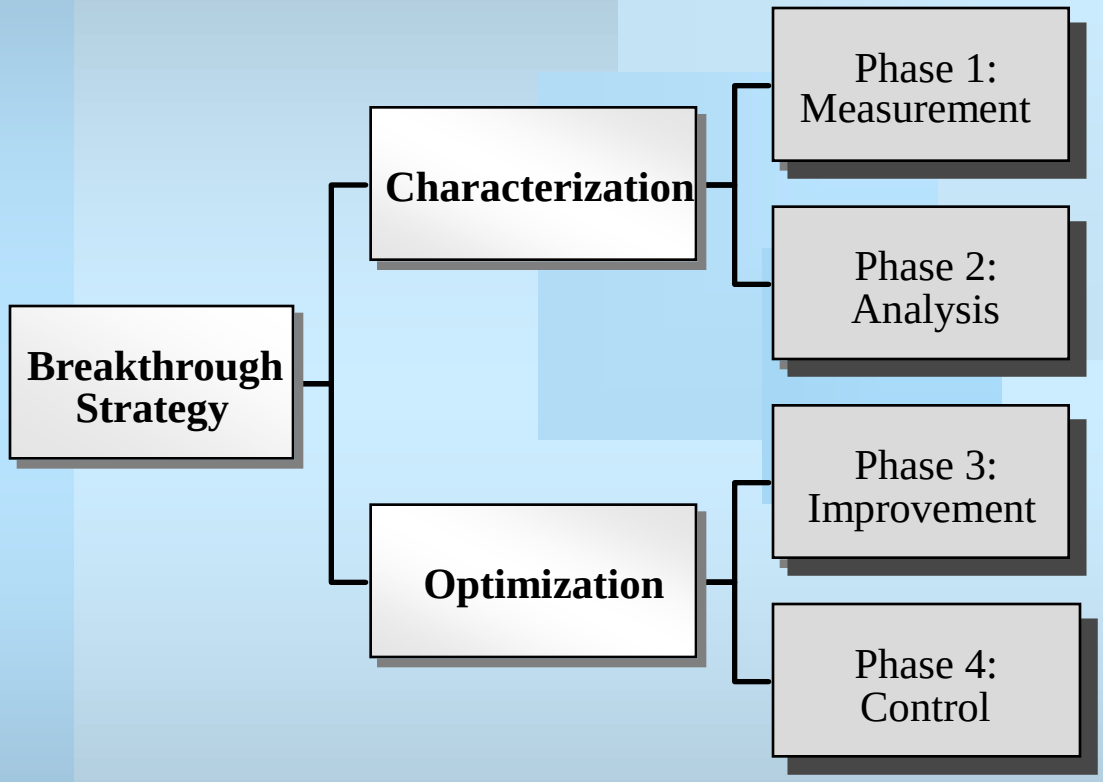
6sigma concept

The Breakthrough Phases



The Breakthrough Strategy

Step I: Process Measurement

- Plan project and identify key process input / output variables
- Perform gage studies essential measurement systems
- Perform short-term capability studies and evaluate control plan

Step II: Process Analysis

- Complete FMEA and evaluate control plan
- Complete Multi-vari studies and identify potential key inputs
- Review data and prioritize key input variables

Step III: Process Improvement

- Verify critical inputs using DOE
- Determine the optimum operating window
- Update the control plan

Step IV: Process Control

- Finalize the process control plan
- Ongoing verification of the stability and capability of the process

What is Six Sigma?

- Bottom line: Six Sigma
  - Defines the goals of the business
  - Defines performance metrics that tie to the business goals
  - Identifies projects using performance metrics that will yield clear business results
  - Applies advanced quality and statistical tools to achieve breakthrough financial performance

Six Sigma - Goal

(Distribution Shifted ± 1.5σ)

σ	PPM
2	308,537
3	66,807
4	6,210
5	233
6	3.4

Process Capability

Defects per Million Opp.

Sigma is a statistical unit of measure that reflects process capability. The sigma scale of measure is perfectly correlated to such characteristics as defects-per-unit, parts-per million defective, and the probability of a failure/error

Six Sigma corresponds to parts per billion if process is centered

Six Sigma -- Practical Meaning

99% Good (3.8 Sigma)		99.99966% Good (6 Sigma)
• 20,000 lost articles of mail per hour	→	• Seven articles lost per hour
• Unsafe drinking water for almost 15 minutes each day	→	• One unsafe minute every seven months
• 5,000 incorrect surgical operations per week	→	• 1.7 incorrect operations per week
• Two short or long landings at most major airports each day	→	• One short or long landing every five years
• 200,000 wrong drug prescriptions each year	→	• 68 wrong prescriptions per year
• No electricity for almost seven hours each month	→	• One hour without electricity every 34 years

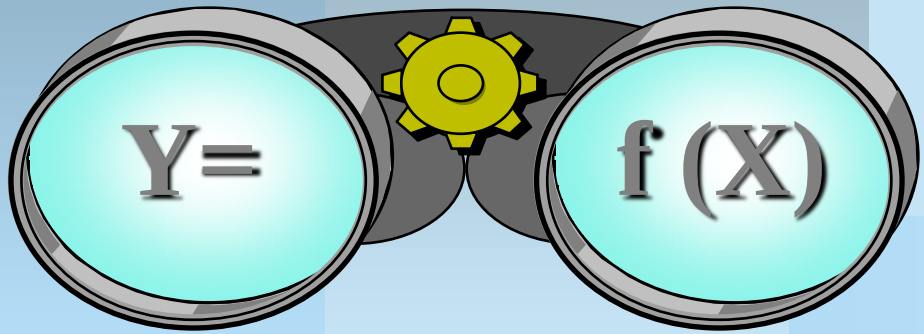
Six Sigma -- As A Value

Issue	Classical	Six Sigma
Analytical Perspective	Point Estimate	Variability
Management	Cost & Time	Quality & Time
Manufacturability	Trial & Error	Robust Design
Tolerancing	Worst Case	Root Sum of Sqs
Variable Search	One Factor @ Time	DOE
Process Adjustment	Tweaking	SPC Charts
Problems	Fixing	Preventing
Problem Solving	Expert Based	Systems Based
Analysis	Experience	Data
Focus	Product	Process
Behavior	Reactive	Proactive
Suppliers	Cost	Relative Capability
Outlook	Short Term	Long Term

Six Sigma -- As A Value

Issue	Classical	Six Sigma
Outlook	Short Term	Long Term
Decision Making	Intuition	Probability
Design	Performance	Producibility
Aim	Company	Customer
Organization	Authority	Learning
Training	Luxury	Necessity
Chain of Command	Hierarchy	Empowered Teams
Direction	Seat of Pants	Bench Mark / Metrics
Goal Setting	Realistic Perception	Reach-Out Stretch
People	Cost	Competitive Advantage
Control	Centralized	Localized
Improvement	Automation	Optimization

The Focus of Six Sigma



To get results, should we focus our behavior on the Y or X?

■ **Y**	■ **$X_1 \ldots X_N$**
■ **Dependent**	■ **Independent**
■ **Output**	■ **Input-Process**
■ **Effect**	■ **Cause**
■ **Symptom**	■ **Problem**
■ **Monitor**	■ **Control**

If we are so good at X, why do we constantly test and inspect Y?

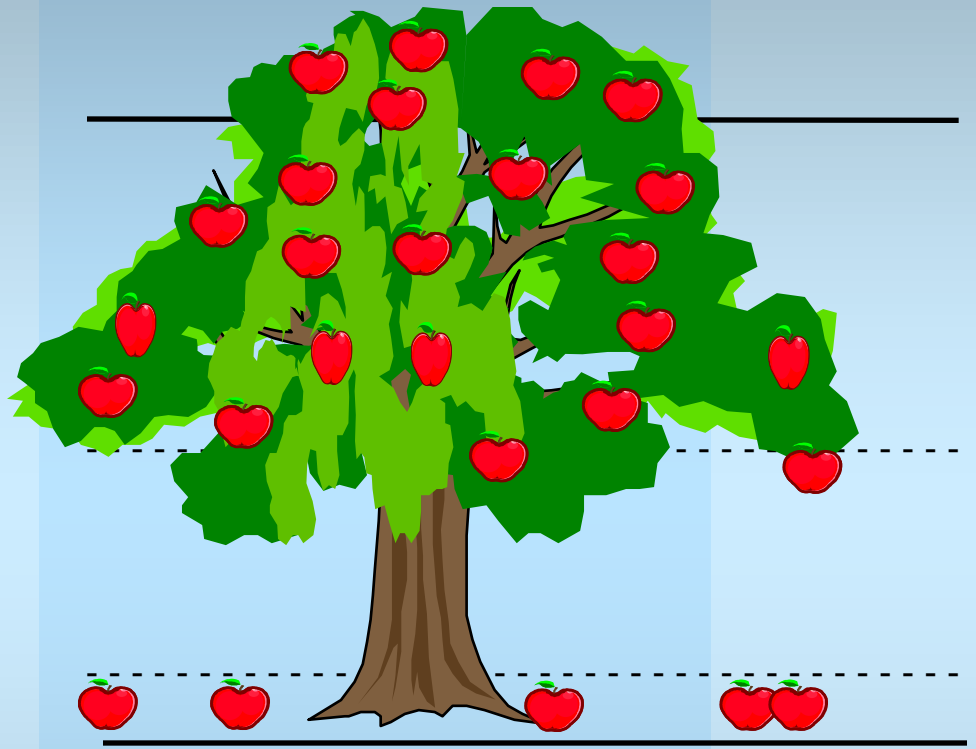
Focus on X rather than Y, as done historically

History of Six Sigma

- **In 1980s Motorola introduced a six sigma strategy aiming to improve yield, against Japanese competitors.**
- **In 1990s ABB, GE, Allied Signal, Nokia and Sony introduced six sigma, focusing on management quality improvement.**

1985-1992	1993-1994	1994-1996	1996-1997	1997-1998
TI	ABB	Allied Signal	Bombardier	Lockheed Martin
Motorola		**GE**		**Sony**
			Nokia Mobile Phone	Crane
			Siebe,plc	**Shimano**
				Polaloid

Harvesting the Fruit of Six Sigma



Sweet Fruit
Design for Manufacturability

5 σ Wall, Improve Designs

Bulk of Fruit
Process Characterization and Optimization

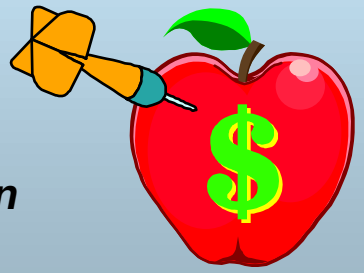
4 σ Wall, Improve Processes

Low Hanging Fruit
Seven Basic Tools

3 σ Wall, Beat Up Suppliers

Ground Fruit
Logic and Intuition

We don't know what we don't know
We can't act on what we don't know
We won't know until we search
We won't search for what we don't question
We don't question what we don't measure
Hence, We just don't know

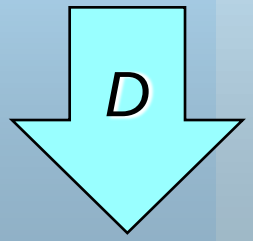


Two Meanings of "Sigma"

σ

- The term "sigma" is used to designate the distribution or spread about the mean (average) of any process or procedure.
- For a business or manufacturing process, the **sigma capability** is a metric that indicates how well that process is performing. The higher the sigma value, the better. Sigma measures the capability of the process to perform defect-free work. A defect is anything that results in customer dissatisfaction.

As defects go down...



the Sigma Capability goes up

D - M - A - I - C

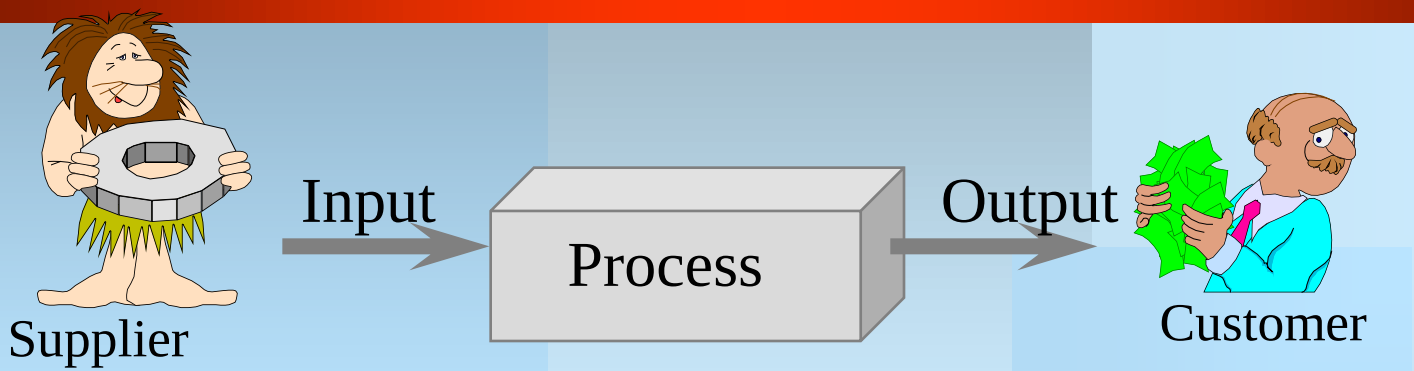
For Each Product or Process CTQ –

Define, Measure, Analyze, Improve, & Control

$Y = f(x)$

Define	1. Customer expectations of the process?
Measure	2. What is the frequency of defects?
Analyze	3. When and where do defects occur?
Improve	4. How can we fix the process?
Control	5. How can we make the process stay fixed?

Who is the Customer?



Process - The activities you must perform to satisfy your customer's requirements.

Input - The material or data that a process does something to or with.

Output - The material or data that results from the operation of a process.

Customer - Whoever receives the output of your process.

Internal Customer Vs. External Customer

Supplier - Whoever provides the input to your process.

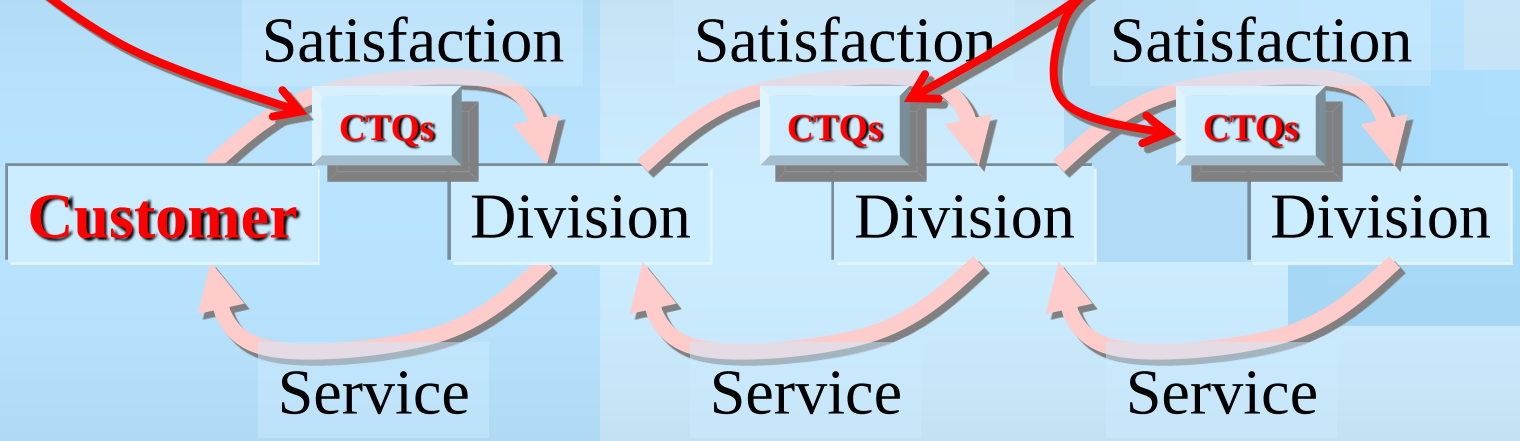
What is critical to the quality of the process?
…according to your customer!

CTQ

Who is the Customer?

Customer driven CTQs are defined by external customers.

Process driven CTQs are driven by internal customers and by other process considerations



This critical perspective of Six Sigma will be repeated often.

To KNOW something, you must be able to quantify it.

So, the question remains, how do you know who your key customers are?

Vital Few Customer CTQs

Vital Few Customer CTQs

（1）Customer Responsiveness/Communication

（2）Market Place Competitiveness - Product/Price/Value

（3）On-Time, Accurate,
and Complete Customer Deliverables

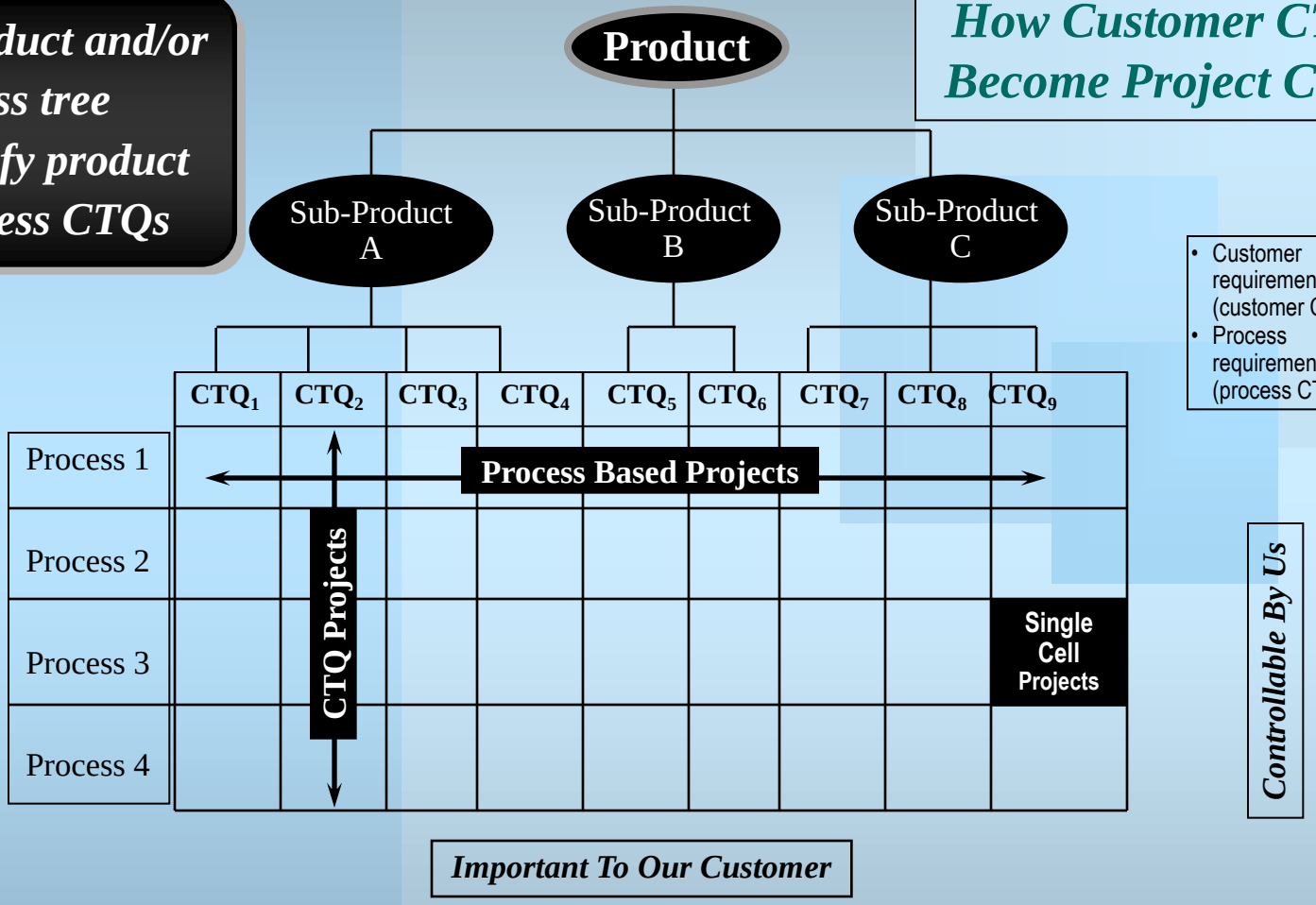
（4）Product/Service Technical Performance

- These **4** Vital Few Customer CTQs will be a critical link for every project.
- They should be familiar to everyone.
- How does your project relate to them?

Process / Product Drill-Down Tree

Define product and/or process tree and identify product and process CTQs

How Customer CTQs Become Project CTQs



- Customer requirements (customer CTQs)
- Process requirements (process CTQs)

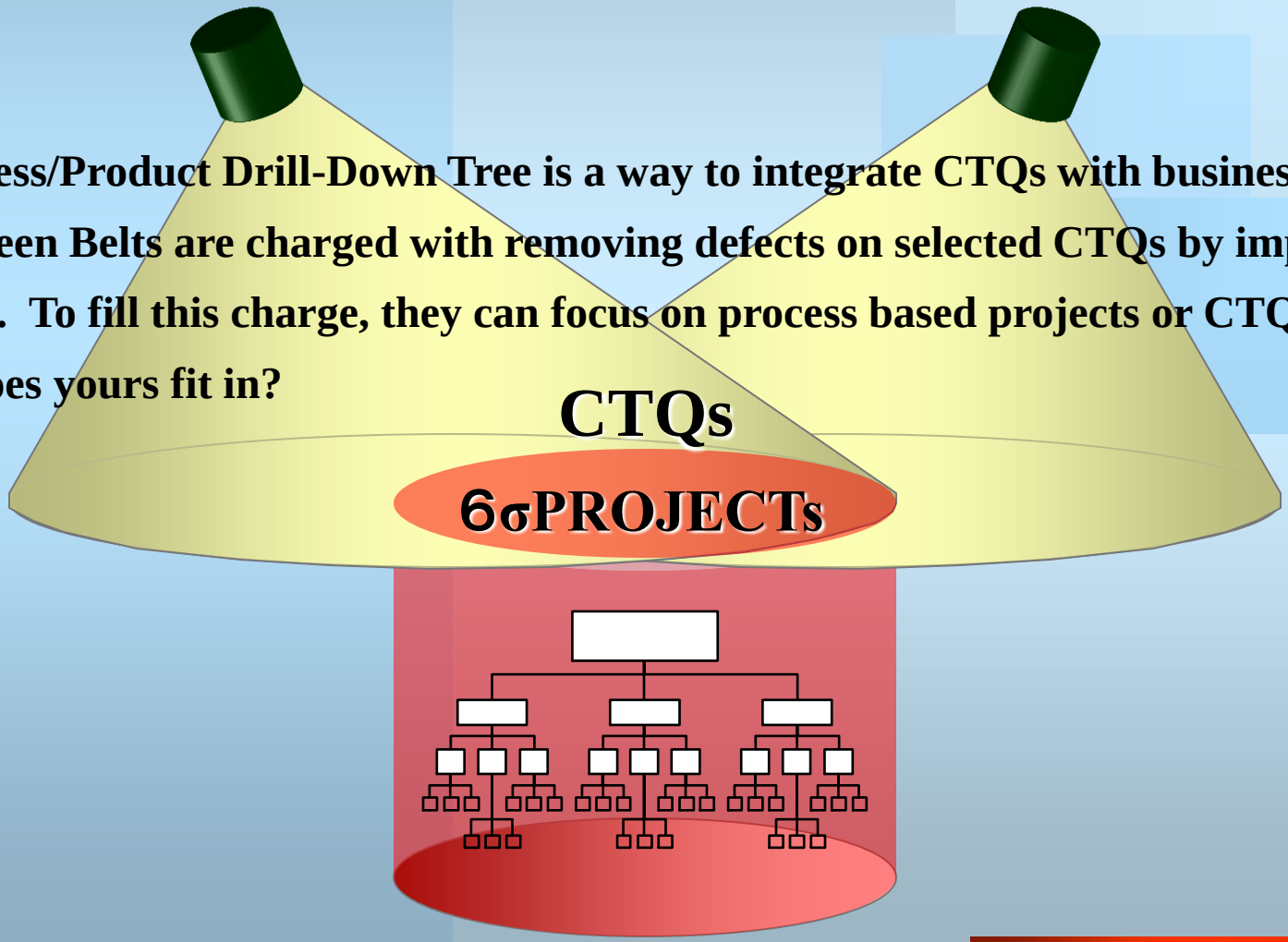
The Black/Green Belt is assigned to work on removing defects on the selected CTQs by improving processes.

Process / Product Drill-Down Tree

Voice of Customer

Business Strategy

The Process/Product Drill-Down Tree is a way to integrate CTQs with business strategy. Black/Green Belts are charged with removing defects on selected CTQs by improving processes. To fill this charge, they can focus on process based projects or CTQ projects. Where does yours fit in?



Process / Product Drill-Down Tree

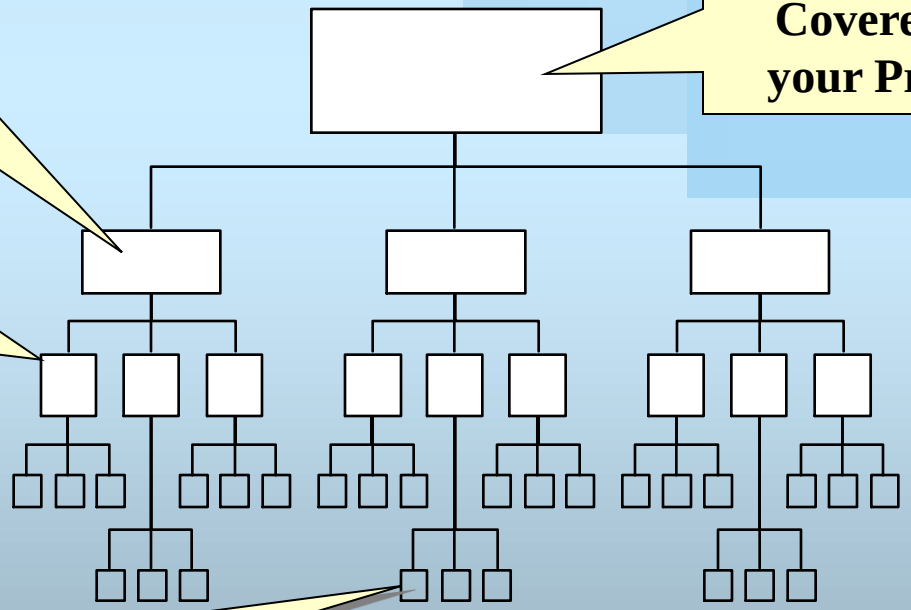
- Purpose:
  - Aids in Project Bounding
  - Clarifies what a project is, and is not
  - Identifies other areas for improvement

"Drill-Down to Granularity"

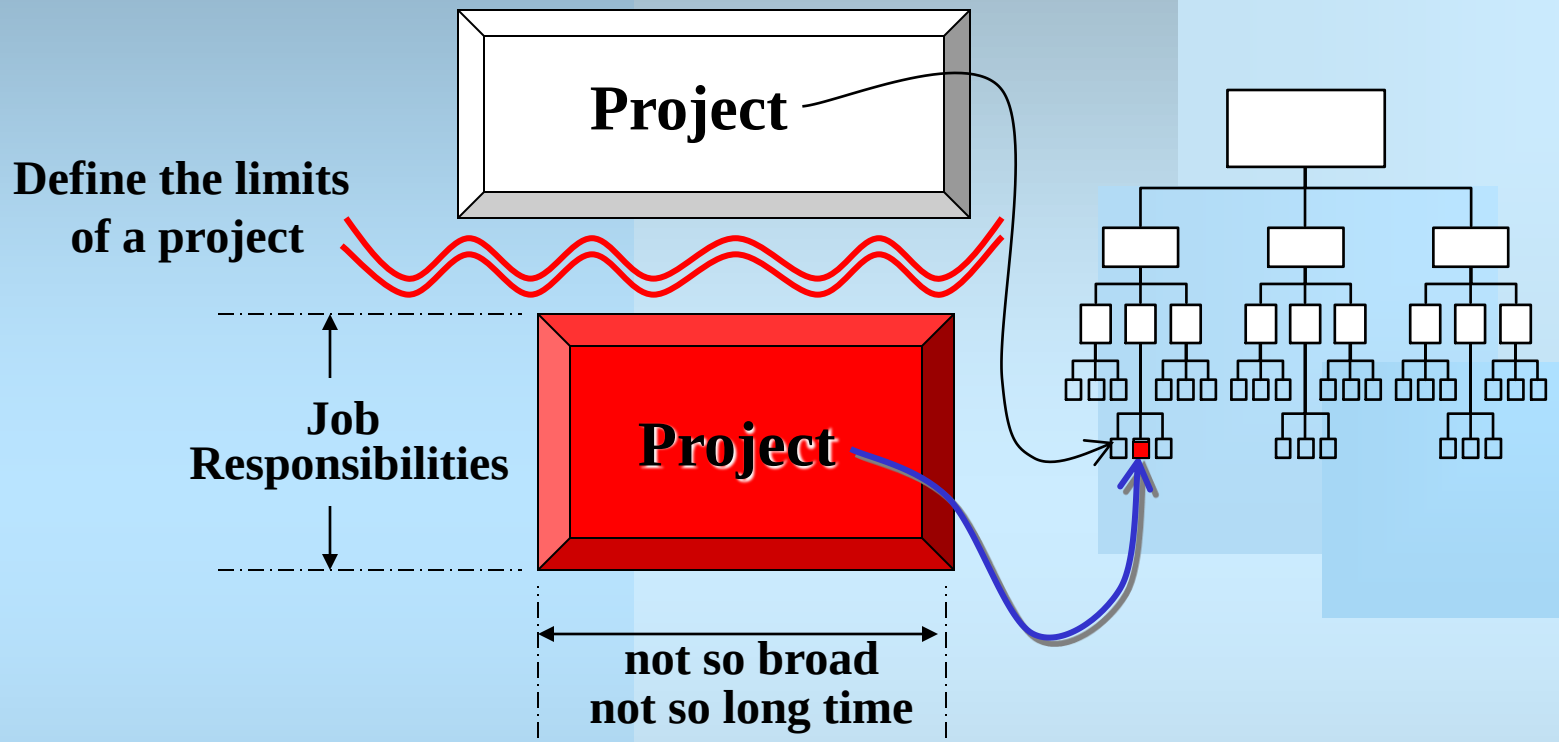
Identify the High Level CTQ Covered By your Project

Break this CTQ into the Component Lower Level CTQs or Processes

Identify Product Groups (i.e., gas or steam, by RCT, etc.) or Process Steps which form the next rational way to subdivide the project



Identify which "*Leaf*" on the tree is your project



- Project bounding is the process of defining the limits of a project.
- It must contribute something.
- It must not be so broad that it is impossible to complete.
- It must be relevant to your job responsibilities.
- It should not duplicate or overlap other existing projects.

Identify Project CTQs

Define	Measure	Analyze	Improve	Control

- **Identify Project CTQs**
- Develop Team Charter
- Define Process Map

- *Identify Customer(s)*
- *Compile & Evaluate Data for Existing Customers*
- *Analyze Voice of the Customer(s)*
- *Translate Customer Needs Into Requirements (CTQs)*
- *Integrate CTQs with Business Strategies*
- *Identify Project CTQs*

Develop Team Charter

Define	Measure	Analyze	Improve	Control

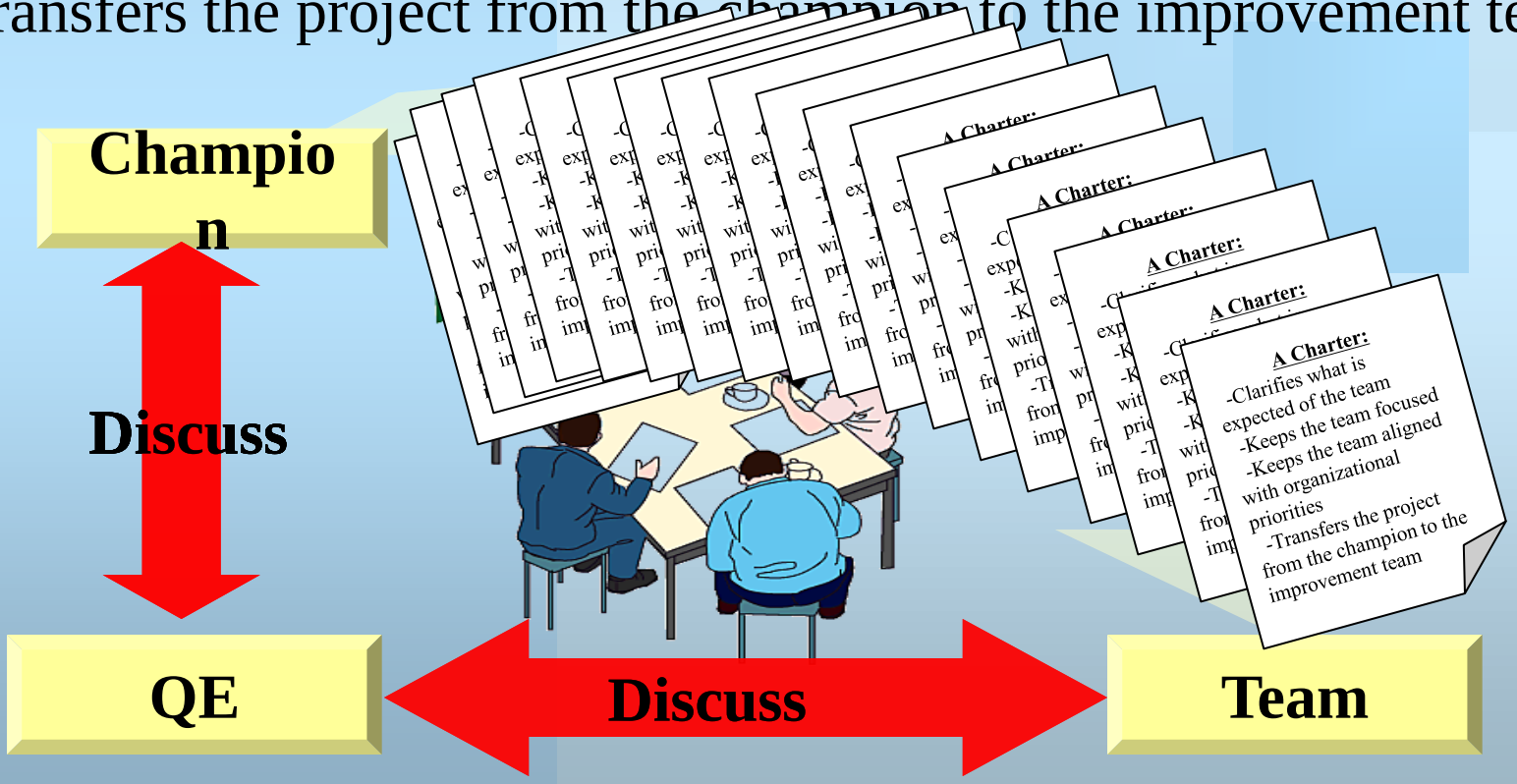
- Identify Project CTQs
- **Develop Team Charter**
- Define Process Map

- *The Business Case*
- *Develop Preliminary Problem Statement*
- *Assess Project Scope*
- *Develop Goal Statement*
- *Select Team & Define Roles*
- *Develop Charter*
- *Obtain Key Business Stakeholder(s) Signoff*

Team Chartering

A Charter:

-Clarifies what is expected of the team
-Keeps the team focused
-Keeps the team aligned with organizational priorities
-Transfers the project from the champion to the improvement team



Five Major Elements of a Charter

- **Business Case**

  Explanation of Why to do the Project

- **Problem and Goal Statements**

  Description of the Problem/Opportunity or Objective in Clear, Concise, Measurable Terms

- **Project Scope**

  Process Dimensions, Available Resources

- **Milestones**

  Key Steps and Dates to Achieve Goal

- **Roles**

  People, Expectations, Responsibilities

The Business Case

- Why is the project worth doing?
- Why is it important to do it now?
- What are the consequences of NOT doing the project?
- What activities have higher or equal priority?
- How does it fit with business initiatives and target?

Problem and Goal Statements

The purpose of the Problem Statement is to describe what is wrong

The Goal Statement then defines the team's improvement objective

Problem Statement

Together they provide focus and purpose for the team

Problem Statement

- **What** is wrong or
  not meeting our customer's needs?
- **When** and **where** do the problems occur?
- **How** big is the problem?
- What's the **impact** of the problem?

Description of the "Pain"

Problem Statement Example

Poor Example:

Our customers are angry with us and late in paying their bill.

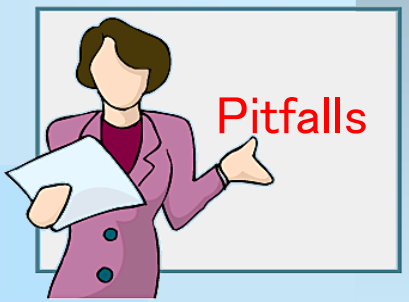
Improved Example:

In the last 6 months (When), 20% of our repeat customers - not first-timers - are over 60 days late (What) paying our invoices. The current rate of late payments is up from 10% in 1990 and represents 30% of our outstanding receivables (Magnitude). This negatively affects our operating cash flow (Impact or Consequence).

Describe the **pain**

The Problem Statement

Key Considerations/Potential Pitfalls



- Is the problem based on observation (Fact) or Assumption (Guess)?
- Does the Problem Statement prejudge a root cause?
- Can data be collected by the team to verify and analyze the problem?
- Is the Problem Statement too narrowly or broadly defined?
- Is a solution included or implied in the statement?
- Would customers be happy if they knew we were working on this?

The Goal Statement

Project Objective

- Definition of the improvement the team is seeking to accomplish?
- Starts with a verb (Reduce, Eliminate, Control, Increase)
- Tends to start broadly - eventually should include measurable target and completion date
- Must not assign blame, presume cause, or prescribe solution!

SMART and K I S S

Specific

Measurable

Attainable

Relevant

Time Bound

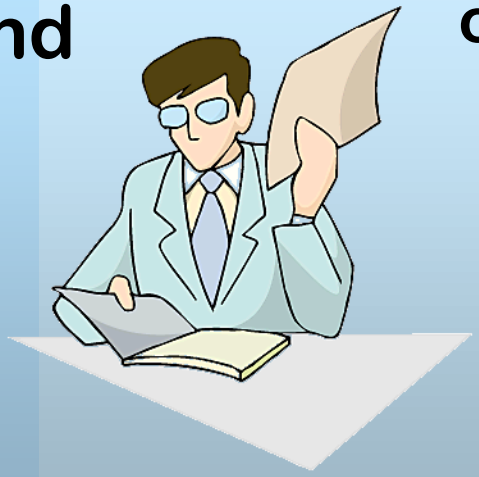
Keep

It

Simple

Stupidly

or **S**tatistically



Project Scope

- What process will the team focus on?
- What are the boundaries of the process we are to improve? Start Point? Stop Point?
- What resources are available to the team?
- What (if anything) is Out-Of-Bounds for the team?
- What (if any) constraints must the team work under?
- What is the time commitment expected of team members?
- What will happen to our “Regular Jobs” while we are doing the project?

Milestones

- A preliminary, high level project plan with dates
- Tied to phases of DMAIC process
- Should be aggressive
  (Don't miss "Window of Opportunity")
- Should be realistic
  (Don't force yourselves into "Band-Aid" solution)

Week:	1	2	3	4
Review charter with Champion		X		
Collect VOC		X	X	
Complete Map		X	X	
Validate Map				X
Collect Data				X

Team Roles

- How do you want the Champion to work with the team?
- Is the team's role to implement or recommend?
- When must the team go to the Champion for approval?

  What authority does the team have to act independently?
- What and how do you want to inform the Champion about the team's progress?
- What is the role of the team leader (Black/Green Belt) and the team coach (Master Black Belt)?
- Are the right members on the team? Functionally? Hierarchically?

Define Process Map

Define	Measure	Analyze	Improve	Control

- Identify Project CTQs
- Develop Team Charter
- **Define Process Map**

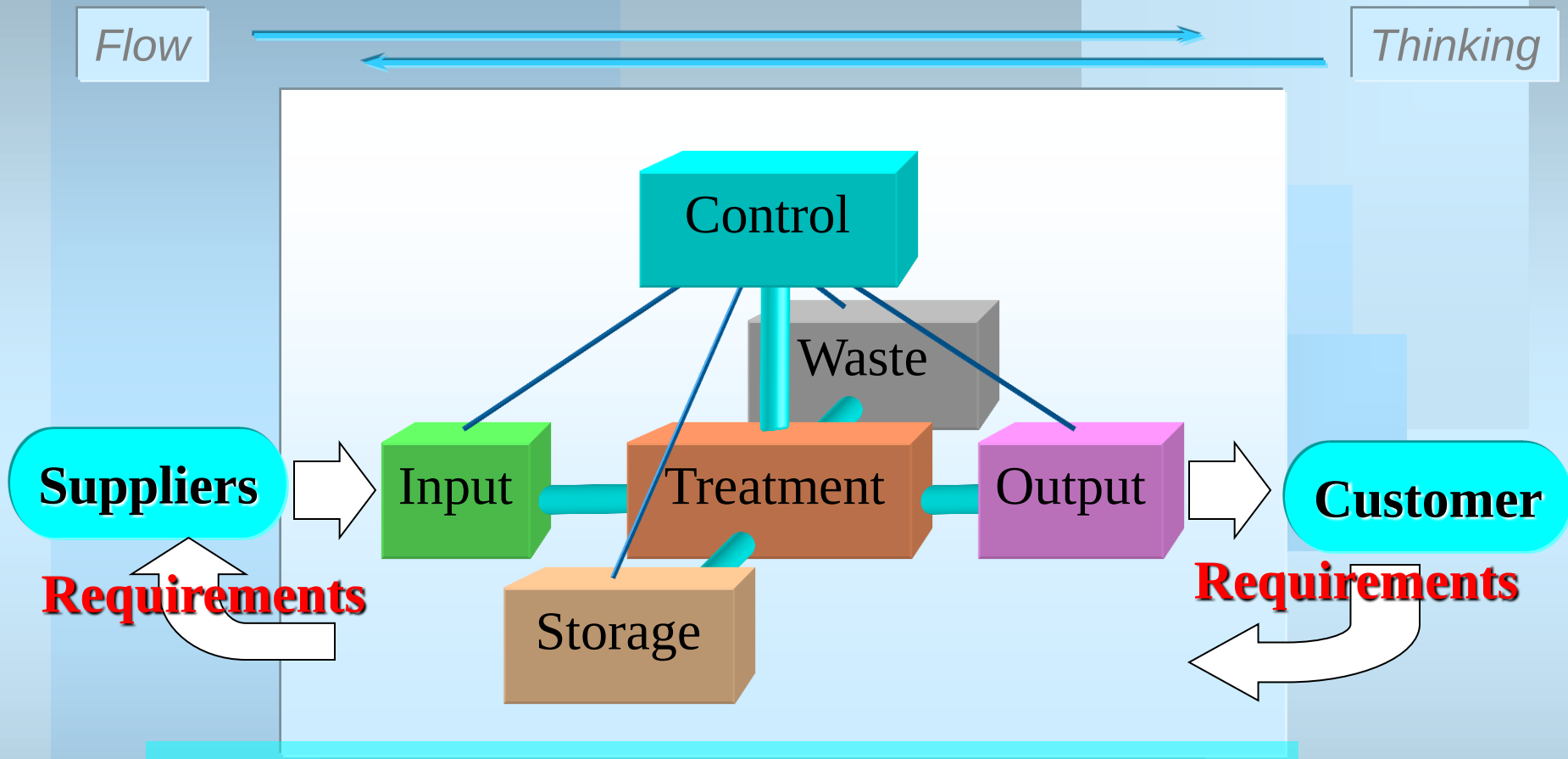
- *Define Process*
- *Connect the Customer to Your Process*
- *Map Business Process*
- *Verify Process Map*

Selecting the Right Projects

Six Issues in Selecting a Project:

- **Process**
- **Feasibility (Is it doable?)**
- **Measurable Impact**
- **Potential for Improvement**
- **Resource Support Within the Organization**
- **Project Interactions**

Business Process Mapping



- Name the Process
- Identify the Outputs, Customers, Suppliers, & Inputs
- Identify Customer Requirements for Primary Outputs
- Identify Process Steps

The Project Approval Process (Finishing Define)

- Enter Your Project into QPT
- Get Approval from your Sponsor
- Discuss the Project with your MBB
- Discuss the Project with your IM representative
  - IM will need to approve the project in QPT
- Present the Project to your Champion
  - Champion Gives Approval for Project
  - Periodic Meetings or Conference Calls will be scheduled for this purpose
- SQE Approves Project in **MIQ**

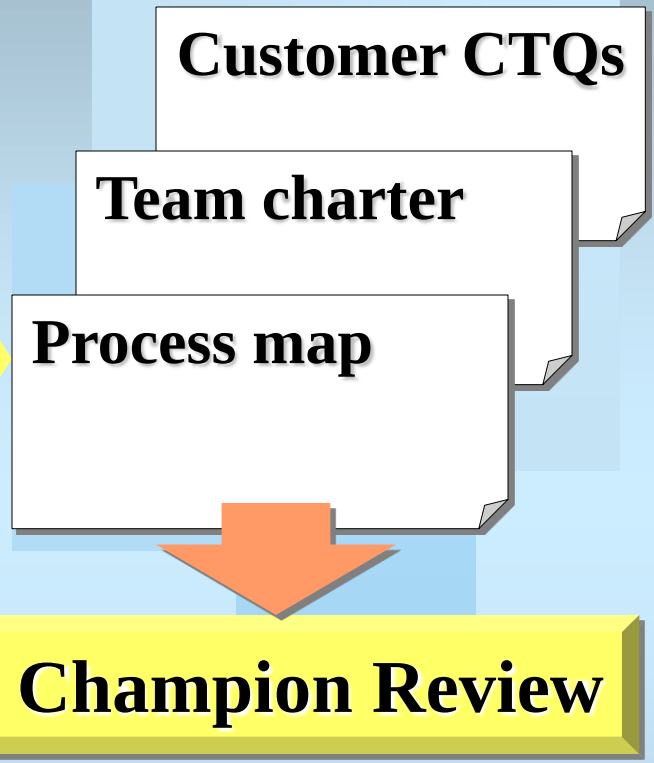
Congratulations!
You have finished defining your project and are off into Measure.

The Define Phase

(1)Who is the customer?

(2)Define
- customer expectations,
- team goals,
- project boundaries

(3)Define the process you are striving to improve by mapping the process.



Check!
- Quantify your customer definition
- Analyze the voice of your customer(s)
- Translate customer needs into CTQs
- Integrate CTQs with business strategies
- Identify project CTQs.

Understanding Processes

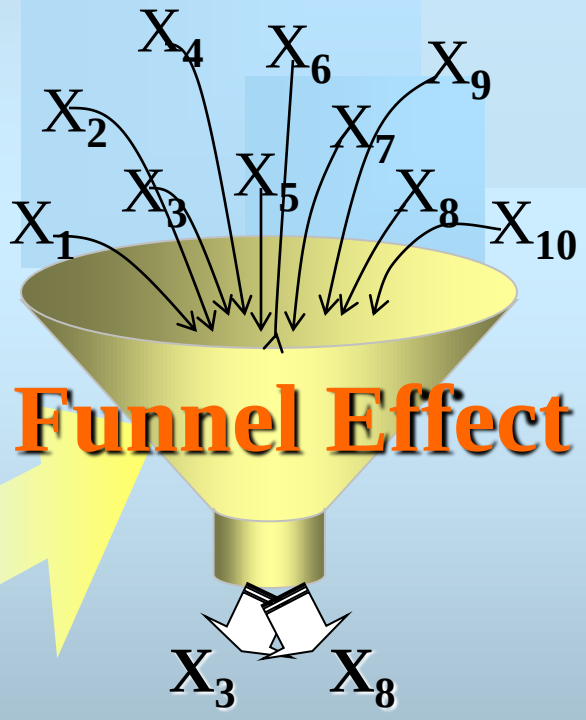
Define | **Measure** | Analyze | Improve | Control

Select CTQ Characteristic

Define Performance Standards

Validate Measurement System

- Fishbone
- C&E Matrix
- FMEA
- Pareto
- QFD

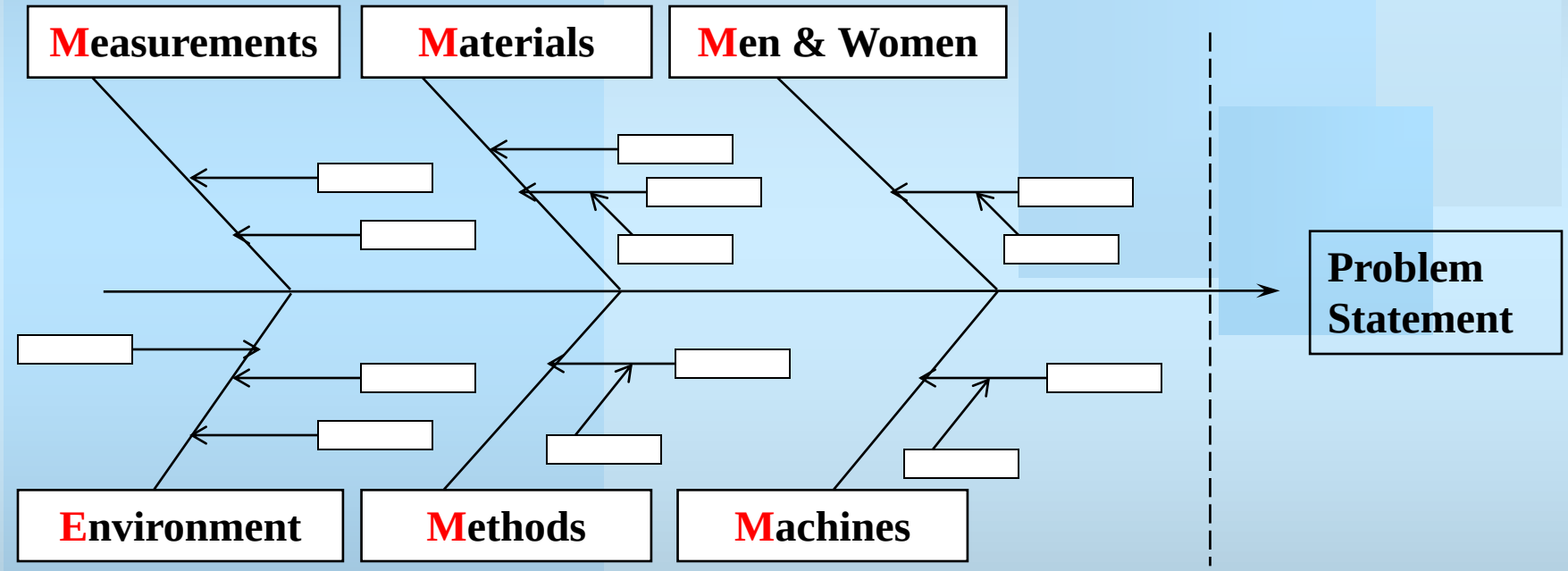


Funnel Effect

Vital Few Xs

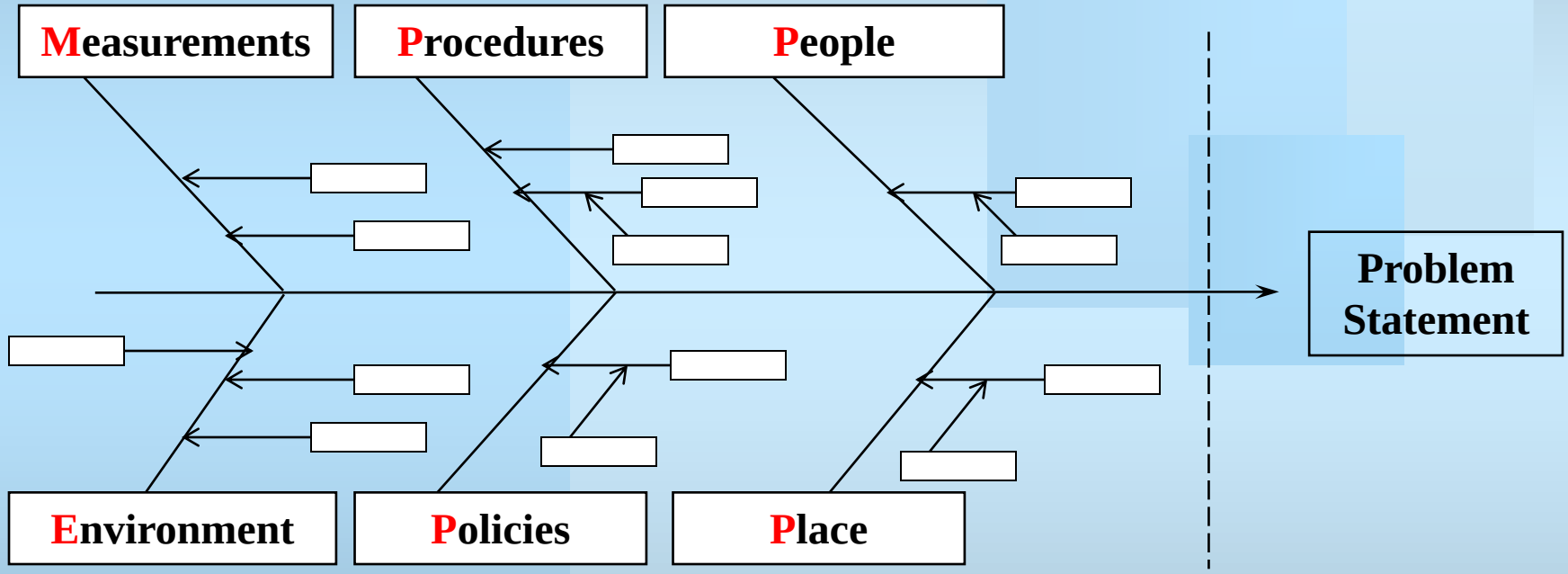
Fishbone Diagram (for Product)

- Draw a blank diagram on a flip chart.
- Define your problem statement.



- *Label branches with categories appropriate to your problem.*

Fishbone Diagram (for Transaction)



C&E Matrix

Cause and Effect Matrix

Ys

Xs

	Process Step	Process Input	Rating of Importance to Customer	1 Requirement	2 Requirement	3 Requirement	4 Requirement	5 Requirement	6 Requirement	7 Requirement	8 Requirement	9 Requirement	10 Requirement	11 Requirement	12 Requirement	13 Requirement	14 Requirement	15 Requirement	Total
1																			0
2																			0
3																			0
4																			0
5																			0
6																			0
7																			0
8																			0
9																			0
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14																			0
15																			0
16																			0
17																			0
18																			0
19																			0
20																			0
																			0
Total				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Lower Spec																
			Target																
			Upper Spec																

FMEA Matrix

Severity × Occurrence × Detection = RPN

Process or Product Name.			Prepared by:		Page ___ of ___
Responsible.			FMEA Date (Orig) _____	(Rev) _____	

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken	SEV	OCC	DET	RPN
What is the process step	What is the Key Process Input?	In what ways does the Key Input go wrong?	What is the impact on the Key Output Variables (Customer Requirements) or internal requirements?	How severe is the effect to the customer?	What causes the Key Input to go wrong?	How often does cause or FM occur?	What are the existing controls and procedures (inspection and test) that prevent either the cause or the Failure Mode? Should include an "SOP" number.	How well can you detect cause or FM?		What are the actions for reducing the occurrence of the Cause, or improving detection? Should have actions only on high RPN's or very [illegible]	Whose Responsible for the recommended action?	What are the completed actions taken with the recalculated RPN? Be sure to include completion month/year				
									0							0
									0							0
									0							0
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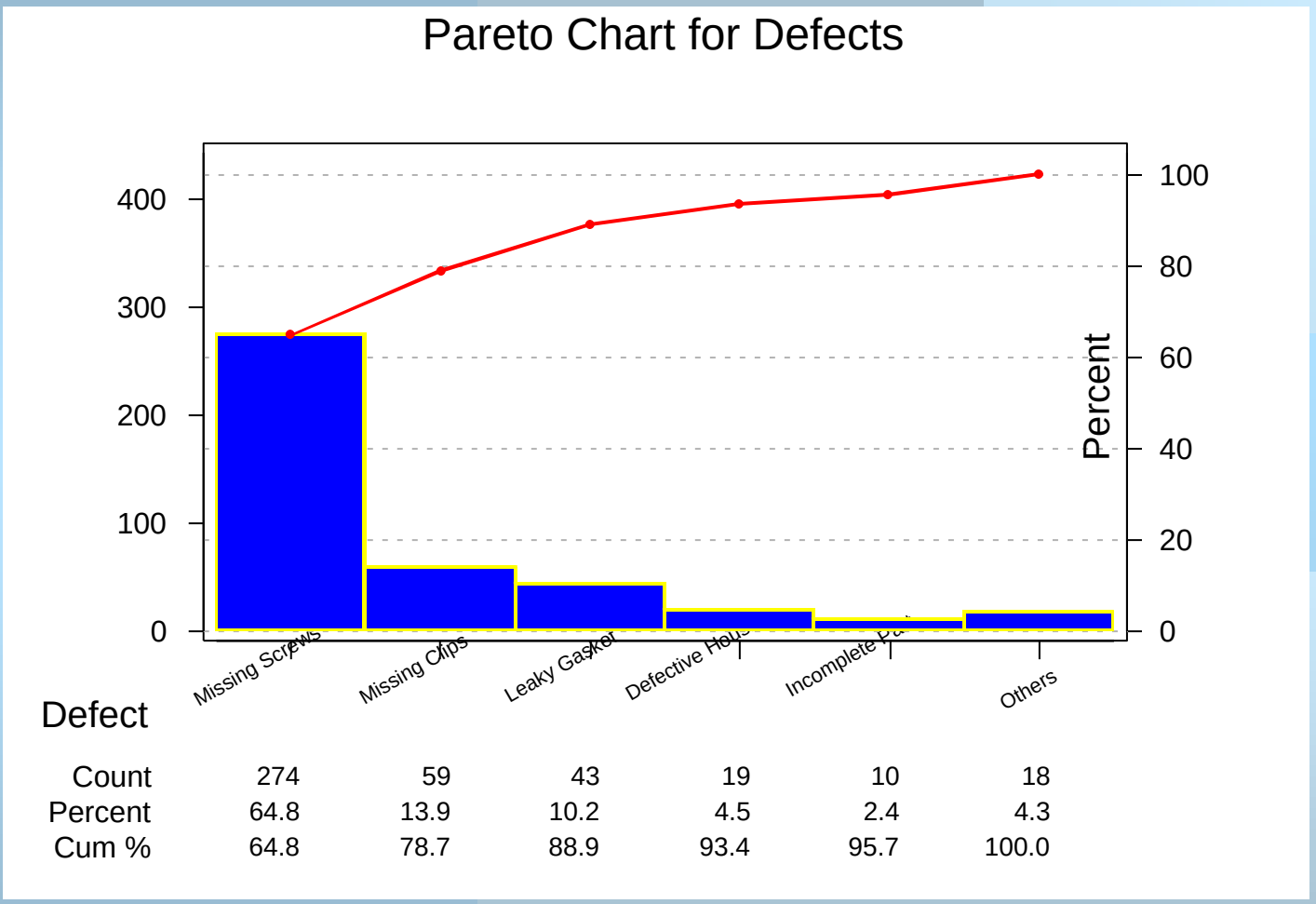
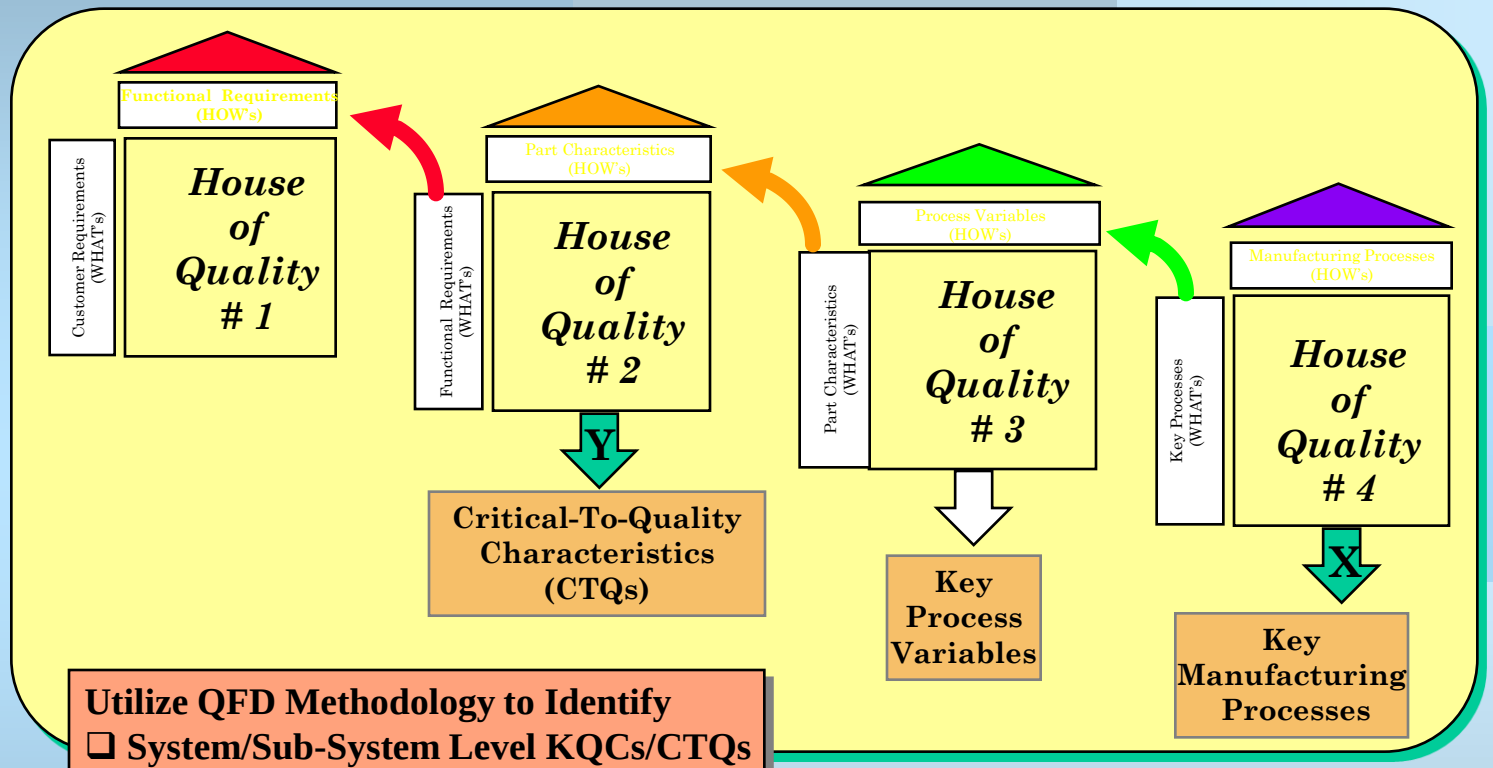
Pareto Chart



Defect						
Count	274	59	43	19	10	18
Percent	64.8	13.9	10.2	4.5	2.4	4.3
Cum %	64.8	78.7	88.9	93.4	95.7	100.0

QFD : Quality Function Deployment



Utilize QFD Methodology to Identify

- ❑ System/Sub-System Level KQCs/CTQs
- ❑ Component Level CTQs
- ❑ Process Level Key Variables

A System for Translating Customers Requirements into Company Requirements at Each Stage From Research and Product Development To Engineering and Manufacturing To Marketing/Sales and Distribution

Performance Standards

Define | **Measure** | Analyze | Improve | Control

- Select CTQ Characteristic
- **Define Performance Standards**
- Validate Measurement System

- RTY
- DPU,DPMO
- Cp , Cpk , Pp , Ppk

Measurement System Analysis

Define | **Measure** | Analyze | Improve | Control

- Select CTQ Characteristic
- Define Performance Standards
- **Validate Measurement System**

- Gage R&R

The Breakthrough Cookbook

Define

A	Identify Customer CTQ
B	Product/Process Tree
C	Bound Project / Benefits
D	Formal Approval

Step	Description	Focus	Tools
Measure			
1	Select CTQ Characteristic	Y	Fishbone, FMEA, Pareto,Customer, QFD
2	Define Performance Standards	Y	Customer, Blueprints
3	Validate Measurement System	Y	Gage Study
Analyze			
4	Establish Product Capability	Y	Capability Indices
5	Define Performance Objective	Y	Team, Benchmarking
6	Identify Variation Sources*	X	Multi-Vari ,Hypothesis Tests
Improve			
7	Screen Potential Causes	X	DOE-Fraction
8	Discover Variable Relationships	X	DOE-Full
9	Establish Operating Tolerances	X	Predict. Eqns., DFSS ,Realistic Tolerancing
Control			
10	Validate Measurement System*	X	Gage Study
11	Determine Process Capability	X	Capability Indices
12	Implement Process Control System	X	Risk Analysis,Mistake Proof, SPC

* *You may want to validate the Measurement System for "X" before step 6.*

Breakthrough Phases

Phase 1 (Define). This phase defines the project. It identifies customer CTQs and ties them to business needs. Further, it defines a project charter and the business process bounded by the project.

Phase 2 (Measurement). This phase is concerned with selecting one or more product characteristics; i.e., dependent variables, mapping the respective process, making the necessary measurements, recording the results on process "control cards," and estimating the short- and long-term process capability.

Phase 3 (Analysis). This phase entails benchmarking the key product performance metrics. Following this, a gap analysis is often undertaken to identify the common factors of successful performance; i.e., what factors explain best-in-class performance. In some cases, it is necessary to redesign the product and/or process.

Phase 4 (Improvement). This phase is usually initiated by selecting those product performance characteristics which must be improved to achieve the goal. Once this is done, the characteristics are diagnosed to reveal the major sources of variation. Next, the key process variables are identified by way of statistically designed experiments. For each process variable which proves to be significant, performance specifications are established.

Phase 5 (Control). This phase is related to ensuring that the new process conditions are documented and monitored via statistical process control methods. After a "settling in" period, the process capability would be reassessed. Depending upon the outcomes of such a follow-on analysis, it may be necessary to revisit one or more of the preceding phases.