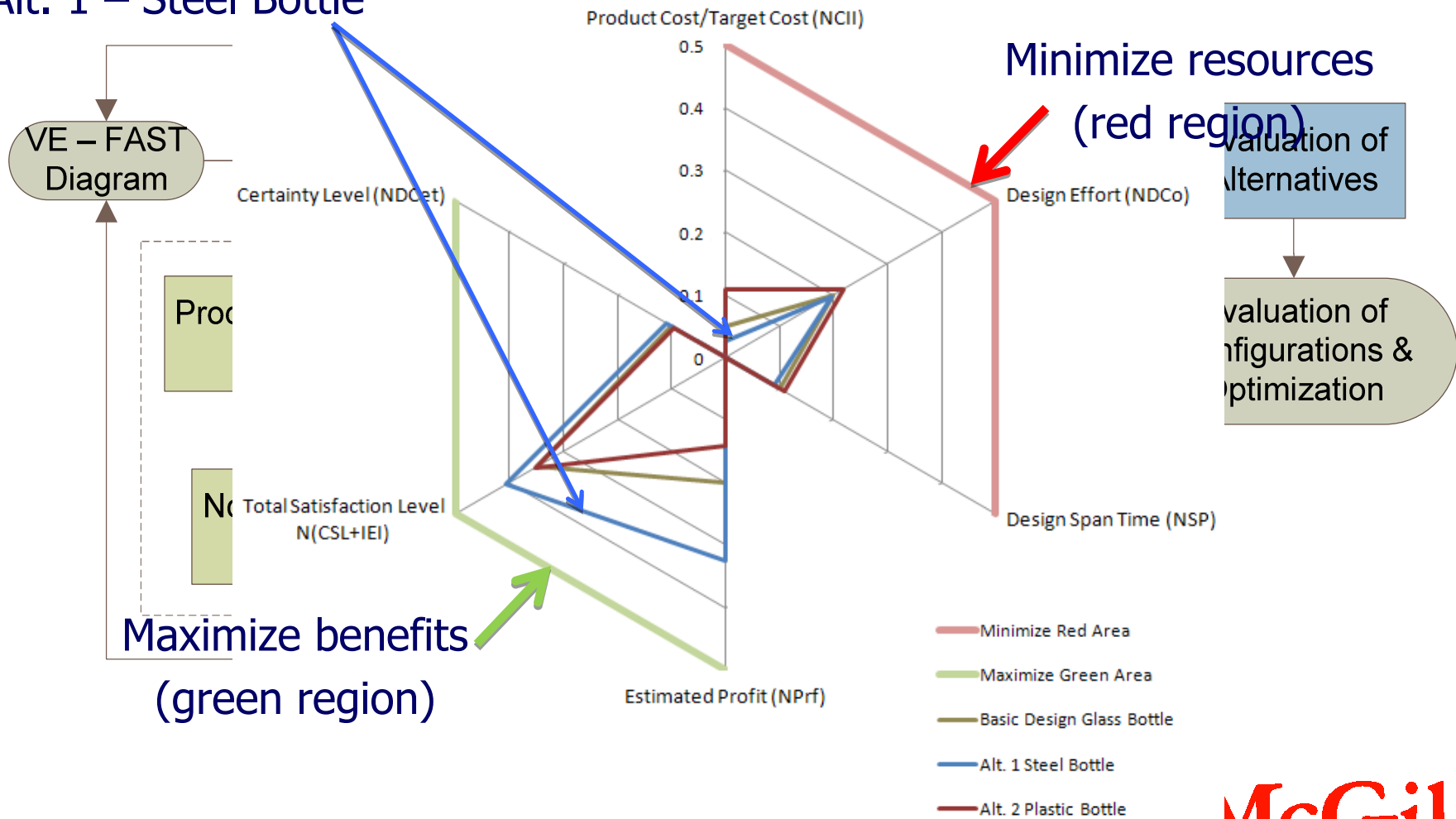


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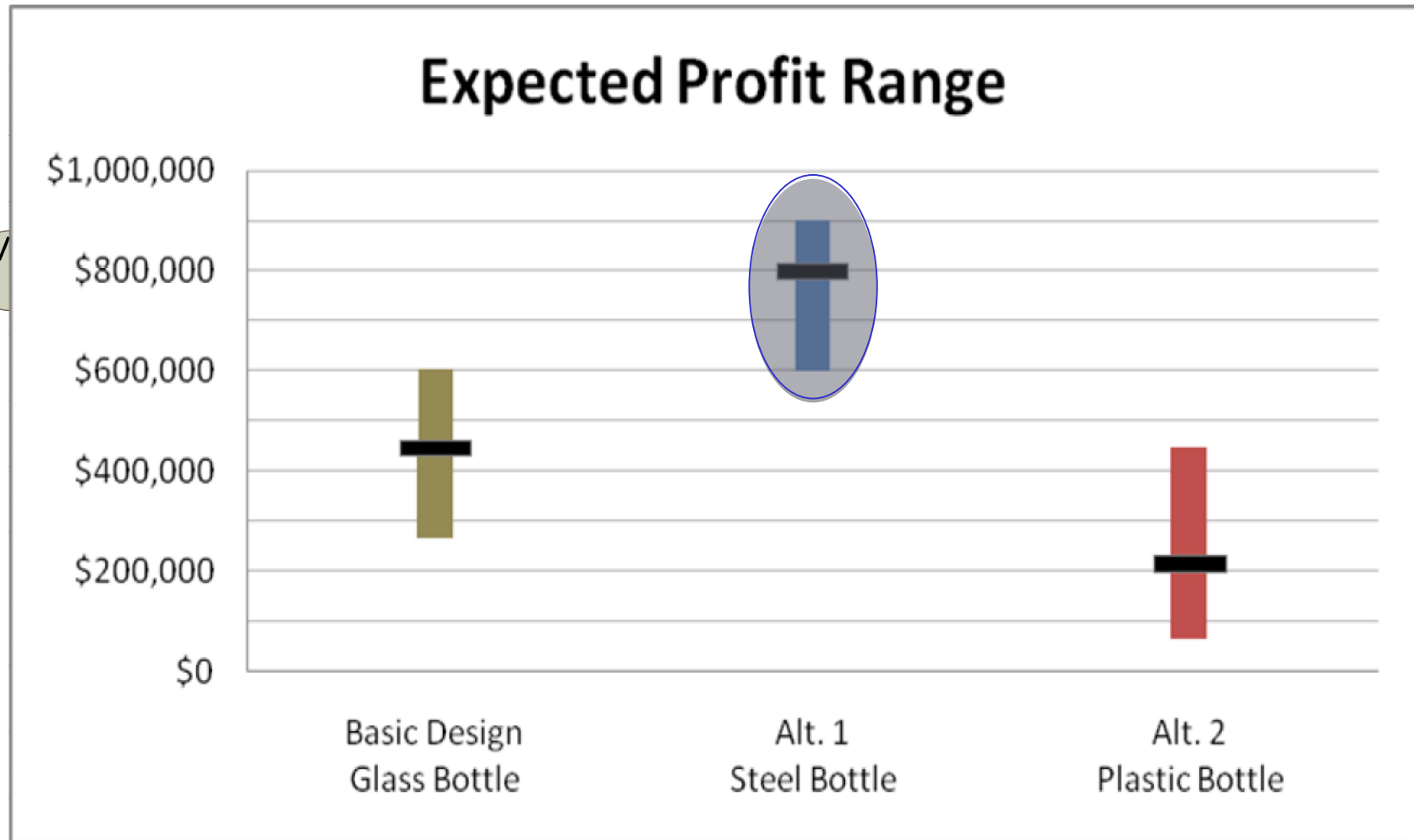
# Details of the Framework: Thermo-Flask

Best Solution  
Alt. 1 – Steel Bottle

Comparison of Risk Integrated Project Metrics



# Details of the Framework: Thermo-Flask



# Details of the Framework: Thermo-Flask

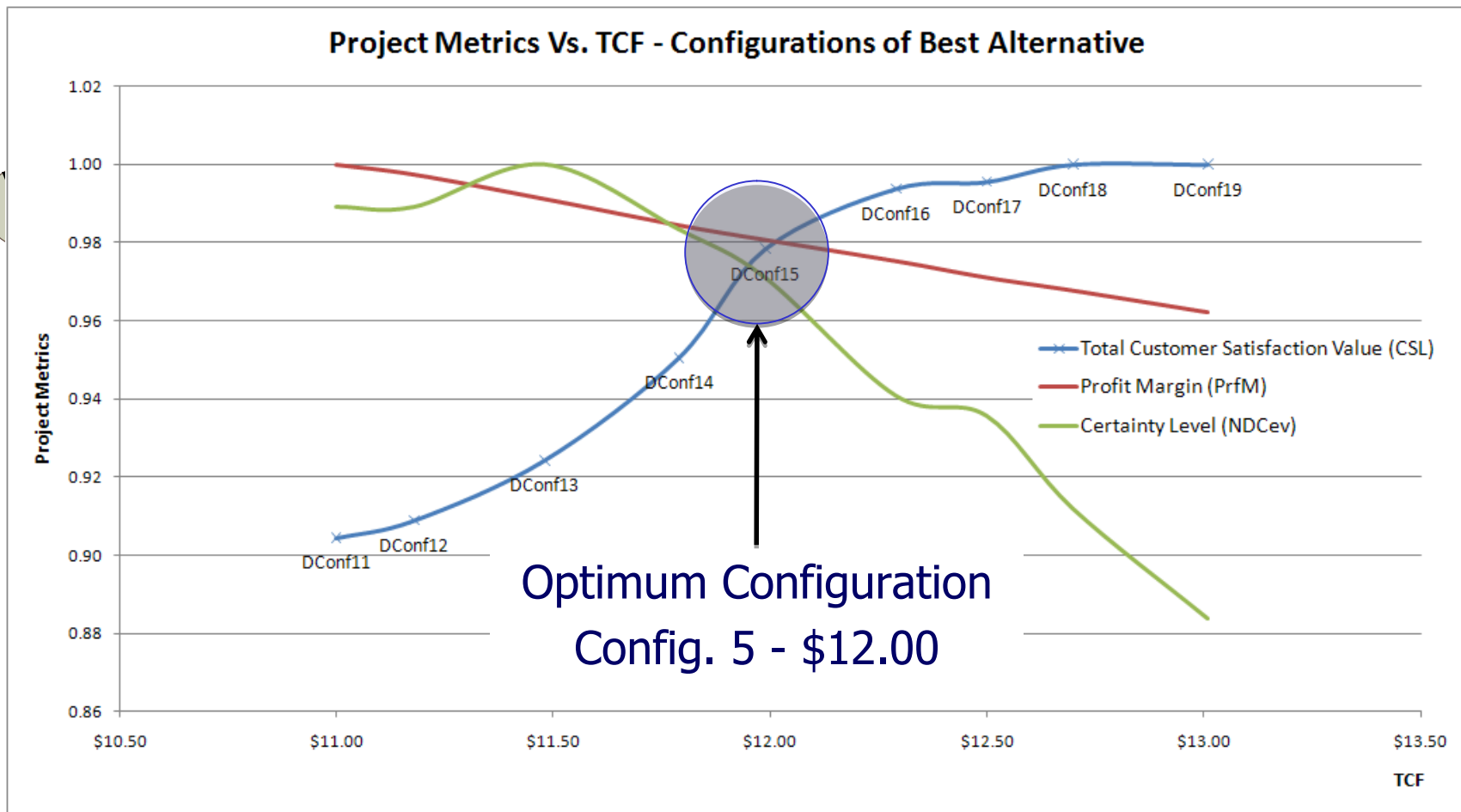
## Step 5) Different cost structures for the Best Solution – Steel Bottle

Development Matrix (DM) - Different Configurations of Best Solution (Steel Bottle)													
Design Characteristics (DC <sup>v</sup> )	Relative Weight of importance of DC (d <sup>B</sup> )	Design Functions (DF <sup>B<sub>jk</sub></sup> )	Relative Weight of importance of DF (f <sup>B<sub>jk</sub></sup> )	Target Cost of DF (TCF <sup>0<sub>jk</sub></sup> ) (\$)	Target Cost of DF for Configurations of Best Solution (Steel Bottle) (TCF <sup>1<sub>jk</sub></sup> ) (\$)								
					DConf <sup>11</sup>	DConf <sup>12</sup>	DConf <sup>13</sup>	DConf <sup>14</sup>	DConf <sup>15</sup>	DConf <sup>16</sup>	DConf <sup>17</sup>	DConf <sup>18</sup>	DConf <sup>19</sup>
secure lid (DC1)	0.170	stop contents	0.30	\$0.56	0.56	0.57	0.59	0.60	0.61	0.63	0.64	0.65	0.66
		allow mouth open	0.30	\$0.56	0.56	0.57	0.59	0.60	0.61	0.63	0.64	0.65	0.66
		keep temperature	0.20	\$0.37	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.43	0.44
		contain contents	0.10	\$0.19	0.19	0.19	0.20	0.20	0.20	0.21	0.21	0.22	0.22
		satisfy temp. & press	0.10	\$0.19	0.19	0.19	0.20	0.20	0.20	0.21	0.21	0.22	0.22
ease to use (DC2)	0.138	allow flow	0.50	\$0.76	0.76	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.90
		avoid spill	0.50	\$0.76	0.76	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.90
high insulation level (DC3)	0.215	keep temperature	1.00	\$2.37	2.37	2.41	2.47	2.54	2.58	2.65	2.69	2.73	2.80
quality body material (DC4)	0.163	avoid breakage	0.50	\$0.90	0.90	0.91	0.94	0.96	0.98	1.00	1.02	1.04	1.06
		satisfy pres., with light weight	0.30	\$0.54	0.54	0.55	0.56	0.58	0.59	0.60	0.61	0.62	0.64
		clean easily	0.15	\$0.27	0.27	0.27	0.28	0.29	0.29	0.30	0.31	0.31	0.32
		keep temperature	0.05	\$0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.11
secure holding (DC5)	0.122	grip bottle	0.70	\$0.94	0.94	0.95	0.98	1.01	1.02	1.05	1.07	1.08	1.11
		be Comfortable	0.30	\$0.40	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.46	0.48
stable base (DC6)	0.110	stay stable	1.00	\$1.21	1.21	1.23	1.26	1.30	1.32	1.35	1.37	1.40	1.43
attractive Ext. color & texture (DC7)	0.081	attract visually	0.60	\$0.54	0.54	0.55	0.56	0.58	0.59	0.60	0.61	0.62	0.64
		satisfy feeling of touch	0.40	\$0.36	0.36	0.36	0.37	0.38	0.39	0.40	0.41	0.41	0.42
		<b>Color Coding</b>											
Totals:	1.000	Change Ripple	n	TCF <sub>t</sub>	TCF <sup>11</sup> <sub>t</sub>	TCF <sup>12</sup> <sub>t</sub>	TCF <sup>13</sup> <sub>t</sub>	TCF <sup>14</sup> <sub>t</sub>	TCF <sup>15</sup> <sub>t</sub>	TCF <sup>16</sup> <sub>t</sub>	TCF <sup>17</sup> <sub>t</sub>	TCF <sup>18</sup> <sub>t</sub>	TCF <sup>19</sup> <sub>t</sub>
	1.000	Change Blossom	7.00	\$11.00	11.00	11.18	11.48	11.79	11.99	12.29	12.50	12.70	13.01
		Change Avalanche											



# Details of the Framework: Thermo-Flask

Choose the optimal configuration based on company strategy



Assumes - medium risk

- balanced customer and company

satisfaction



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# Benefits

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The proposed set of tools stresses a quantitative approach to decision-making through increased product knowledge early in the design process by providing:

- easily accessible and visualizable product information
- easily comprehensible analysis
- the comparative impact of engineering change

# Conclusion

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Decision-making is improved through increased product knowledge.

- Issues are addressed through quantitative techniques which are integrated into a decision support system.
- Analysis is performed in a comparative manner with respect to the original design.
- Design related information is presented in a compact form to provide a one-glance summary.

# Future Work

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- Further investigation of techniques for many-to-many mapping design characteristics to lower level functions.
  - Current state: Design characteristics are assumed to be mutually exclusive, and they are combined when there is significant overlap.
- Integrating methods and instructions for standardized data quantification.
- Increasing the extent of automation.

# Thank You...

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# Acknowledgement

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