Product & Process Development

introduction to the design process

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introduction

1. What are we going to do and why?
2. Getting Organized – organizational commitment
3. The development process
4. Six Sigma
5. Understanding the user needs – ***voice of the customer***
6. Benchmarking - **EXAMPLE**

Goals and objectives of session

- Goal – Present the design / development process
- Objectives
  a. Teach the fundamentals of the development process
  b. Make sure participants can organize a project
  c. Make sure participants can evaluate the project needs
  d. Make sure that the participants can define the project requirements and deployment plan

What is ***Design*** ?

- ***Cambridge Dictionary of American English***

  - The process of originating and **developing a plan** for a product, structure, system, or component with intention - *proposal, drawing, model, description*

  - The result of implementing that plan in the form of the ***final product of a design process***

- ***Solving a situation that has more than one solution***

Why ***Design***?

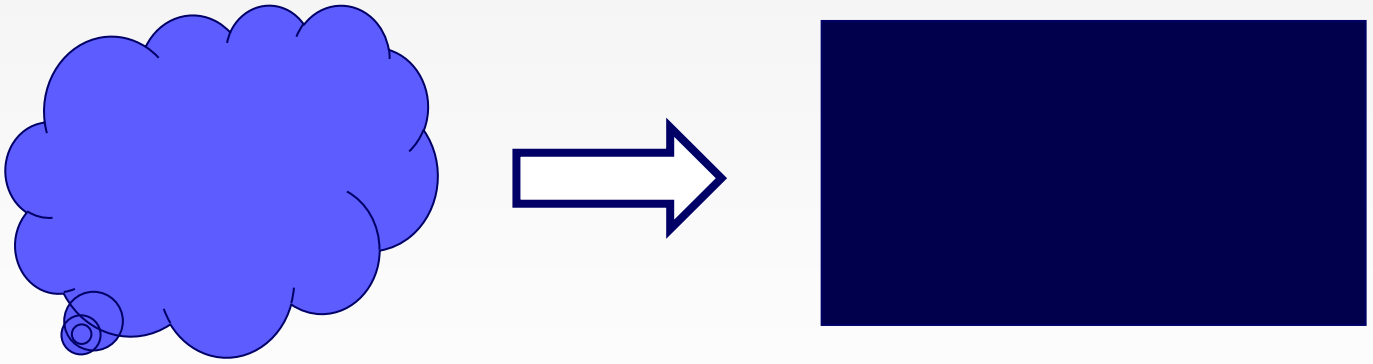
- To **solve an existing problem** – *"this package breaks during transportation and it … "*
- To **improve an existing solution** – *" we want to increase the fuel efficiency by 20% for the next year models…"*
- To take **advantage of an opportunity** – *"most people have internet but do not have time to run errands…"*

The Design Process

- ***Design process*** is a collection or methods and tools that help teams design better products
- Designing a system is a fluid process. That is, the procedure itself has to be adapted to the situation in which it is being applied.

The Process of Designing

- ***Designing*** is the process of making many decisions that converts an ***abstract concept*** into ***a reality***

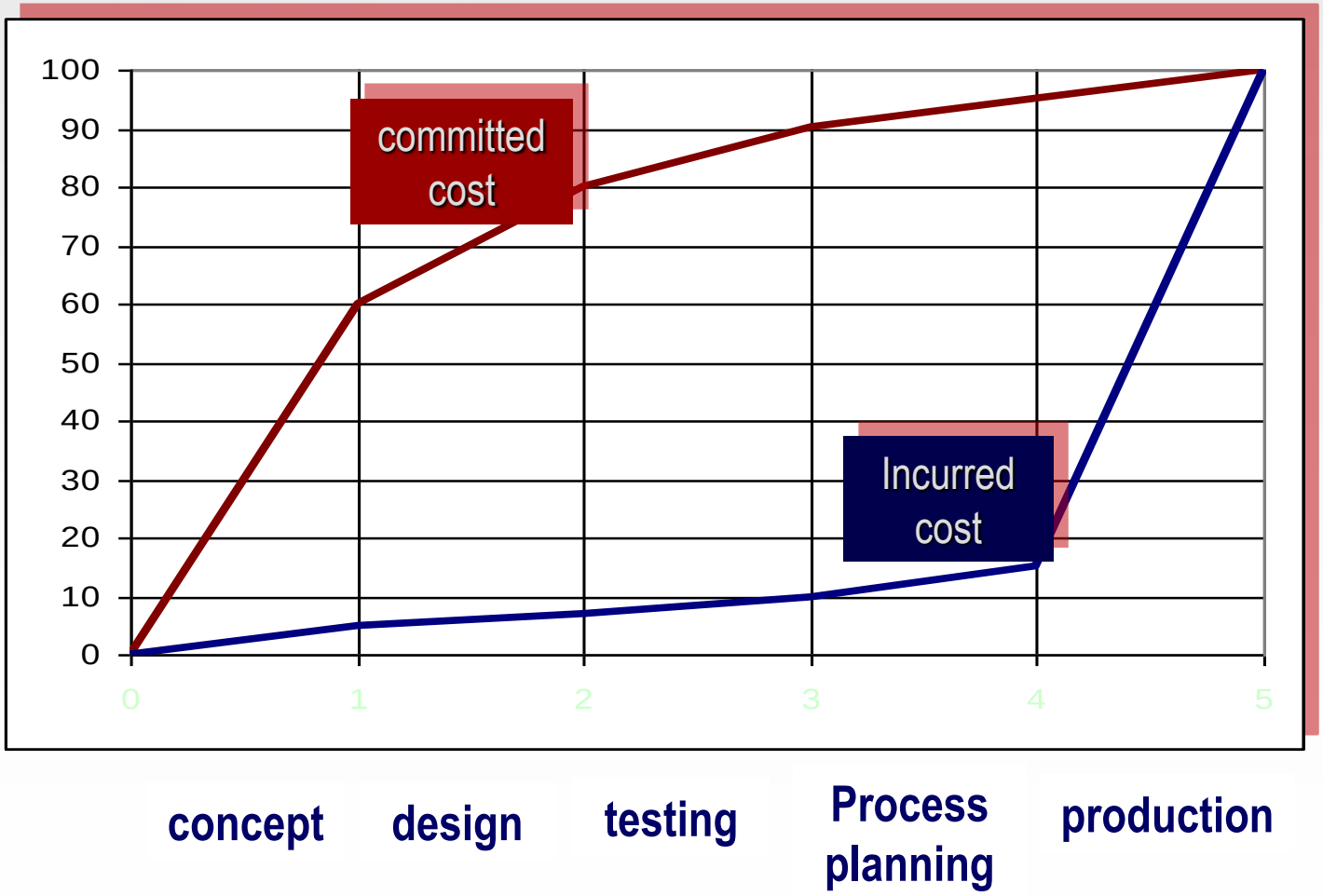


Abstract **Concrete**

The Design Process

- We want a process where **intentionally** we create **useful** products and services

Incurred vs Committed Costs



The Rule of 10

Level of completion	Cost to find & repair defect
the part itself	x
at sub-assembly	10x
Final assembly	100x
At the dealer / distributor	1000x
At the customer	10000x

Situation Statement

1. You are going down the road and your fan belt breaks, what do you do?
2. Develop a storm shutter that will disrupt the market - Capture 25% market share in 4 years
3. Buy a Christmas gift for your wife, husband, mother, father, daughter, son,…

Defining the project

Getting Started

- You have the situation
- You define scope, goals and objectives
- You may define your schedule, resources needed
- You may identify the risks
- You must do some planning

PROJECT ROADMAP

Conclude

- **Retrospective**
  - ✓Identify key learnings

Delivery

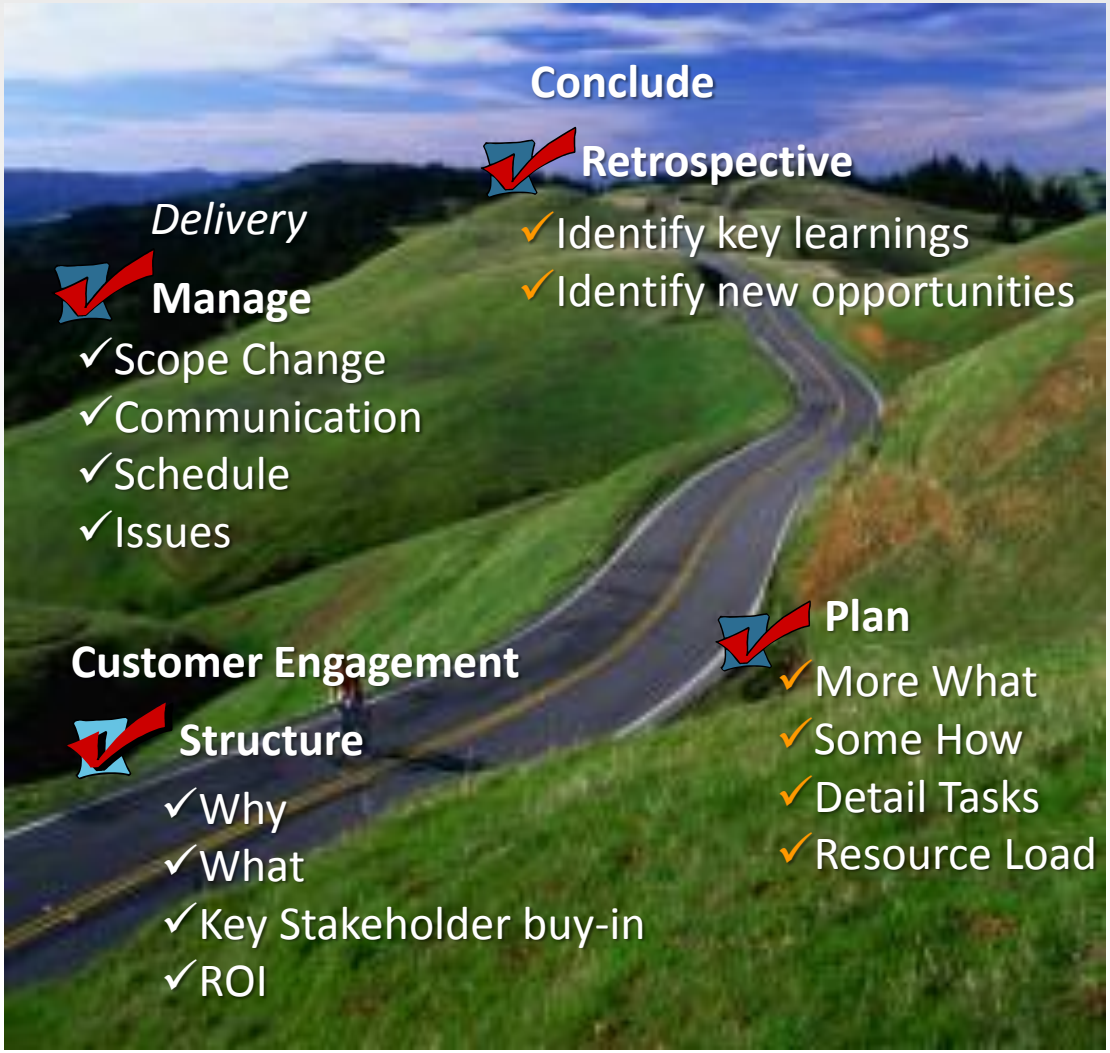
- **Manage**
  - ✓Scope Change
  - ✓Communication
  - ✓Schedule
  - ✓Issues

Customer Engagement

- **Structure**
  - ✓Why
  - ✓What
  - ✓Key Stakeholder buy-in
  - ✓ROI

- **Plan**
  - ✓More What
  - ✓Some How
  - ✓Detail Tasks
  - ✓Resource Load

PROJECT ROADMAP



What is a ***Project***?

- A project is a ***temporary endeavor*** undertaken to create a **unique product**, **service**, or ***result*** (*PMBOK 2004*).
- A project is a problem scheduled to be solved (*Dr. J.M.Juran*)
- *A project can be initiated to solve a problem or take advantage of an opportunity*

A historic opportunity

- April 12, 1961 the USSR put the 1st man in orbit – Yuri Gagarin
- This was a threat to the US international power

Yuri Gagarin in the bus to a launch pad just before his historic flight on April 12, 1961.

John F. Kennedy issued his famous challenge in May 1961

"I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to Earth "

Example of a Successful Project

- $100 billion moon race
- The US won the race to the Moon because it ***committed vast resources to a well thought-out "game plan" right from the start*.**
- Stuck to that plan despite occasional technical and political problems.

Lunar Program Project

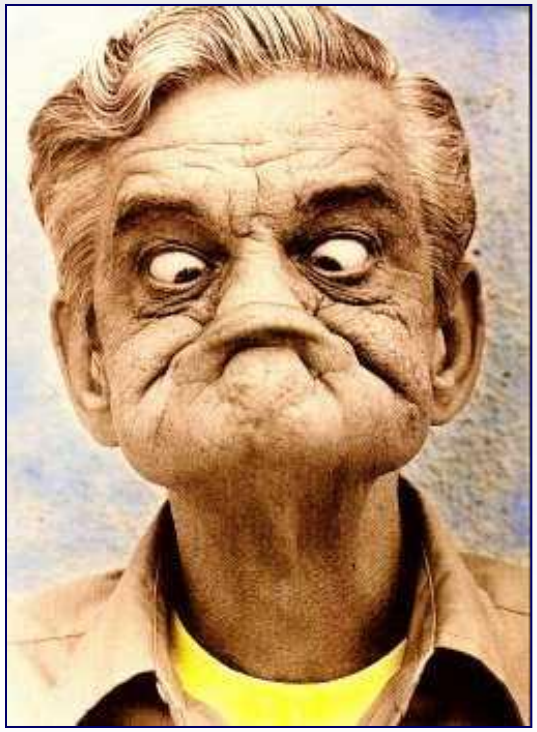
Scope	Land a man on the moon and return
Time	Before Dec 31, 1969
Performance	Go to the moon and return safely
cost	$100 billion

Project Planning Example

- *Request*

  *Final Product Sterilizer – develop a new system that can package and sterilize the final product in **50% of the actual time** and with **20% increase in quality***

Project Planning Exercise – 10 minutes



- Let us divide the class in **groups of 4 persons each**
- Prepare a 1 page project plan to get the project completed by March 1st, 2009

Writing the Project Executive Summary

“Nothing is impossible for the person who doesn't have to do it.”

Developing a Project Executive Summary

- This is the 1st step after being assigned to solve a problem or explore an opportunity
- It is not a project plan, it is a summary
- The objective of the PES is to communicate to the stakeholders
  - ✓ the issue to be addressed
  - ✓ what are the deliverables
  - ✓ what resources are required
  - ✓ when is it estimated to be completed

Example of project planning
actual situation

- ✓ ACME TUNA CORP is interested in remaining competitive in the market of processing frozen fish loins (thawing, canning, cooking and packaging)
- ✓ The existing thawing system has
  - ☑ *Significant material handling costs*
  - ☑ *Long thawing times*

Project's Objective

- Develop a system that produces the same quality (or better) at a lower total cost per unit –
- The operations that will be impacted with the development are
  - ✓Transport of frozen loins from freezer to thawing system
  - ✓Thawing process
  - ✓Transport of thawed fish loins to canning operation or to chiller

Project's Objective

- The main objective is to develop a better thawing system that is cost effective, based on
  - ✓ Labor requirements
  - ✓ Space requirements
  - ✓ Handling times and distances
  - ✓ Thawing times
  - ✓ Utilities costs
  - ✓ Maintenance and Cleaning Costs
  - ✓ Final product cost.

Project Requirements

requirement	justification	specification
Labor	The company wants to reduce operational cost	Reduction + 10% of costs per pound
Space	There is no more space available	Use of to 90% of existing space
Handling times and distances	There is too much time due to transportation and handling – non value added	Reduce handling times by 40% Reduce transportation load by 50%
Thawing times	Thawing takes too much time, process can be changed	Reduce thawing time by 50%

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Project Executive Summary

Project Description

- **Issue Statement** – describe the problem to be solved, or the opportunity to be examined. The idea is to justify the project
- **Project Objective Statement (POS)** – in this section you must describe WHY you are going to work on the project, what is the mission of the team

Project Executive Summary

example – tuna processing plant

- **Issue Statement**

The operational costs are increasing every year, at this rate the site will be cease to be competitive by 2009

- **Project Objective Statement (POS)**

Develop a thawing system to reduce operational costs by 50% by 2008

Project Executive Summary

- ***Major Deliverables –*** here the team describes what results will be produced at the completion of the project. Achieving these deliverables signals the end of the project
- ***Metrics and Targets –*** These are indicators that will assist in measuring the success of the project
- ***Assumptions –*** this is description of the rules of the game, what is being counted on

Project Executive Summary

example – tuna processing plant

- **Major Deliverables** –
  - ✓ Proven design for a thawing system
  - ✓ Proven design for a fish handling system
  - ✓ Design and validation data for both systems
  - ✓ Work Standards and Operating Procedures for both systems.
- **Metrics and targets**
  - ✓ % of reduction of labor costs, 50%
  - ✓ % of reduction in utility costs, 50%

Project Executive Summary

- **Assumptions –**
  - ✓ *Help and collaboration of parties involved.*
  - ✓ *Will have access to raw material testing facilities and key employee participation*
  - ✓ *All construction work will be subcontracted*

Project Executive Summary

- **Milestones** - significant events on a project
- **Estimated Costs and Resources**
  - List of cost of the project and what resources are needed for completion

Project Executive Summary

milestone	definition	duration
Project Definition	clearly define the goals,requirements, restrictions and project schedule	*3 weeks*
Development of Thawing System	develop a better system for thawing the frozen fish.	*6 weeks*
Development of the System Layout	change the existing system layout to make it more efficient.	*4 weeks*
Validate System	make sure the system will work as designed	*6 weeks*

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Project Executive Summary

- **Estimated Costs and Resources**
  - ✓ Net Benefit - reduction of labor cost by $ 40,000 a month
  - ✓ Reduction of energy and water costs by $25,000 a month
  - ✓ Project costs = $300,000.00

Project Executive Summary

- ***Dependencies*** – this is a list things on which the successful completion of the project depends on.
- ***Risks, Issues*** – this is a list of things that can go wrong and adversely affect the outcome of the project

Project Executive Summary

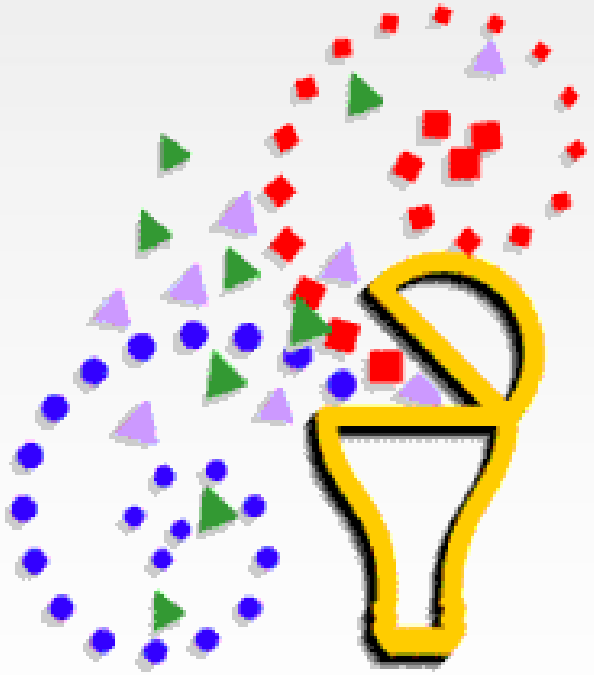
- **Dependencies** –
  - All the utilities are available
  - All the testing and quality personnel are available
- **Risks and Issues**
  - Changes in thawing can change fish characteristics

Project Planning Exercise

- ***Request***

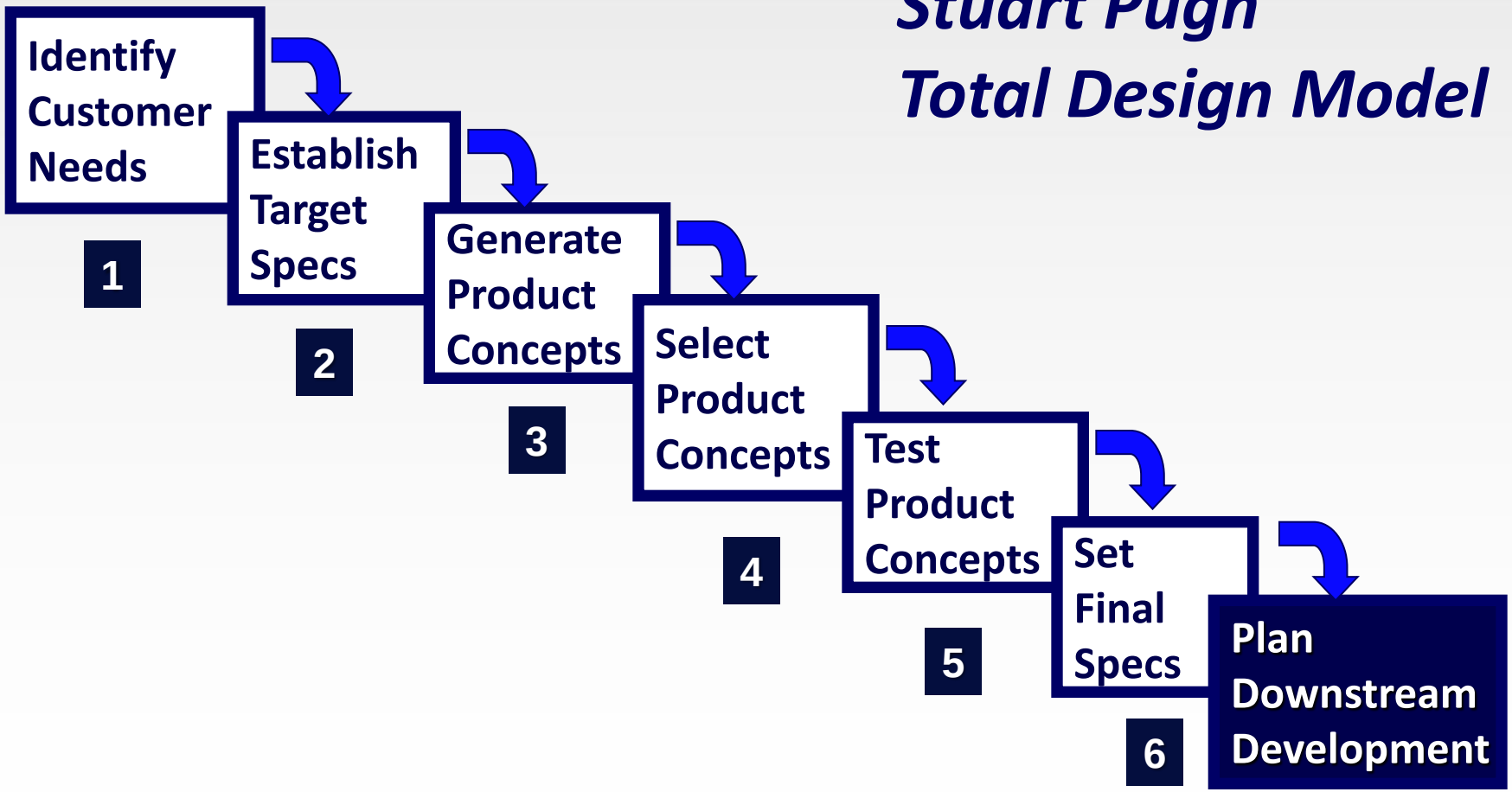
  *Final Product Sterilizer – develop a new system that can package and sterilize the final product in **50% of the actual time** and with **20% increase in quality***

The Design Methodology



Design Methodology

Stuart Pugh
Total Design Model



Advantages of Structured Methods

- ***Decision Process*** is explicitly communicated facilitating group buy-in
- ***Checklists*** ensure that important issues are not forgotten
- ***Structured Methods*** are largely self-documenting

Objectives of Development Methods

- ***WHAT*** – We want to address the reason why we are doing this project and what problem to be solved
- ***How*** –We must "create" different solutions for the problem
- ***Which One –*** We must select the best solution for addressing the problem

1 - *Identify Customer Needs*

- Products and services are designed to satisfy the needs of the customers
- Knowing and understanding the ***voice of the customer*** is very important
- The main challenge is that the customer may not know how to describe what is wanted
- The outcome of this step is a list of **customer requirements**

1 - *Identify Customer Needs*

Identify The WHAT ?

- ***Activities***
  - ✓ Write Problem Statement
  - ✓ Interact with Technical Marketing and/or sales groups to obtain a list of customer needs
  - ✓ Customer analysis (dissatisfied customers)
- ***Deliverables***
  - Customer Needs List or Product Design Specifications

1 - *Identify Customer Needs*

- Most information related to the customer needs must be evaluated and analyzed to obtain useful trends and other information
- Possible Methods
  a. Affinity Diagrams
  b. Parametric Analysis
  c. Quality Function Deployment

1 - *Identify Customer Needs*

- The ***customer needs*** can be identified by using market research techniques such as
  - ✓Surveys & questionnaires
  - ✓Customer complaints
  - ✓Focal groups
  - ✓Trade publications
  - ✓Patents
  - ✓competitors

Additional Sources of Information

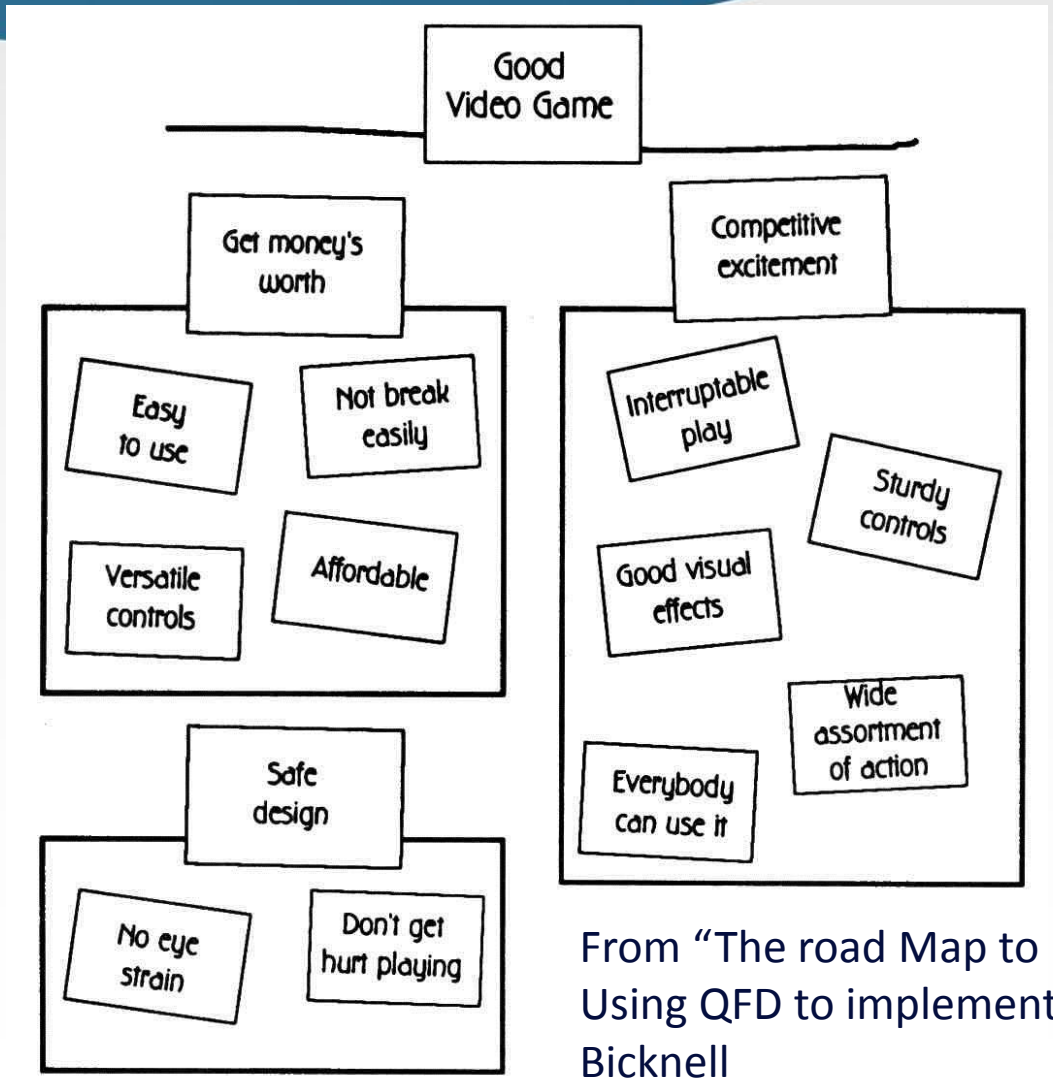
- ✓ Thomas Register
- ✓ Market Share Reporter
- ✓ National Bureau of Standards
- ✓ Census of Manufactures
- ✓ Moody's Industry Review
- ✓ Consumer Reports Magazine
- ✓ Trade Magazines
- ✓ Market Research Databases
- ✓ Web
- ✓ Vendors
- ✓ Technical Specialists
- ✓ Experts/Friends in Industry

Affinity Diagram

Gather large amounts of data (ideas, opinions, issues) and organize them into groupings.

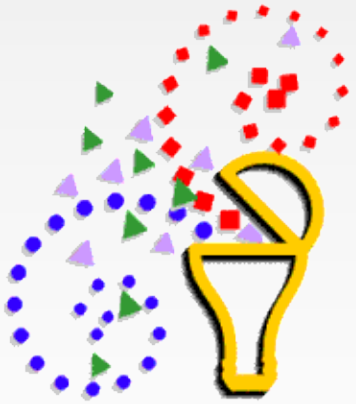
- Construction:
  - Record data on cards (Post-it notes)
  - Place cards on board
  - Group cards that seem to be related (without talking)
  - Establish a summary title for each group
  - Critically evaluate each group. Remove “How’s” from “What’s” categories
  - Eliminate redundancy

Affinity Diagram – example
video game



From "The road Map to Repeatable Success - Using QFD to implement change" by Barbara Bicknell

Parametric Analysis



Parametric Analysis

- This is a analysis method that allows for the identification of relationships, trends and opportunities using actual **product information**

1. **Create a table of product data** for all the competitors - *weight, horsepower, mpg, ram, hard drive, speed*,…
2. **Plot product data**, one parameter vs another parameter – horsepower vs mpg, towing capacity vs mpg, turning radius vs

Parametric Analysis

3. **Start with the "obvious" relationships –** plot horsepower vs miles per gallon
4. **Then proceed with the none obvious relationships** – legroom vs horsepower

Parametric Analysis

5. **Evaluate possible trends between parameters –** check if there is a correlation between horsepower and towing capacity , or horsepower and fuel efficiency

✓ **The trends you identify can indicate:**

a. that there are some fundamental correlations of the technology

b. That there is some certain way of doing things – this you could repeat or go against the grain

Parametric Analysis – *example*

- You are to design a car that can compete with
  - Toyota's **Camry**
  - Honda's **Accord**
  - Ford's **Fusion**
  - Nissan's **Altima**
  - Hyundai's **Sonata**
  - BWM's **328i** (just for fun!!!)

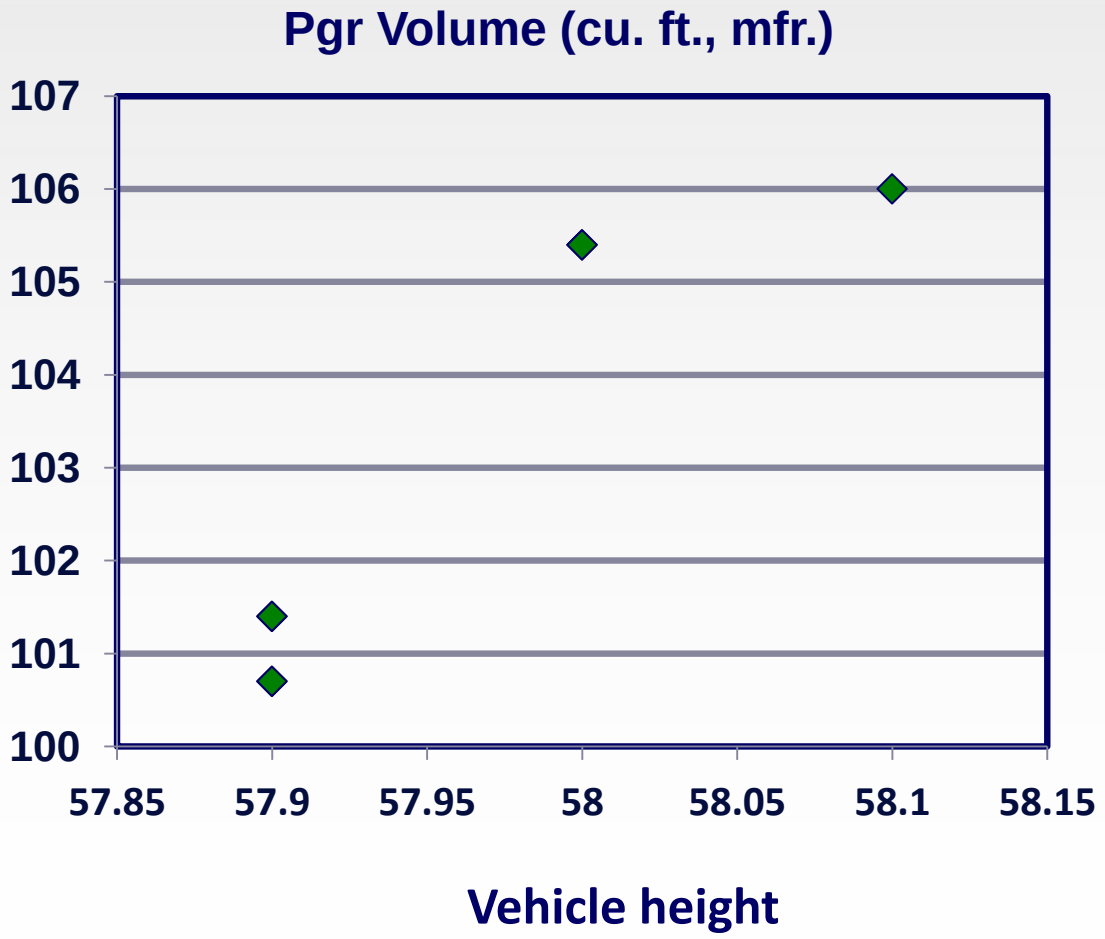
Parametric Analysis – *example*

- You gather some specifications of these cars

	Honda Accord	Toyota Camry	Nissan Altima	Hyundai Sonata	Ford Fusion	BMW 328i
Curb Weight	3230	3263	3145	3253	3101	3362
Wheelbase (in.)	110.2	109.3	109.3	107.4	107.4	108.7
Length (in.)	194.1	189.2	189.8	188.9	189.2	188.9
Width (in.)	72.7	71.7	70.7	72.1	71.7	72.1
Height (in.)	58.1	57.9	57.9	58	57.9	58
Passenger Vol (cu. ft.	106	101.4	100.7	105.4	101.4	105.4
Cargo Vol(cu. ft.)	14	15	15.3	16.3	15	16.3
Headroom - front	41.4	38.8	40.6	40.1	38.8	40.1
Headroom 2nd row	38.5	37.8	36.8	38.2	37.8	38.2
Legroom front	42.5	41.7	44.1	43.7	41.7	43.7
Legroom 2nd row	37.2	38.3	35.8	37.4	38.3	37.4
Shoulder Room front	58.2	57.8	55.7	57.4	57.8	57.4
mpg(City)	22	21	23	21	20	18
mpg (Highway)	31	31	32	32	29	28
Horsepower	177	175	158	175	160	230
Torque	161	168	161	180	156	200

Parametric Analysis – *example*

- ✓ Plot the obvious relationships 1st
- ✓ In this plot, the higher the vehicle the greater the passenger volume



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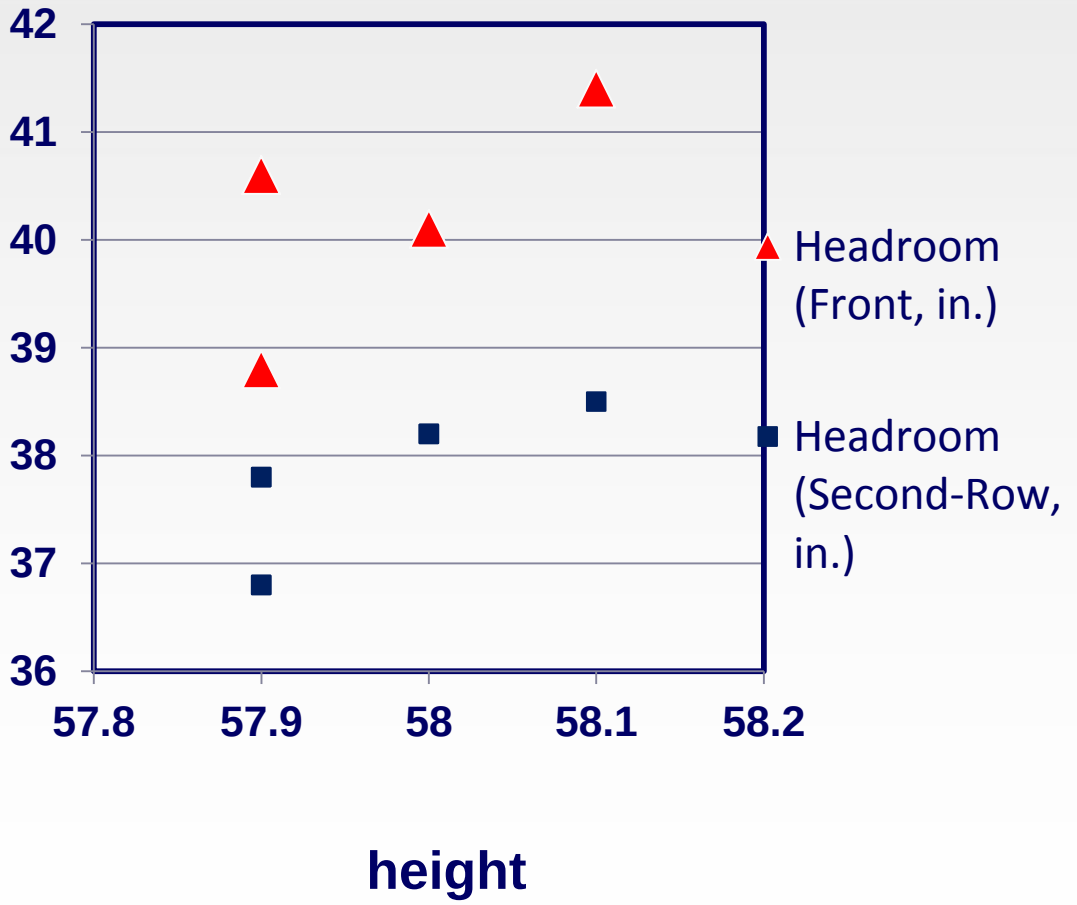
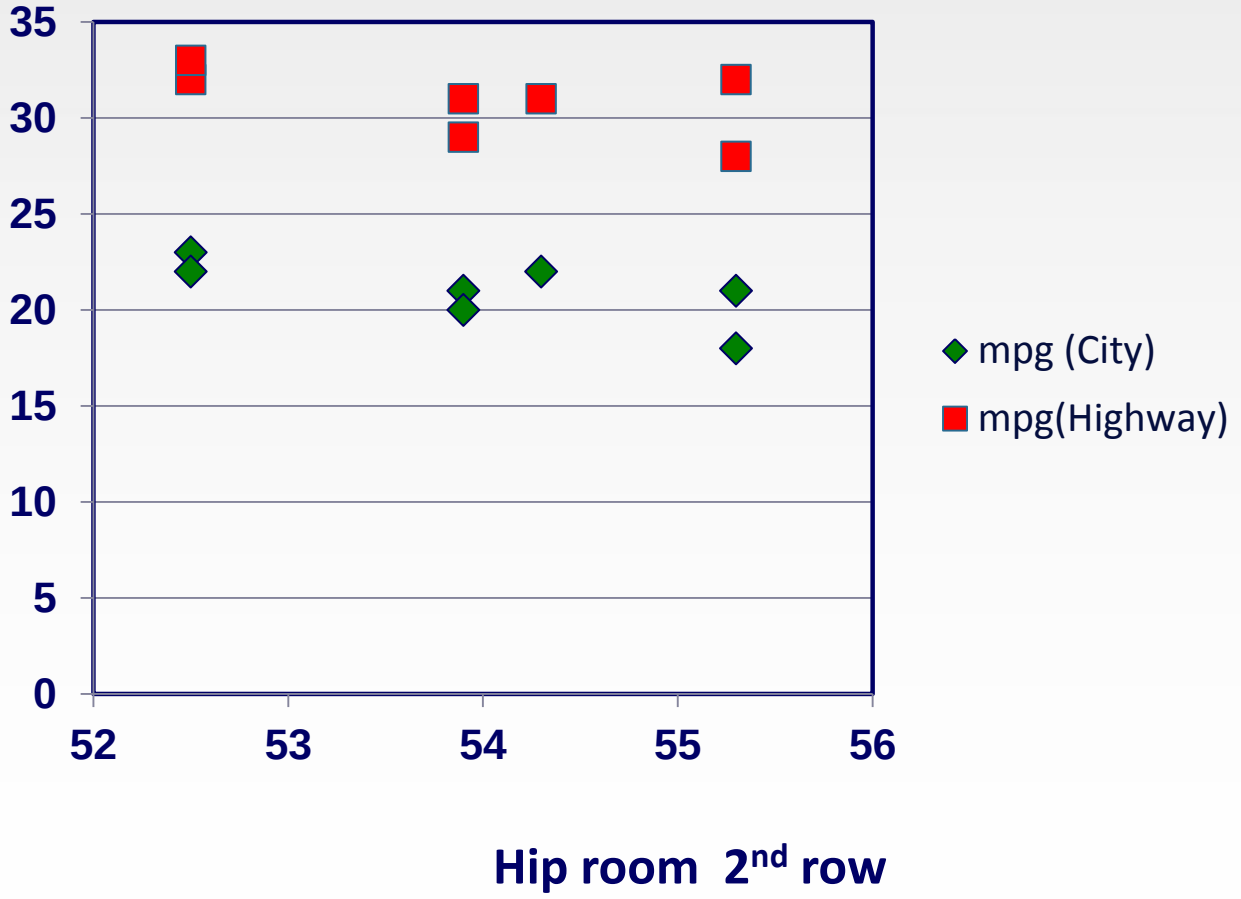
Parametric Analysis – *example*

- ✓ You can plot multiple parameters (2 is good)
- ✓ In this plot, the higher the vehicle the greater headroom space



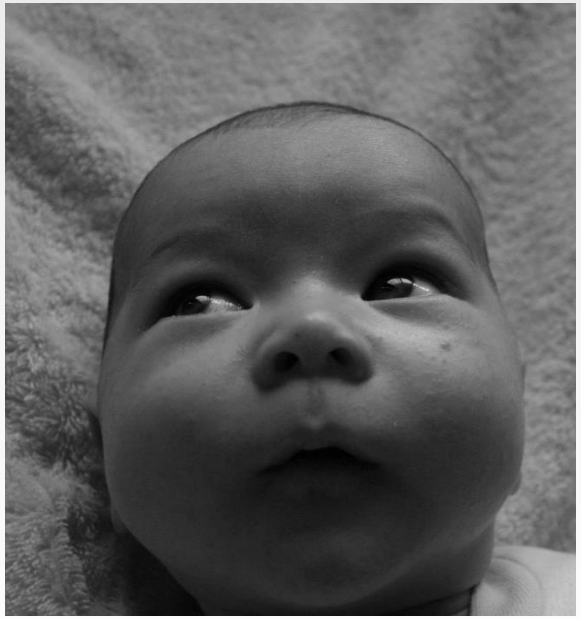
Parametric Analysis – *example*

- ✓ Some plots do not provide any useful information



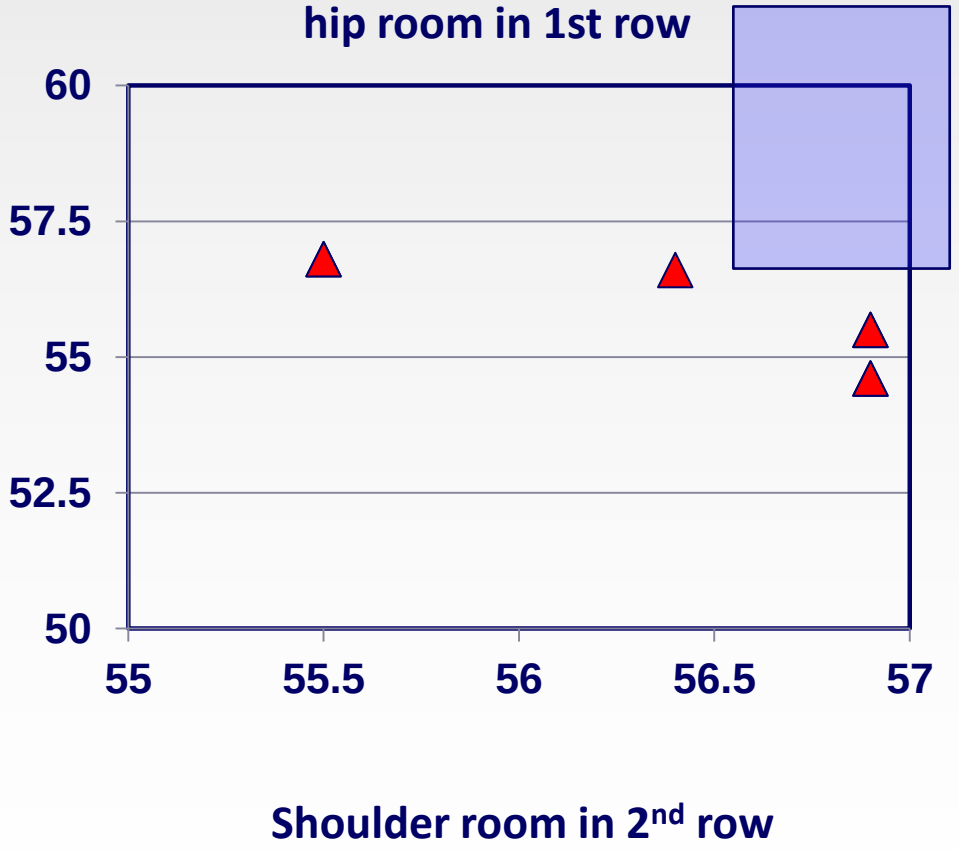
Parametric Analysis – *exercise*

- Take the data set provided for the car comparison and conduct a ***parametric analysis***

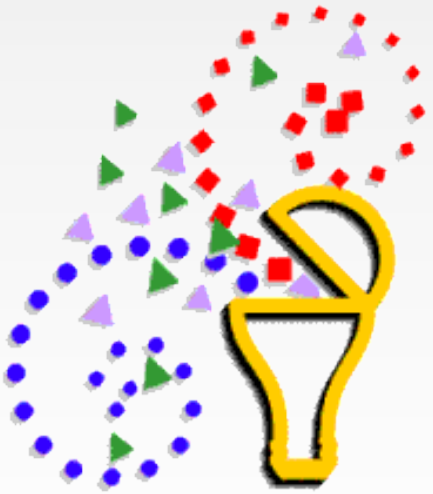


Parametric Analysis – *example*

- ✓This plot suggests that the hip room in the 1st row decreases as the shoulder room in the 2nd row increases
- ✓OPPORTUNITY – design a car that has both hip room and should shoulder room



Quality Function Deployment



Quality Function Deployment

- The ***product's quality*** can be defined as how well it meets the expectations of the users
- **QFD** translates user requirements into Design Specifications that can be used to develop the product or solution
- Prioritize Design Features
- Evaluates the Competition
- Develops the ***House of Quality***

QFD Approach

Translate **qualitative wants** into **quantitative targets**

- Customer cares about final product - design requirements
- Targets apply to individual building blocks or parts

QFD Key Points

- Use customer input (not engineering specification) to define what is important
- Focus on important items (not everything)
- Determine targets for important items - limit variations around target

The QFD Process

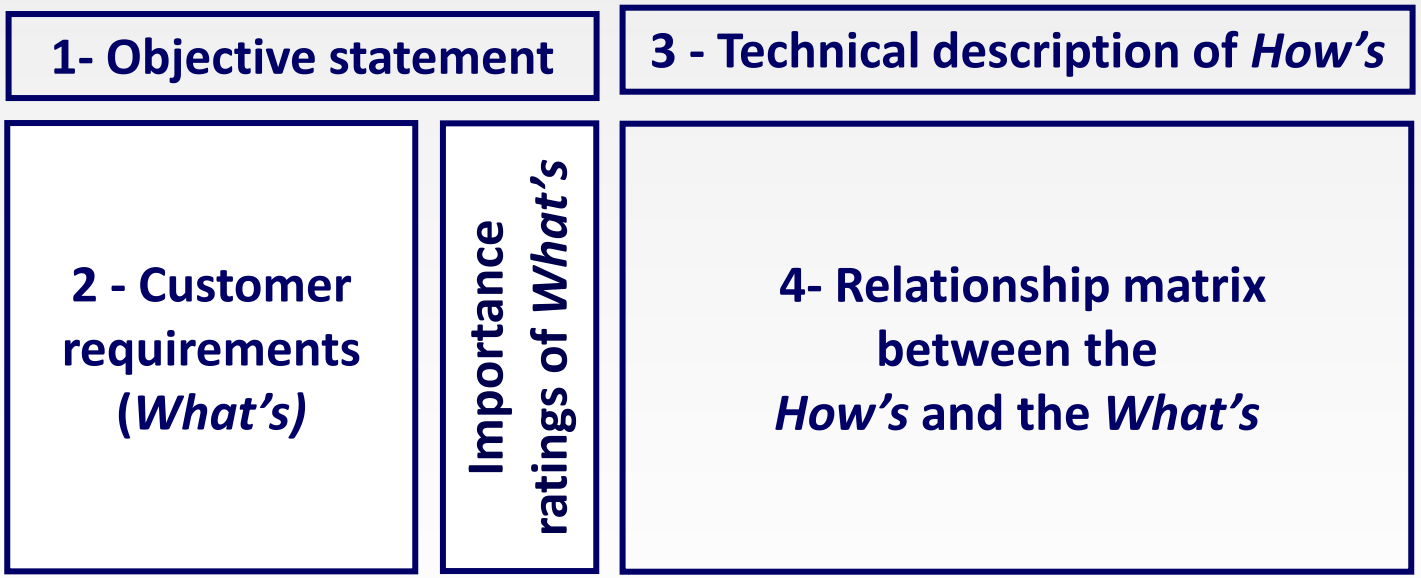
1. Identify the Customer(s)
2. Determine Customer Requirements/Constraints
3. Prioritize each requirement
4. Competitive Benchmarking
5. Translate Customer Requirements into Measurable Engineering specifications
6. Set Target values for each Engineering Specification

QFD Steps

1. Establish the **Objective**
2. Listen to customers, document the ***Voice of the Customer.*** Develop a list of **customer requirements** and establish **weighting factors** for each – this is a list of ***WHAT*** the customer wants
3. Develop a list of ***technical requirements*** – this is list of **HOWs** the customer ***wants*** will be satisfied
4. Determine the relationships between the **technical requirements** and the **customer requirements**

Partial House of Quality

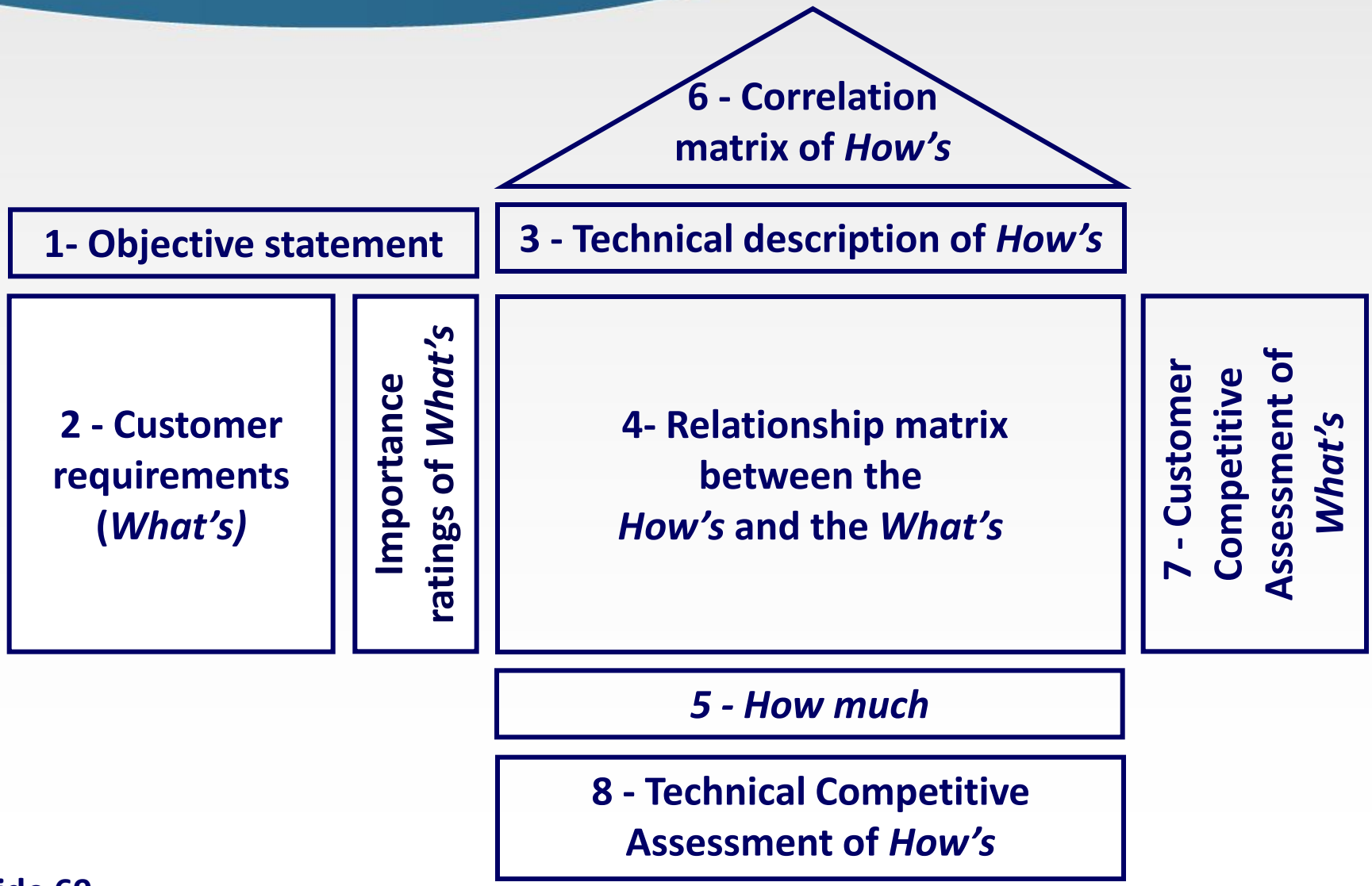
The HOWs



The WHATs

For each ***what*** we need to have one or more ***how's***

The Full House of Quality



QFD Example
An Automobile Bumper

Customer Request:

There is too much damage to bumpers in low-speed collisions. Customer wants a better bumper.

QFD Example
An Automobile Bumper

Step 1: Identify Customer(s)

- Repair Department
- Automobile Owner
- Manufacturing Plant
- Sales Force

QFD Example
An Automobile Bumper

Step 2: <u>Determine Voice of the Customer & Customer Requirements</u>

- ✓ I want something that looks nice (basic)
- ✓ It must hold my license plate (performance)
- ✓ I want it strong enough not to dent (excitement)
- ✓ It must protect my tail-lights and head-lights (performance)
- ✓ I don’t want to pay too much (basic)

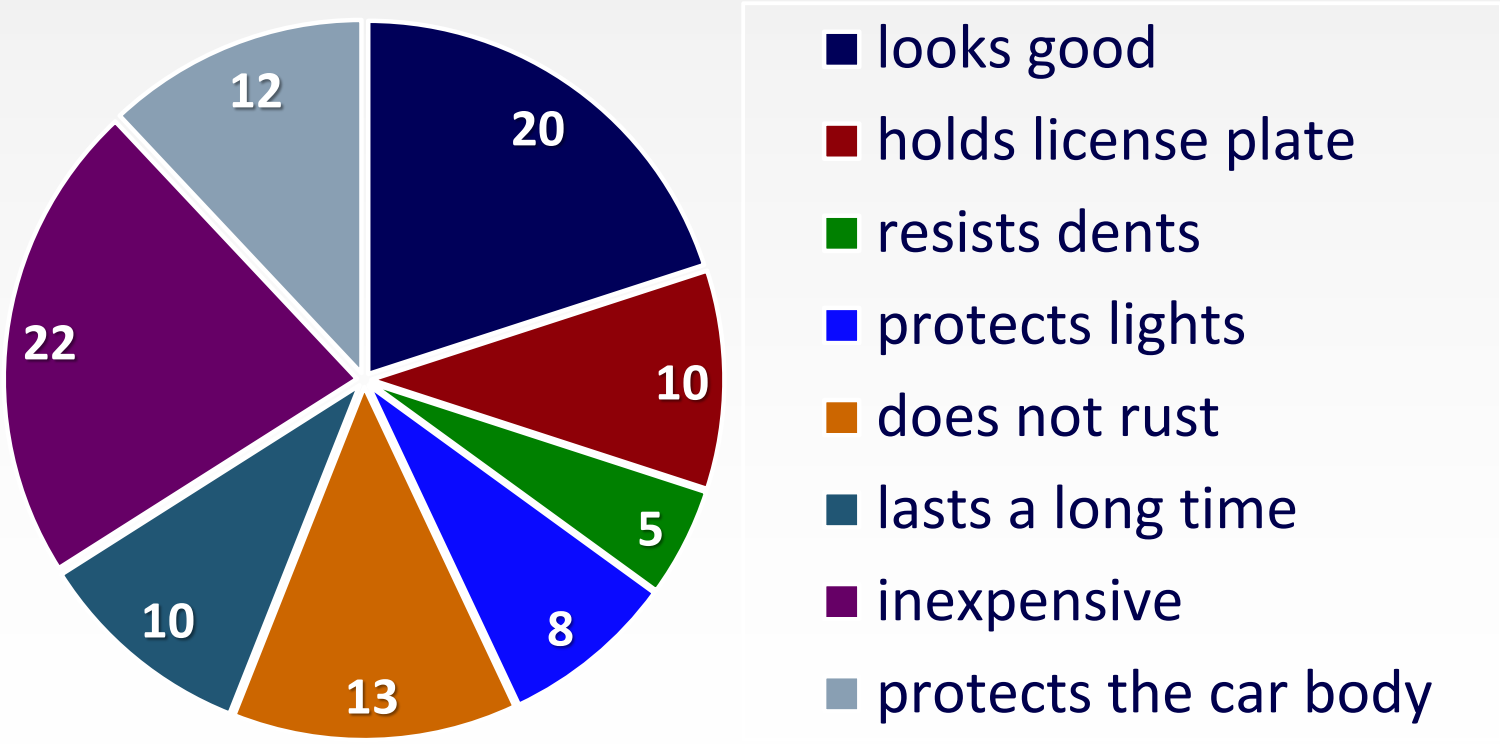
Voice of the customer to customer requirement

Step 2: <u>Determine Voice of the Customer & Customer Requirements</u>

- ✓ looks good
- ✓ holds license plate
- ✓ resists dents
- ✓ protects lights
- ✓ does not rust
- ✓ lasts a long time
- ✓ inexpensive
- ✓ protects the car body

QFD Example
An Automobile Bumper

Step 2: Prioritize Customer Requirements



QFD Example
An Automobile Bumper

Customer requirements	
looks good	20
holds license plate	10
resists dents	5
protects lights	8
does not rust	13
lasts a long time	10
inexpensive	22
protects the car body	12

- ✓ These are **customer requirements** – how do we design for requests such as ***"it must last a long time"?***
- ✓ We must design for **engineering requirements**

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From customer requirement to technical requirements

Step 3: Determine The Technical Requirements

Customer requirement (what?)	Technical requirements (how?)
Looks good	*Surface finish, formability, hardness*
Lasts a long time	*Corrosion resistance*
inexpensive	*Cost, weight, formability*
Resists dents	*Toughness, hardness, stiffness*

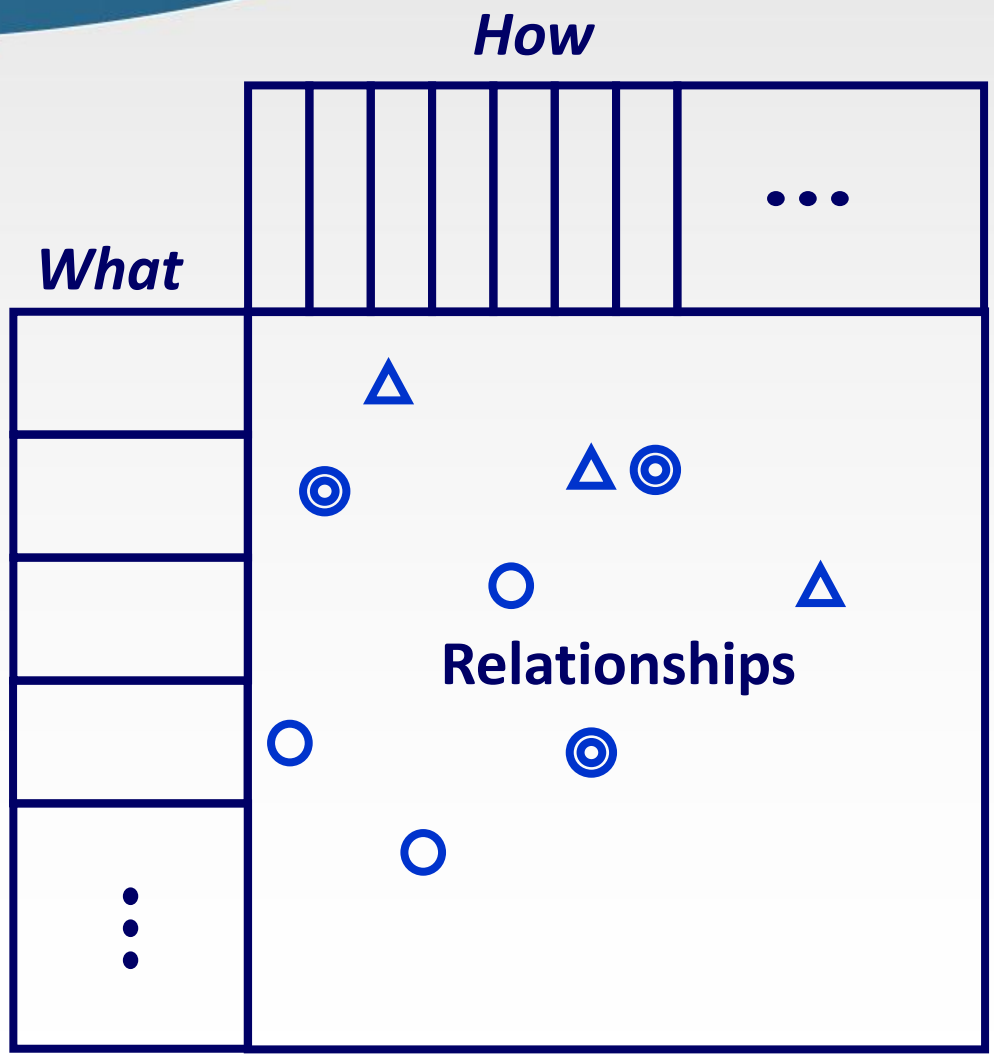
Relationship Matrix

- Interactions occur
- Define a ***relationship matrix*** between ***What*** and ***How*** to the level of ***strong*** , ***medium***, ***weak***
- This begins the cross checking feature of QFD
- blanks indicate inadequate translation of ***What*** to ***How***.

Relationship Matrix

Determine individual relationships between *what's* and *how's*

- △ - **weak**
- ○ - **medium**
- ◎ - **strong**



relate *customer requirements* to *technical requirements*

Step 4: <u>Relate Customer Requirements to Technical Requirements</u>

relationship	symbol	ranking
strong	◎	9
medium	○	3
weak	△	1

QFD Example
An Automobile Bumper

technical requirements

Customer requirements

		Yield strength	modulus	toughness	weight	Surface finish	cost	Corrosion resistance	hardness	formability
looks good	20					◎			△	○
holds license plate	10	◎	△							
resists dents	5		◎	◎					△	
protects lights	8	○	◎							
does not rust	13							◎	○	
lasts a long time	10						◎	◎		
inexpensive	22	△			○		◎			○
protects the car body	12	◎	◎	◎						

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Step 5 - *establish technical requirement limits*

technical requirements

Customer requirements

		Yield strength	modulus	toughness	weight	Surface finish	cost	Corrosion resistance	hardness	formability
looks good	20					◎			△	○
holds license plate	10	◎	△							
resists dents	5		◎	◎					△	
protects lights	8	○	◎							
does not rust	13							◎	○	
lasts a long time	10						◎	◎		
inexpensive	22	△			○		◎			○
protects the car body	12	◎	◎	◎						

technical requirements

77,000psi	15 mpsi	350 pis	0.5 lb/ft	glossy	$15/ft	Rating A	60 BHN	75 / 100

QFD Exercise – *Captain's Coffee Cup*

Customer:

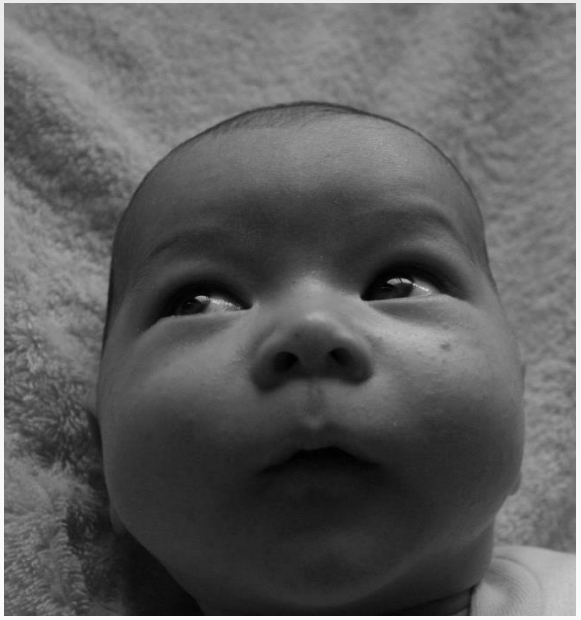
- People who use cups for drinking on boats

Project Focus Area:

- Create best cup for use on a boat

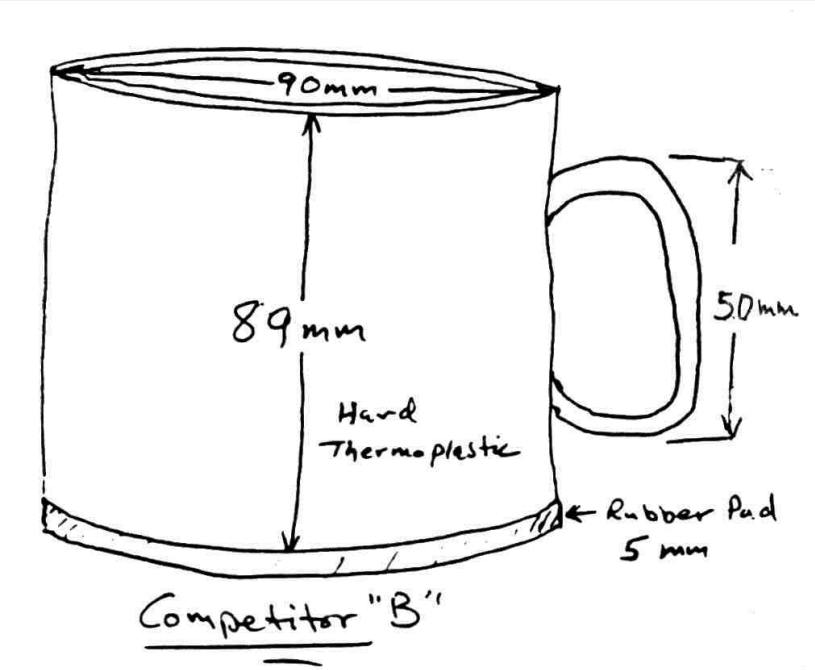
Time Constraint:

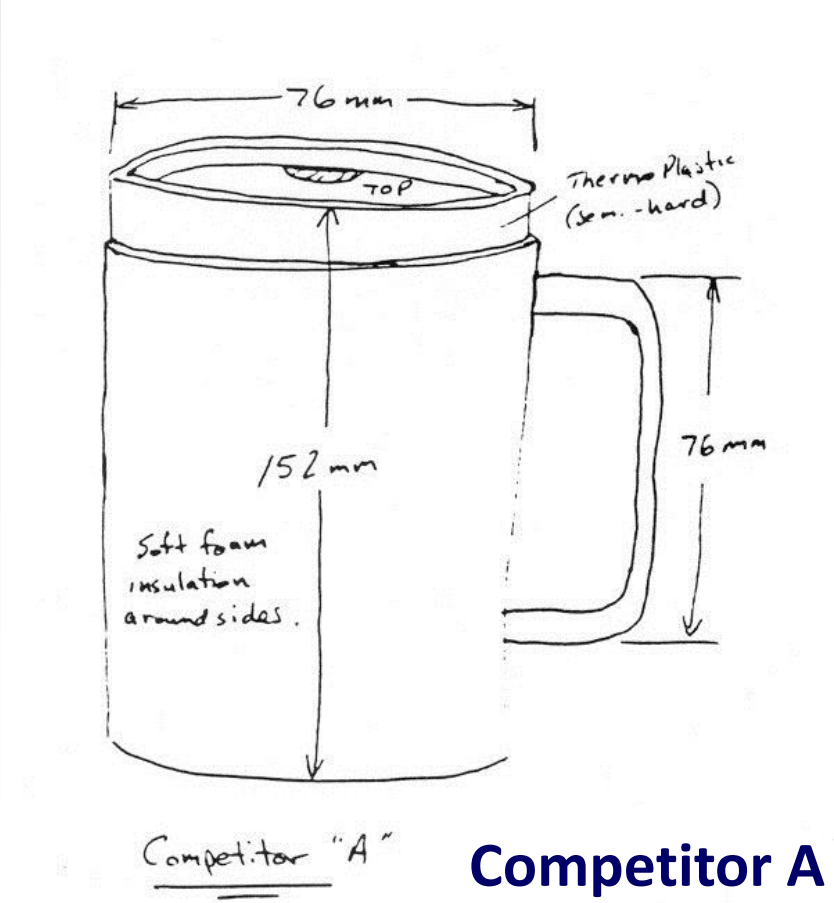
- 6 months from start of product development to market



Competitors

Competitor B





Competitor A

Determine the **WHAT**s and **HOW**s

Determine the WHATs

- ✓ what the customer wants - a product feature and characteristic
- ✓ this is not something that is directly actionable,
- ✓ i.e. we don't yet know what to do to get the feature /characteristic of the product

Determine the HOWs

- This is a statement on how a designer can meet the customer requirements actionable items
- Example

☑**What** – soft bed

☑**How** –material stiffness

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Coffee mug
Customer needs - *What's*

- Holds a lot of coffee
- Keeps drink warm
- Stable
- Stays where put
- Durable
- Looks Good
- Splashless
- Easy to Hold

Coffee mug
Technical requirements - *how's*

- ✓ Height
- ✓ Bottom area
- ✓ Handle size
- ✓ Top area
- ✓ Durability of material
- ✓ Color
- ✓ Volume
- ✓ Height of CG, %
- ✓ Insulation value
- ✓ Top covered?
- ✓ Weight
- ✓ Bottom coefficient of friction

Listening to the Customer

Vegetable Peeler Design

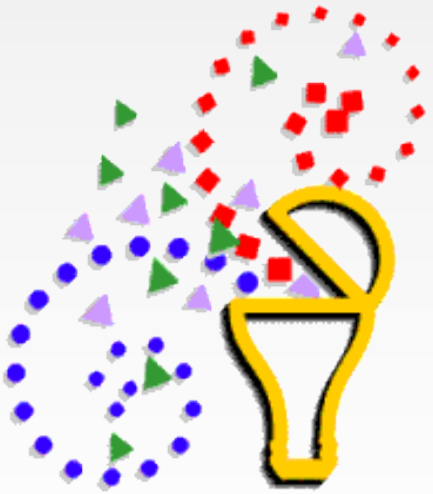
Listening to the Customer

- “Carrots and potatoes are very different."
- "I cut myself with this one."
- "I just leave the skin on."
- "I'm left-handed. I use a knife."
- "This one is fast, but it takes a lot off."
- "How do you peel a squash?"
- "Here's a rusty one."
- "This looked OK in the store."

Customer Requirements

- peels a variety of produce.
- can be used ambidextrously.
- create minimal waste.
- save time.
- durable.
- easy to clean.
- safe to use and store.
- comfortable to use.
- stays sharp or can be easily sharpened.

product
design
specifications



Product Design Specification

- This is an organized method for documenting the ***specifications*** of the desired solution

requirement	Motivation or justification	Target Value	Need or desire

Establish Target Specifications

- ***Activities***
  - Identify metrics for each customer need
  - Identify ideal and marginally acceptable target values
  - Identify leverage opportunities
  - *Translate customer requests into engineering parameters*

Establish Target Specifications

- ***Deliverables***
  - Relationship Matrix (Technology vs. requirements)
  - Engineering Metrics Sheet (EMS)
  - Product Design Specifications

Identify Customer Needs - *example*

High Speed Point of Sale

- "Design a ***cost effective*** high speed inkjet printer for printing receipts, capable of ***outperforming*** any of the existing receipt printing systems now in the marketplace"

Product Design Specifications

- This a list of design specifications of what does the solutions have to satisfy in order to meet design goals

Product Description *Example*

- ***Problem Statement*** – There are many land mines that are in former war fields, these go undetected until the explode when an unaware person walks over it.
- ***Objective*** - Create a cost effective land mine detector to be used in former war zones in the ***"3rd World"***

MINE DETECTOR - PDS

- **Functional Performance**: The autonomous mine detector is designed to sweep a 20’ x 20’ terrain with the capability of detecting up to four land mines.
- **Requirement: Time**

  - Complete sweep of area in 10 minutes

- **Requirement: Budget constrained**

  - $400 of reimbursed capital

  - $100 of out of the pocket capital

MINE DETECTOR - PDS

- **Requirement: Must be back-portable**
  - Fit in 2’ x 2’ x 2’ box
  - Weigh less than 50 lbs
- **Requirement: Does not detonate mine**
  - Sniffer at least 9” above center of mine
  - Parts of vehicle that touch ground at least 9” radius from center of mine

The importance of the PDS

- A Product Design Specification (PDS) is a structured description of the purpose, functions, characteristics and other kinds of information that describe the design problem.
- Developing a proper PDS is the essential first step in any design process.

The importance of the PDS

- A good PDS is especially important when designing in teams, because it's vital that the whole team solve the *same* problem.
- Sometimes, different team members will be working on slightly different problems - without knowing it.

The importance of the PDS

- Each will end up with slightly different solutions - slightly different designs - that will be incompatible. These kinds of problems can be quite small but can lead to huge losses in efficiency and product quality.

MINE DETECTOR - PDS

- **Requirement: Operates in various climates**
  - Functions in temperatures ranging from -10°F to 120°F
  - Functions in precipitation (handles daily maximum rainfall recorded in South Bend)
  - System functions in a maximum of 3” of snow/water

MINE DETECTOR

- **Requirement: Undetectable by enemy**
  - Cannot be radio controlled
  - Cannot be wire controlled
- **Requirement: Sufficiently powered for one sweep**
  - Battery powered (Type to be decided)
  - Battery life of 10 or more minutes
- **Requirement: Safe for use**
  - Designed for operator of 18 years or older

Identify Customer Needs - *example*

High Speed Point of Sale

- "Design a ***cost effective*** high speed inkjet printer for printing receipts, capable of ***outperforming*** any of the existing receipt printing systems now in the marketplace"

PDS for HS POS (partial list)

Requirement	Motivation	Target
Size		
Weight		
Shipping		
Disposal		
Company Constraints		

PDS for HS POS (partial list)

Requirement	Motivation	Target
Size	The new printer system is targeted to compete with present systems. We want these printers to be smaller than existing printer since the space on sales counters in a precious commodity	

PDS for HS POS (partial list)

Requirement	Motivation	Target
Size	The new printer system is targeted to compete with present systems. We want these printers to be smaller than existing printer since the space on sales counters in a precious commodity	❖Depth <= 7” ❖Width <= 6” ❖Height <= 8”

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PDS for HS POS (partial list)

Requirement	Motivation	Target
Weight	We want these printers to be lighter than the existing systems so that it is very easy to move it very quickly from one counter to another. Make it so that one person can carry it without suffering any injuries	

PDS for HS POS (partial list)

Requirement	Motivation	Target
Weight	We want these printers to be lighter than the existing systems so that it is very easy to move it very quickly from one counter to another. Make it so that one person can carry it without suffering any injuries	Weight < 7 pounds

PDS for HS POS (partial list)

Requirement	Motivation	Target
Shipping	We want to be able to ship these printers even by air mail in case we have to replace one very quickly. So the unit and the required packaging should still satisfy the requirements for Next Day Service	❖Depth <= 7” ❖Width <= 6” ❖Height <= 8” ❖Weight < 20 lbs

PDS for HS POS (partial list)

Requirement	Motivation	Target
Disposal	The system will be design so that it can be taken apart very easily. Neither the printer nor the supplies can have any toxic materials	

PDS for HS POS (partial list)

Requirement	Motivation	Target
Disposal	The system will be design so that it can be taken apart very easily. Neither the printer nor the supplies can have any toxic materials	❖Disassembly time <=2 hours ❖NO TOXICS, ❖Use recycled materials ❖Follow EU disposal standards

PDS for HS POS (partial list)

Requirement	Motivation	Target
Company Constraints	We want this new product to be aligned with Ithaca POS Jet 1000, we do not want to have people who own existing HS POS InkJet Solutions to dump this printer or take away from their market share. We want to beat direct thermal printers	

PDS for HS POS (partial list)

Requirement	Motivation	Target
Company Constraints	We want this new product to be aligned with Ithaca POS Jet 1000, we do not want to have people who own existing HS POS InkJet Solutions to dump this printer or take away from their market share. We want to beat direct thermal printers	❖Cost of Printer <= DT ❖Total Cost of Owners ❖HS TIJ <= 0.75 Direct Thermal

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PDS for HS POS (partial list)

Requirement	Motivation	Target
Speed		
Power consumption		
Service		
Data permanence		
Ease of use		

Generate Product Concepts

Activities

- *Identify critical sub- problems*
- *Patent search*
- *Literature search*
- *Competitive benchmarking assessment*
- *Concept generation*

Generate Product Concepts

Deliverables

- *Function diagrams*
- *Concept classification tree*
- *Concept combination table*
- *Concept description/sketches*

Concept Generation

- ***Clarify the problem***
  - *problem decomposition*

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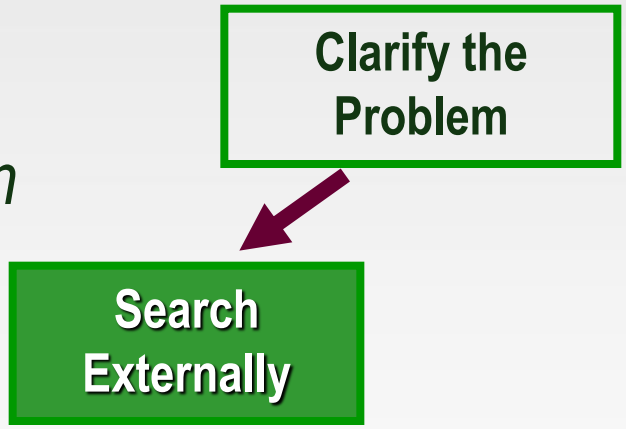
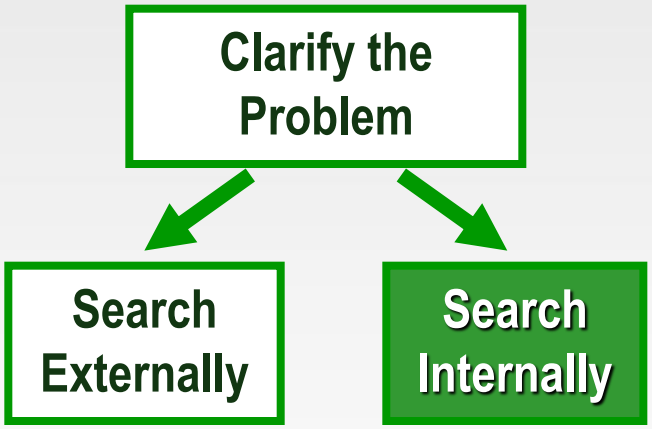
Concept Generation

- ***Clarify the problem***
  - *problem decomposition*
- ***External Search***
  - *Lead users*
  - *Experts*
  - *Patents*
  - *Literature*
  - *Benchmarking*



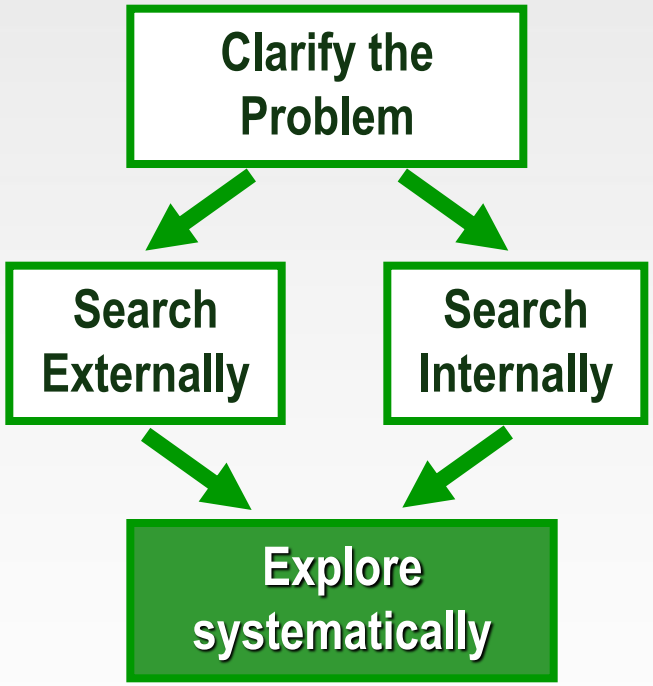
Concept Generation

- ***Internal Search***
  - *Individual Methods*
  - *Group Methods*



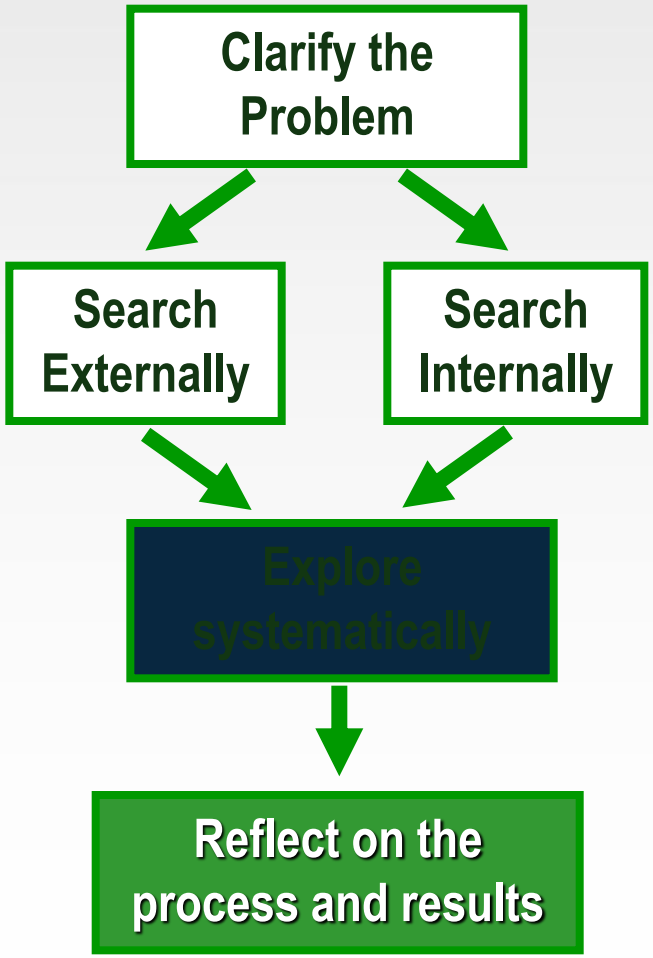
Concept Generation

- ***Internal Search***
  - *Individual Methods*
  - *Group Methods*
- ***Systematic Exploration***
  - *Classification Tree*
  - *Combination Table*



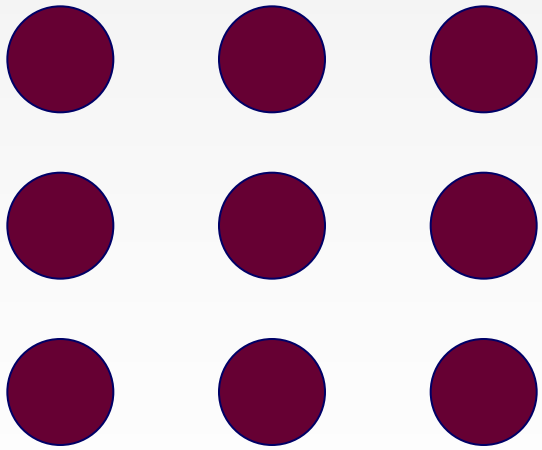
Concept Generation

- ***Internal Search***
  - *Individual Methods*
  - *Group Methods*
- ***Systematic Exploration***
  - *Classification Tree*
  - *Combination Table*
- ***Reflect on the Process***
  - *Continuous Improvement*



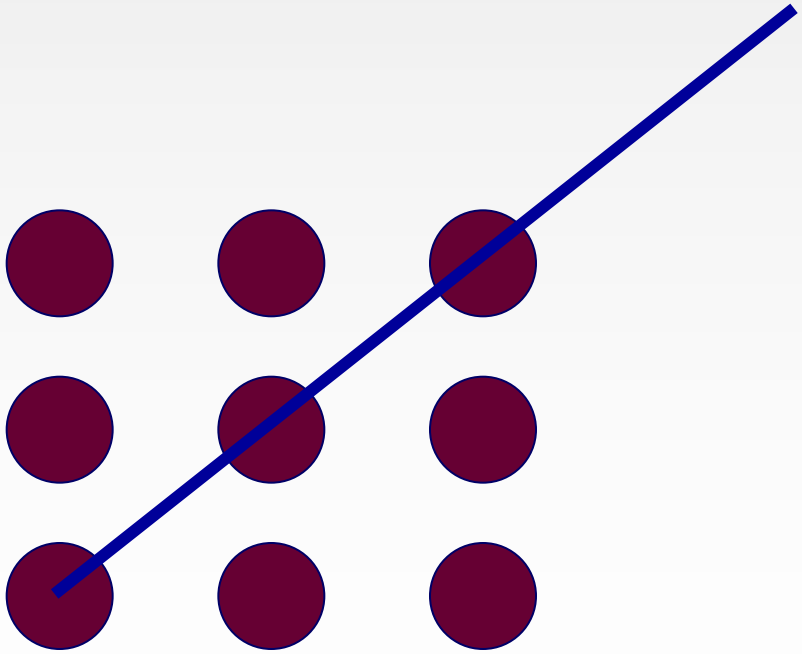
Concept Generation

Problem – Connect the dots with 4 lines or less



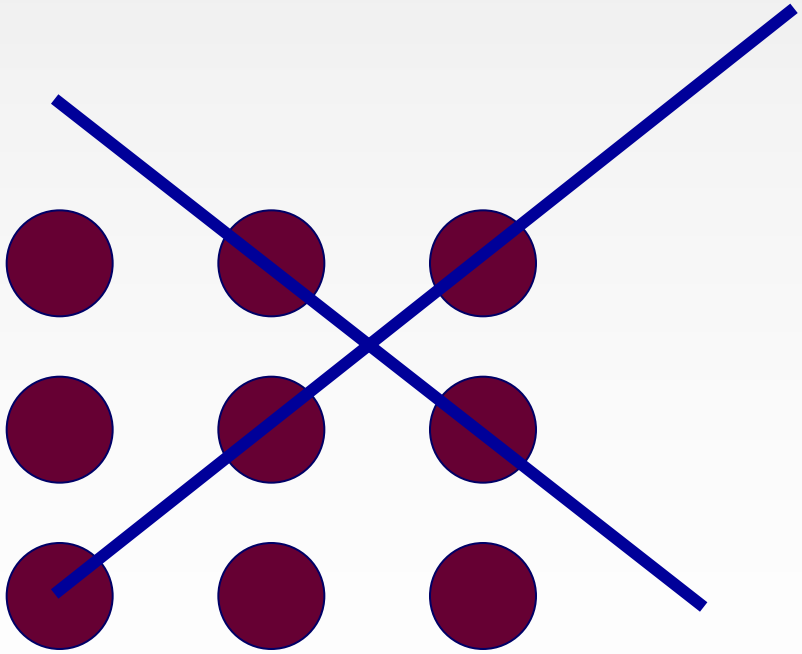
Concept Generation

Problem – Connect the dots with 4 lines or less



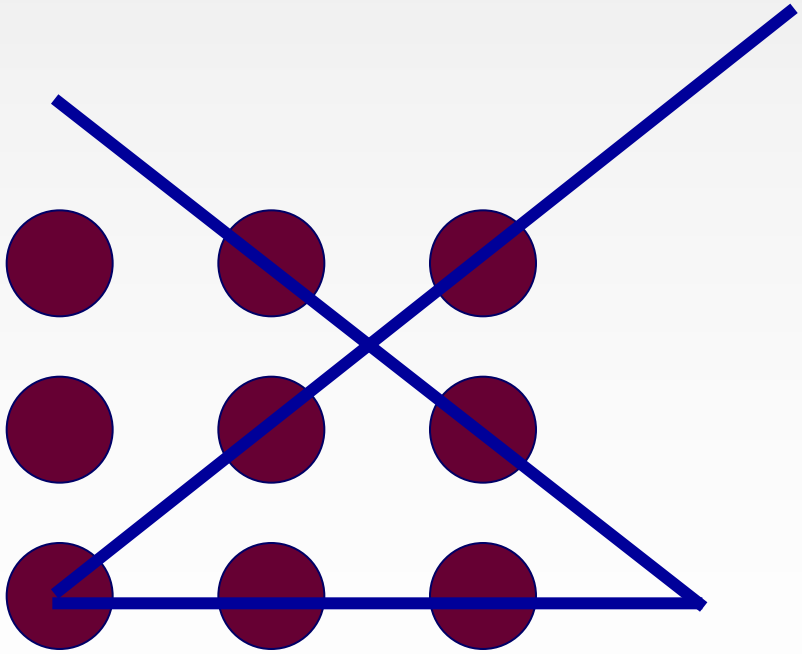
Concept Generation

Problem – Connect the dots with 4 lines or less



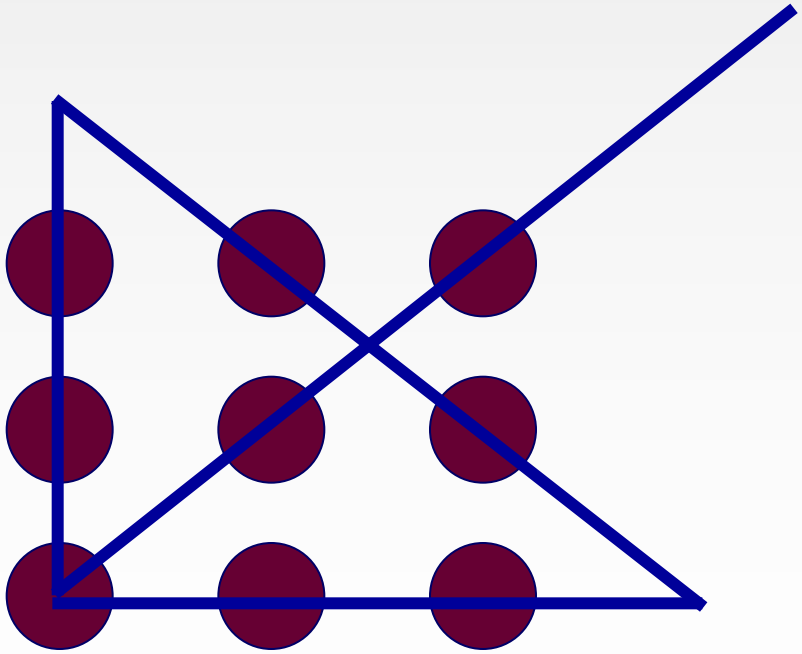
Concept Generation

Problem – Connect the dots with 4 lines or less



Concept Generation

Problem – Connect the dots with 4 lines or less



Brainstorming

- The term **Brainstorming** has become a commonly used word in the English language as a generic term for creative thinking.
- The basis is the generation of ideas in a group situation based on the principle of suspending judgment - a principle which scientific research has proved to be highly productive in individual effort as well as group effort.
- The generation phase is separate from the judgment phase of thinking

Classic Brainstorming

- Arrange the meeting for a group of the right size and makeup (typically 4-8 people)
- Write the initial topic on a flipboard, whiteboard or other system where everyone can see it.
- The better defined, and more clearly stated the problem, the better the session tends to be.
- Make sure that everyone understands the problem or issue

Classic Brainstorming
the ground rules

- Avoid criticizing ideas / suspend judgement. All ideas are as valid as each other
- Lots, Lots & Lots - a large number of ideas is the aim
- Free-wheeling. Don't censor any ideas, keep the meeting flow going.
- Listen to other ideas, and try to piggy back on them to other ideas.
- Avoid any discussion of ideas or questions, as these stop the flow of ideas.

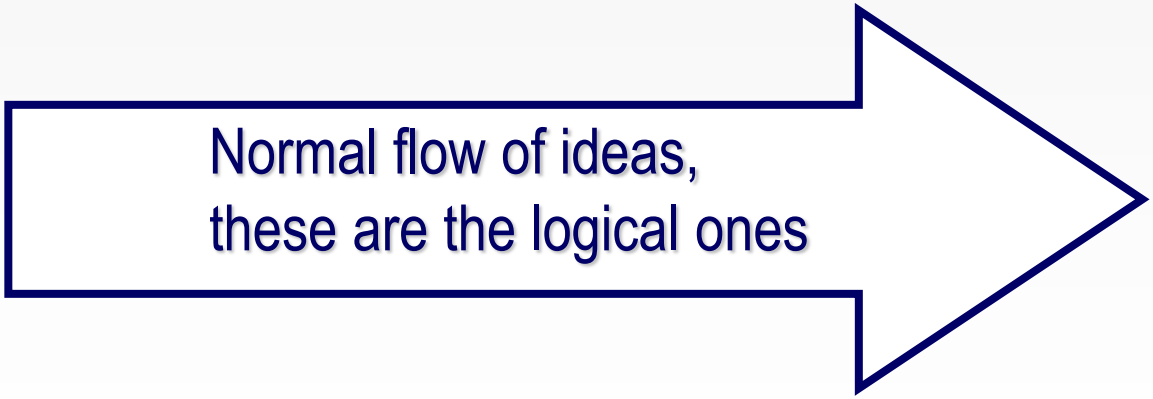
Classic Brainstorming
the ground rules

- Have someone facilitating to enforce the rules and write down all the ideas as they occur
- Generate ideas - either in an unstructured or structure way
- Clarify and conclude the session.
- Ideas that are identical can be combined, all others should be kept.
- It is useful to get a consensus of which ideas should be looked at further or what the next action and timescale is

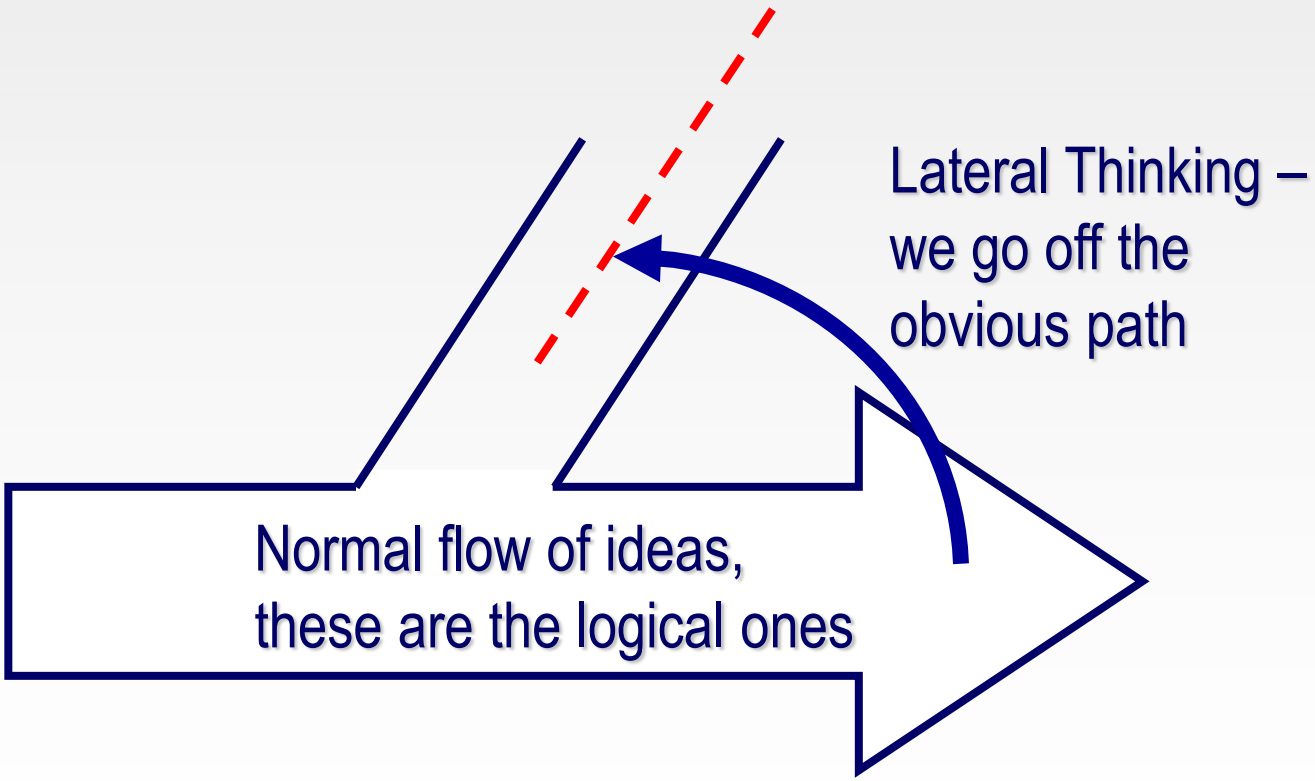
Lateral Thinking

- The entry in the Concise Oxford Dictionary reads: "*seeking to solve problems by unorthodox or apparently illogical methods.*
- Lateral thinking is about moving sideways when working on a problem to try different perceptions, different concepts and different points of entry.
- The term covers a variety of methods including *provocations* to get us out of the usual line of thought.

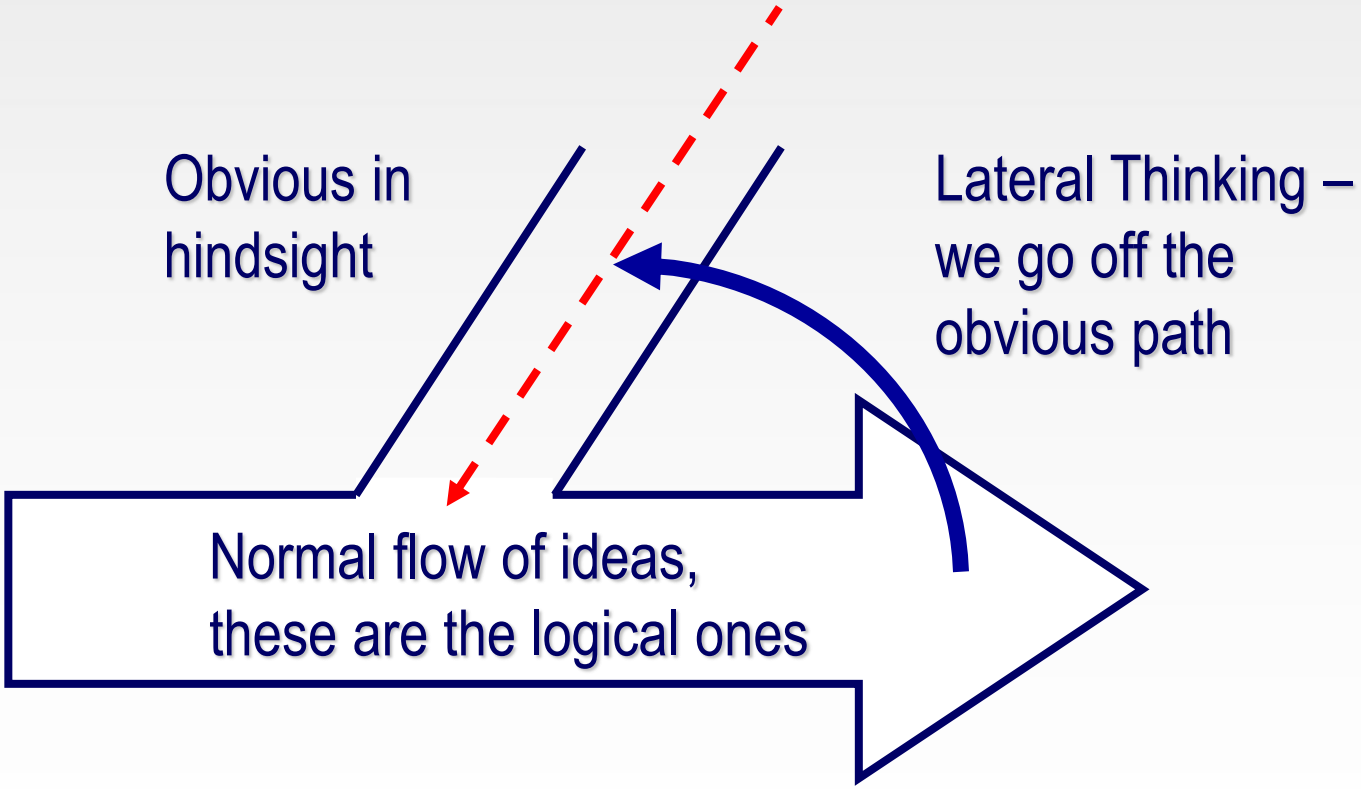
Lateral Thinking



Lateral Thinking



Lateral Thinking



Lateral Thinking

- Lateral thinking is cutting across patterns in a self-organizing system, and has very much to do with perception
- "Lateral thinking" can be used in two senses:
  - ***Specific***: A set of systematic techniques used for changing concepts and perceptions, and generating new ones.
  - ***General***: Exploring multiple possibilities and approaches instead of pursuing a single approach

Lateral Thinking Example

- Granny is sitting knitting and three year old Susan is upsetting Granny by playing with the wool.

Lateral Thinking Example

- Granny is sitting knitting and three year old Susan is upsetting Granny by playing with the wool.
- *One parent suggests putting Susan into the playpen.*

Lateral Thinking Example

- Granny is sitting knitting and three year old Susan is upsetting Granny by playing with the wool.
- *The other parent suggests it might be a better idea to put Granny in the playpen to protect her from Susan. A lateral answer!*

Select Product Concepts

Activities:

- *Develop and Define a list of attributes*
- *Determine weights of attributes*
- *Rate and rank the concepts*
  - *Controlled Convergence*
  - *Rating / Weighting*
- *Combine and improve concepts*

Developing a List of Attributes

- The attributes are a list of desirable characteristics that describe the ideal solution
- Many times it can be the requirements of the PDS or a condensed list of these requirements

Example of List of Attributes - HS POS

attribute	definition
DPI	Dots per inch, a measure of image quality
Energy consumption	This is a measure of the power to operate the machine
footprint	The space it takes on the counter
Total Cost of Ownership TOC	This is a measure of the money that will be spent to purchase and operate the machine
Ease of maintenance	This is a measure of the time and effort it takes to replace paper and ink

Select Product Concepts

Deliverables:

- *Concept screening matrix*
- *Concept scoring matrix*

The Controlled Convergence Method

1. List all concepts
2. Setup a matrix
3. Select the “best” idea, this will be the ***datum idea***

The Controlled Convergence Method

4. Compare each idea with the datum with each attribute
   - *i. - If the idea is better, use "**+**"*
   - *ii. - If the idea is worse, use "**-**"*
   - *iii. - If the idea is the same, assign an "**=**"*
5. Add all the "+"; all the "–"and all the "="
6. Select the idea with the more"+" and less "-"

example

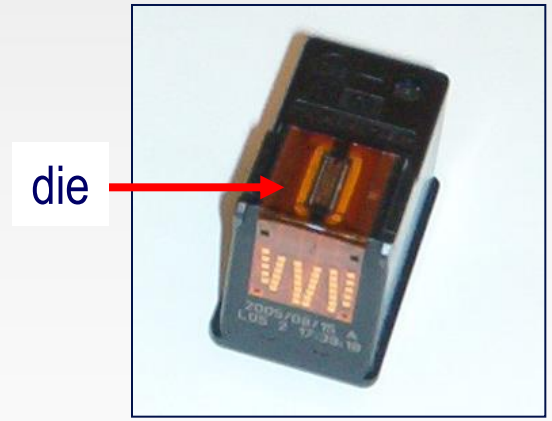
High Speed Point of Sale

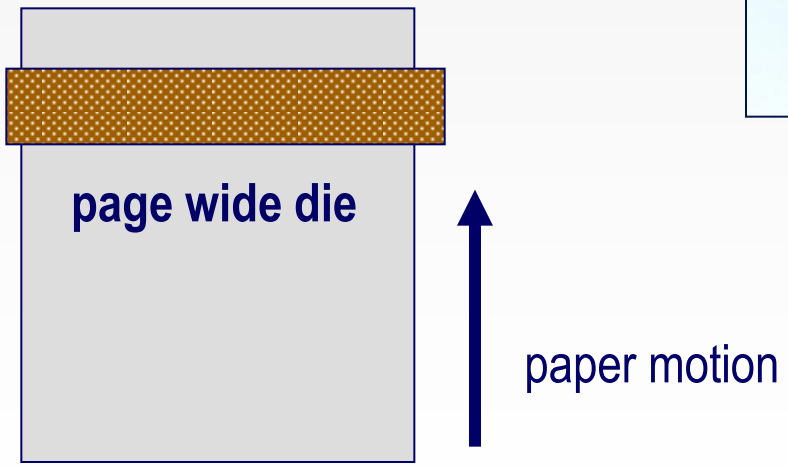
- "Design a ***cost effective*** high speed inkjet printer for printing receipts, capable of ***outperforming*** any of the existing receipt printing systems now in the marketplace"

List all Concepts

Page Wide Array –

die will be made as wide as the paper

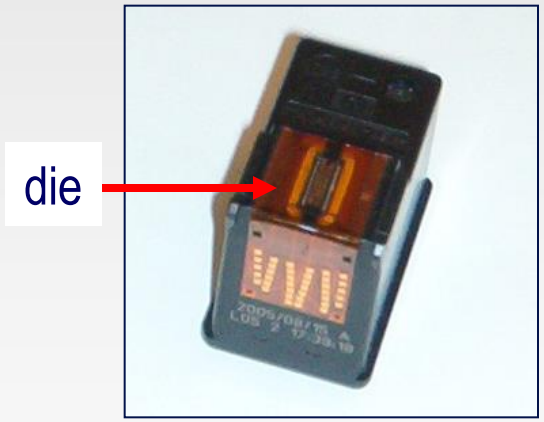


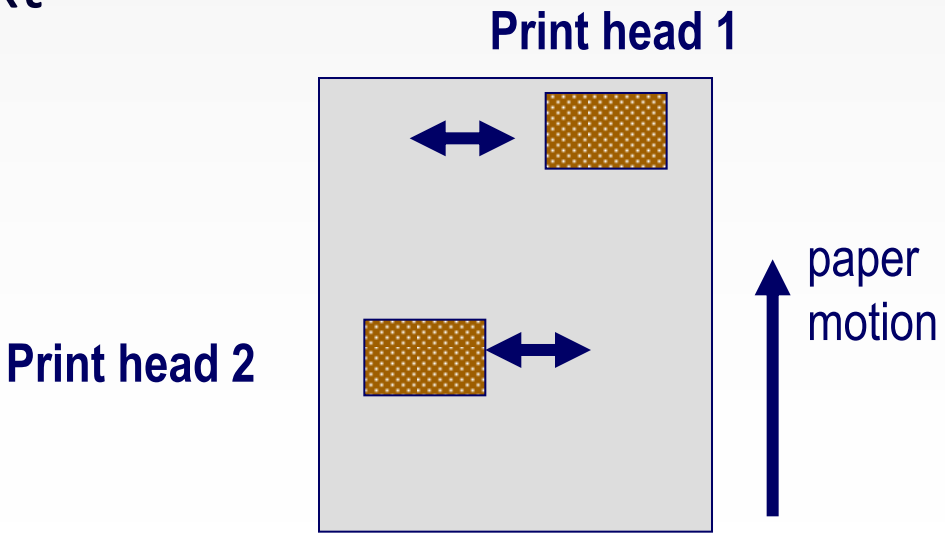


List all Concepts

Multiple Print Head –

this printer uses 2 or 3 print heads, all working concurrently and each one prints part of the text





List all Concepts

Direct Thermal –

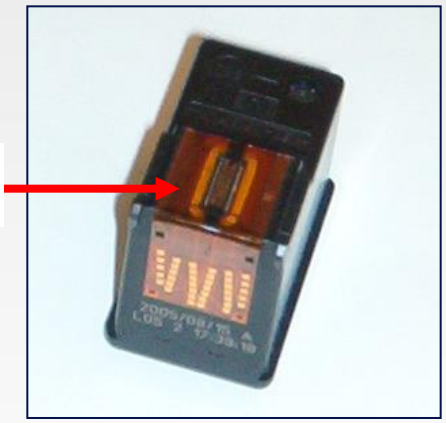
this is the actual system which uses thermal paper and a thermal element

This will be our datum

List all Concepts

Table Rock –

this is a printer cartridge that has a 0.75” wide die and it is readily available



Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI				
Speed				
Cost				
TCO				
Ink Volume				
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

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Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed				
Cost				
TCO				
Ink Volume				
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

mjr

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost				
TCO				
Ink Volume				
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO				
Ink Volume				
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume				
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability				
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability	=	+		+
footprint				
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability	=	+		+
footprint	=	=		+
ease of operation				
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability	=	+		+
footprint	=	=		+
ease of operation	+	+		+
power usage				
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability	=	+		+
footprint	=	=		+
ease of operation	+	+		+
power usage	+	+		+
sum of +				
sum of -				
sum of =				

Controlled Convergence Matrix

attributes	Page Wide Array	Multiple Print Head	Direct Thermal	TableRock
DPI	+	+		+
Speed	+	+		-
Cost	-	-		=
TCO	-	-		-
Ink Volume	=	-		-
Manufacturability	=	+		+
footprint	=	=		+
ease of operation	+	+		+
power usage	+	+		+
sum of +	*4*	*5*		*5*
sum of -	*2*	*3*		*3*
sum of =	*3*	*1*		*1*

mjr