FMEA

Failure Mode & Effects Analysis

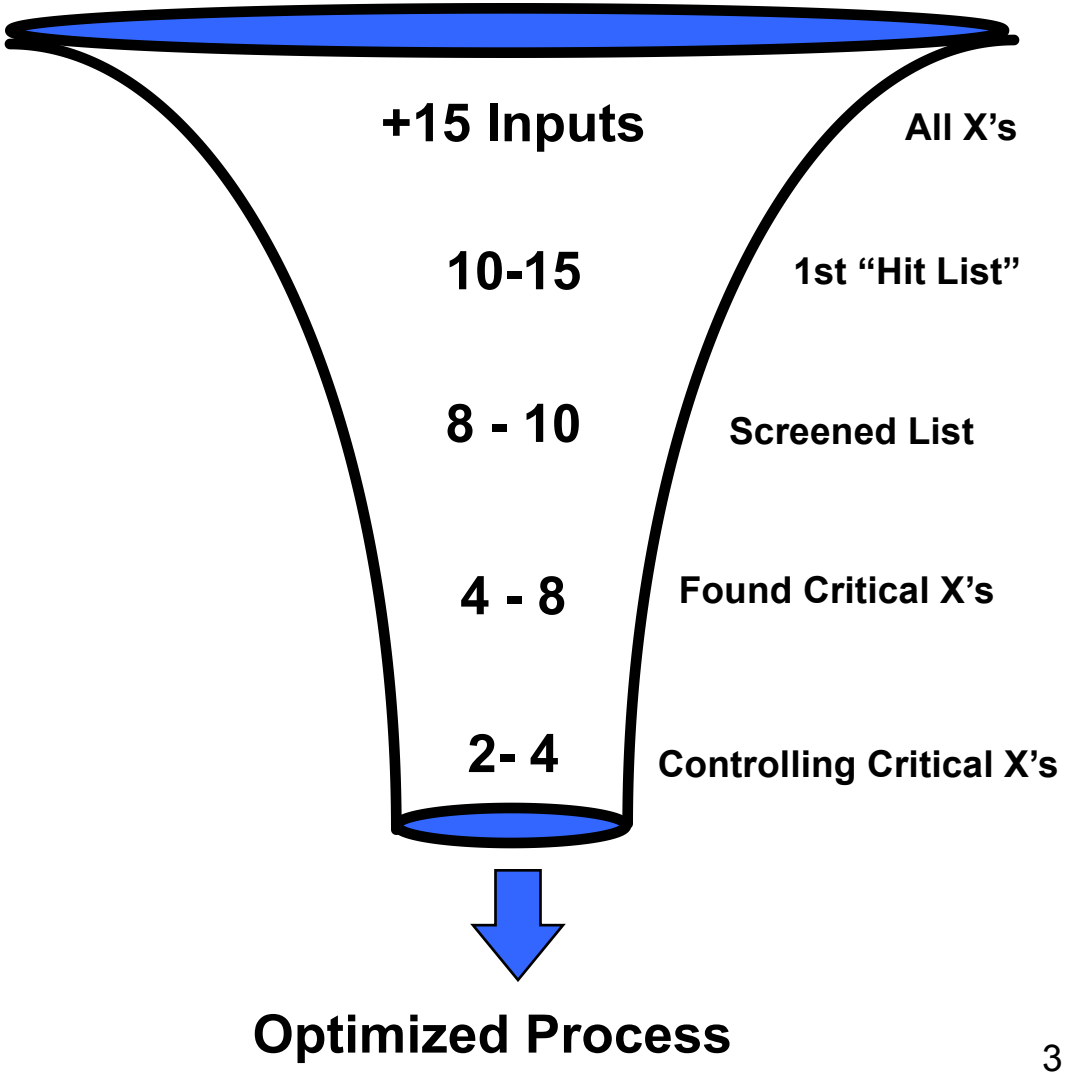
常州企业管理中心 **www.CZQYGL.COM**

Objectives

- Link FMEA To Measure-Analyze-Improve-Control
- Introduce The Steps To Create A FMEA
- Show Examples
- Perform An Exercise

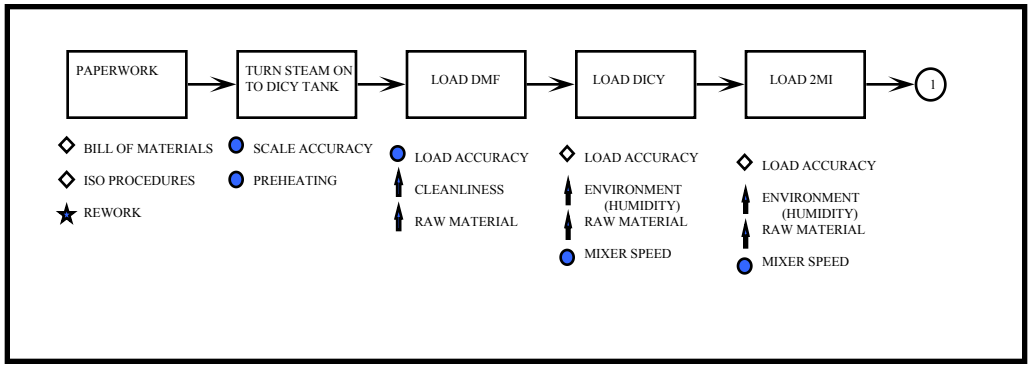
Dynamics of The Methodology - The Funnel Effect

- Process Map
- C&E Matrix
- **FMEA**
- Multi-Vari Studies
- Experimentation
- Control Plans / SPC



The Flow

Process Map Identifies all Xs and Ys



Cause and Effects Matrix

Prioritizes Xs and Ys

OUTPUTS

INPUTS

	Process Step	Process Inputs	1 Heavies in Product	2 Lights in Product	3 Moisture in Product	4 Acidity in Product	5	6 Low Capacity From Unit	7 Excessive Downtime	8 Material Losses	9	10 Corrosion of Equipment	11 Poor Reactor Performance	Total
139	Day Tanks	Analysis	10	10	9	9								336
9	Reactor	Cat./HF Ratio						5				8	7	157
7	Reactor	Rxr Temperature						6		5		4	7	149
73	Lights Removal	Condenser Leak			4				8	2		4	1	148
74	Lights Removal	Reboiler Leak			4				8	2		4	1	148
131	Purification	Low Stages	8						8					144
144	Final Storage	Containers	3	2	6	6								140
100	Neutralization	pH Value		6		6						3		138
16	Catalyst Stripper	Plugage						3	6			5	3	137
111	Drying	Decomposition	2	6		3				2		2		134
39	Drier	Water Carryover			4				6			5	1	132
34	Drier	Molecular Sieve			3	3		2	7	2				125

FMEA takes the high priority Xs and begins to analyze them

Process Step/Part Number	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.
COATING & IMAGING	DIRTY PHOTOMASK	MICROCRACKING, DELAMINATION, STREAKS	8	LOW FREQUENCY OF CLEANING	8	SOP, VISUAL INSPECTION	7	448	INCREASE FREQUENCY TO ONCE EVERY 20 PANELS	MG
									IMPROVE CLEANING METHOD	PF
									PURCHASE OFF-LINE CLEANING SYSTEM	MG
									TEST ON-LINE MASK REPLACEMENT	PF

Process/Product
Failure Modes and Effects Analysis
(FMEA)

Process or Product Name:		
Responsible:		

Prepared by:

FMEA Date (Orig) _____ (Rev) ___

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	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 cusotmer?	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 eith the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect cause or FM?	
									0
									0
									0
									0
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									0
									0
									0
									0
									0

FMEA
WHAT DOES IT DO ?

* **Funnels "X's"**
  Ranks The Items We Should Work On First

* **Identifies Holes In Our Control Plans**

* **Leads Us To Ask More Questions About The Process**

Definition - FMEA

- **A Systematized Group of Activities That:**
  - **Identifies the ways in which a process can fail to meet critical customer requirements**
  - **Estimates the risk of specific causes with regard to these failures**
  - **Evaluates the current control plan for preventing these failures from occurring**
  - **Prioritizes the actions that should be taken to improve the process**

Should be a dynamic document, continually reviewed, amended, updated

History

- **First used in the 1960's in the Aerospace industry during the Apollo missions.**
- **In 1974 the Navy developed MIL-STD-1629 regarding the use of FMEA.**
- **In the late 1970's, automotive applications driven by liability costs, began to incorporate FMEA into the management of their processes.**
- **In the mid 1980's, automotive instituted Process FMEA to validate manufacturing processes.**
- **In 1991 ISO 9000 recommended use of Product and Process FMEA.**

TYPES OF FMEAs

- **PRODUCT FMEA - Focus on product and Design Process.**
  - **Components/Parts/Raw Materials/System**
- **PROCESS FMEA - Focus on the process.**
  - **Process Flow/Process Sequence/Process Steps/Operators**
  - **Order entry/Invoice payment/On time Delivery**
- **APPLICATION FMEA**
  - **Suppliers Side - Upstream**
  - **Customers Side - Downstream**
- **SERVICE FMEA - Focus on Field Service after Sales**
  - **Reliability/Maintainability/Warranty/Spare Parts**

- **PRODUCT FMEA**
- **PROCESS FMEA**
- **APPLICATION FMEA**
- **SERVICE FMEA**

Our area of focus today!

What is a FMEA?

FMEA is a disciplined procedure that allows an individual to anticipate failures and prevent their occurrence.

Concept

Identify ways the product or process can fail. Then plan to prevent those failures.

Role of Process FMEA

- Key tool of a team to improve the process in a preemptive manner (before failures occur)
- Used to prioritize resources to ensure attention to process improvement efforts that are beneficial to customer
- Used to document completion of projects and resultant improvements to risk calculations
- Should be a dynamic document, continually reviewed, amended, updated

Purposes of Process FMEA

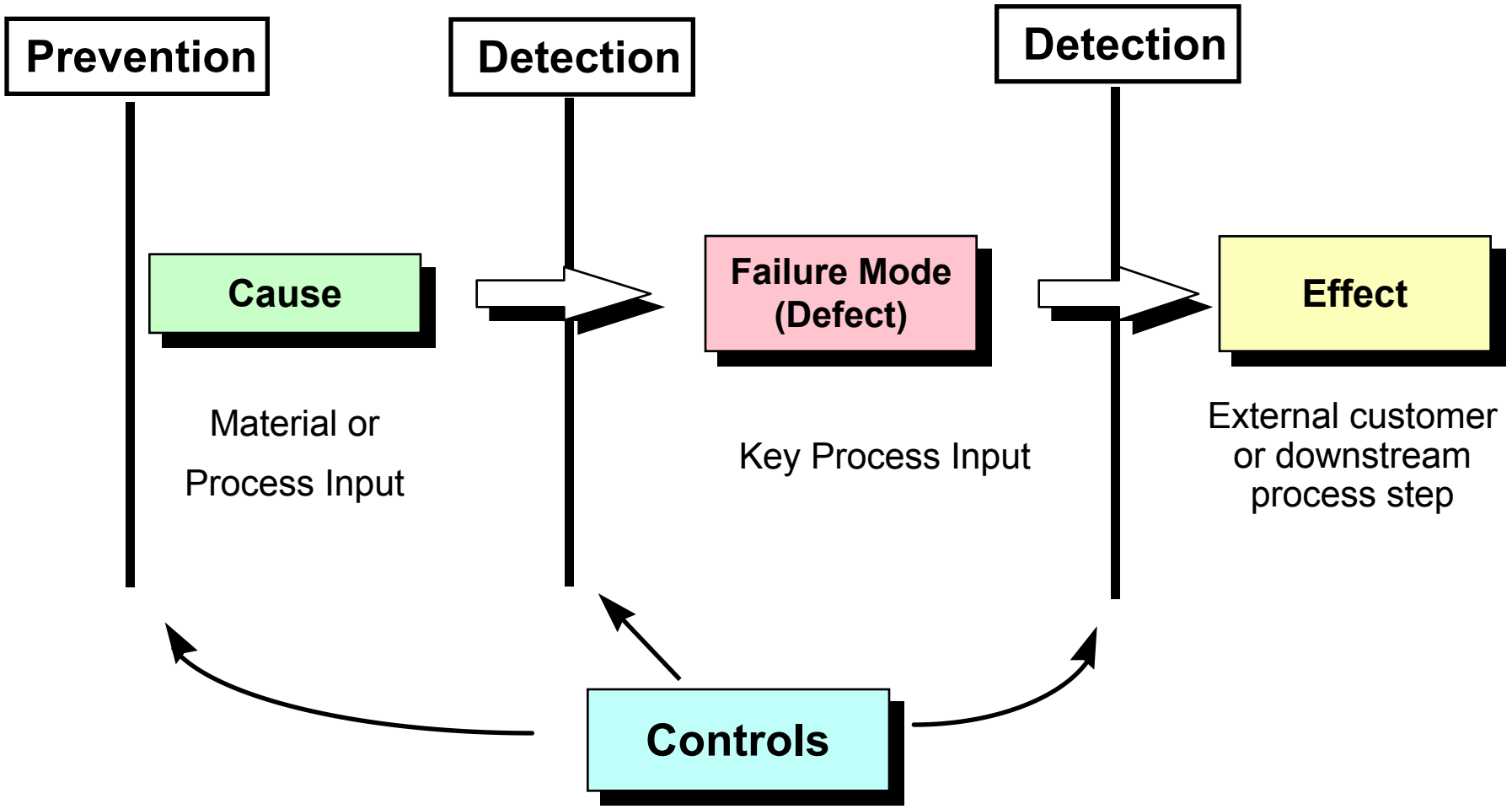
- Assists in the analysis of new processes
- Identifies deficiencies in the Process Control Plan so that actions can be taken to improve
- Establishes the priority of actions
- Helps evaluate the risk of process change
- Identifies potential variables to consider in Multi-vari and DOE studies
- Guides the development of new processes by helping teams understand weaknesses of current processes
- Helps set the stage for breakthrough strategy

How Does It Work ?

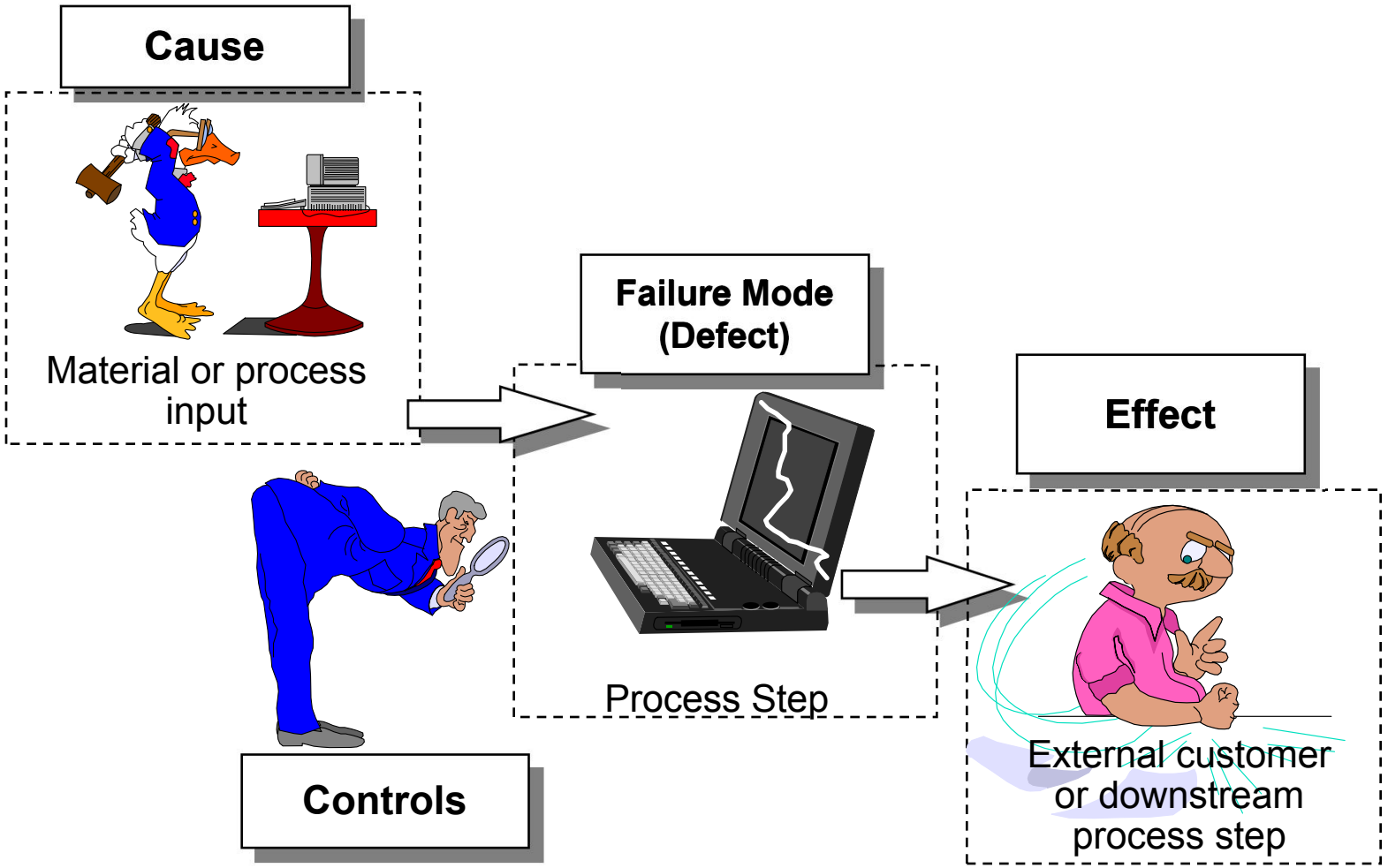
Identifies two areas for Improvement Actions

- **Prevention (Proactive):**
  - **Prevent a Failure Mode from occurring**
  - **Emphasis on avoiding causes, detecting Failure Modes earlier or reducing impacts of failure consequences**
- **Detection (Reactive):**
  - **Emphasis on identifying techniques or detecting methods to pinpoint an occurred failure**
  - **The effectiveness of the detection becomes the focal point**

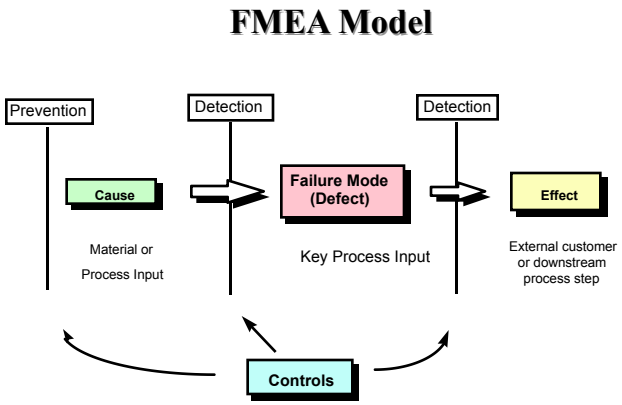
FMEA Model


Prevention
Detection
Detection
Cause
Failure Mode (Defect)
Effect
Material or Process Input
Key Process Input
External customer or downstream process step
Controls

FMEA Model


Cause
Material or process input
Failure Mode (Defect)
Process Step
Effect
External customer or downstream process step
Controls

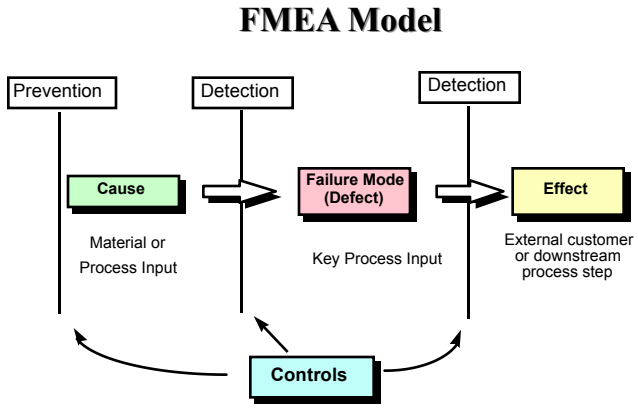
Definition of Terms



- **Failure Mode - the way in which a specific key process input fails - if not detected and either corrected or removed, will cause Effect to occur.**

Example:

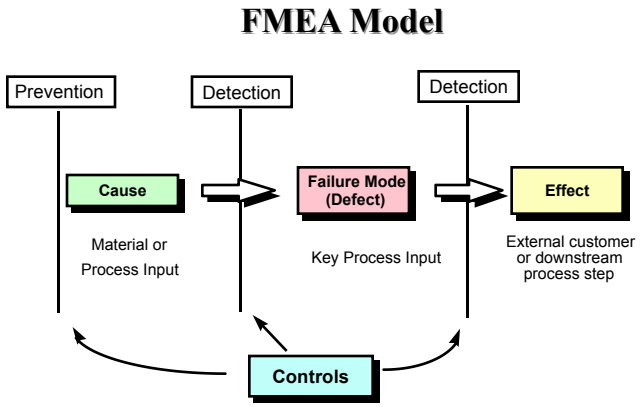
Definition of Terms



- **Effect - impact on customer requirements. Generally external customer focus, but can also include local effect or downstream processes.**

Example:

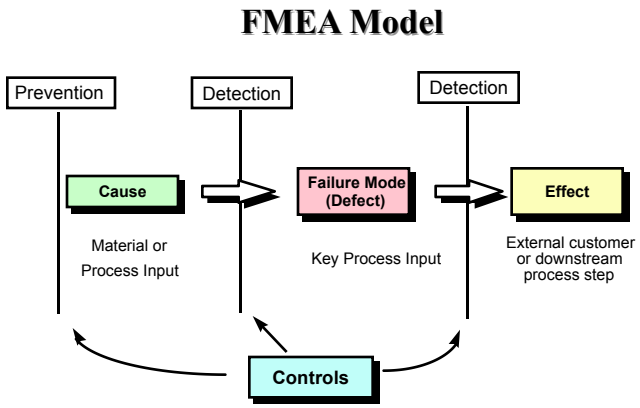
Definition of Terms



- **Cause**
  - **Sources of variation that causes the Failure Mode to occur.**

Example:

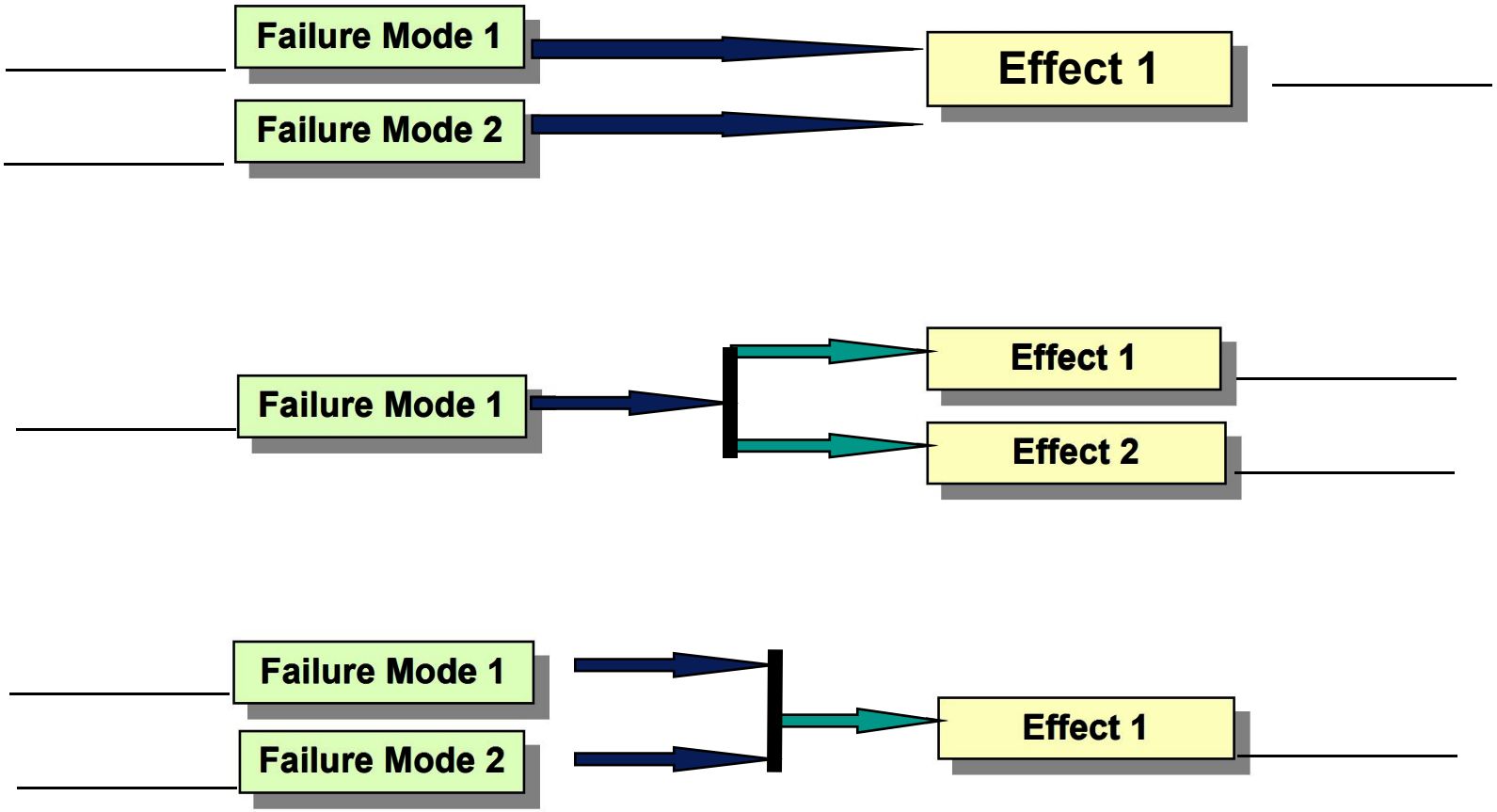
Definition of Terms



- **Controls**
  - **Systematized methods/devices in place to prevent or detect *failure modes* or *causes* (before causing effects).**
  - **Prevention and Detection consists of foolproofing, automated control, set-up verifications, audits, checklists, Inspection, laboratory testing, training, SOP's, preventive maintenance, etc.**

Example:

Linking Failure Modes to Effects



The relationship between the Failure Mode and the Effect is not always 1-to-1

Which One Is Right ?

Poor Raw Steel Stock

Corroded Contacts

Dead Battery → **Cause**

Bulb Doesn't Shine → **Failure Mode**

Flashlight Doesn't Work → **Effect**

Poor Raw Steel Stock

Corroded Contacts → **Cause**

Dead Battery → **Failure Mode**

Bulb Doesn't Shine → **Effect**

Flashlight Doesn't Work

Poor Raw Steel Stock → **Cause**

Corroded Contacts → **Failure Mode**

Dead Battery → **Effect**

Bulb Doesn't Shine

Flashlight Doesn't Work

Risk Priority Number (RPN)

- **The output of a FMEA is the "Risk Priority Number"**
  The RPN is a calculated number based on information you provide regarding:
  - **the severity of the effect to the customer**
  - **how often the Cause occurs**
  - **the current ability of the process to detect the failures before reaching the customer**

- **It is the product of three quantitative ratings:**

RPN = Severity ∗ Occurrence ∗ Detection

Risk Priority Number

- **Risk Priority Number is not sacred ; Go back & Review It**
- **Scaling for Severity, Occurrence and Detection can be locally developed. You'll see an example in a following case study**
- **Other categories can be added.**

Definition of RPN Terms

- Severity (of Effect)- importance of effect on customer requirements - could also be concerned with safety and other risks if failure occurs (1=Not Severe, 10=Very Severe)
- Occurrence (of Cause)- frequency with which a given Cause occurs and creates Failure Mode. Can sometimes refer to the frequency of a Failure Mode (1=Not Likely, 10=Very Likely)
- Detection (capability of Current Controls) - ability of current control scheme to detect:
  - the causes before creating failure mode
  - the failure modes before causing effect
  - 1=Likely to Detect, 10=Not Likely at all to Detect

General Rating Scales

RATING	DEGREE OF SEVERITY	LIKELIHOOD OF OCCURRENCE	ABILITY TO DETECT
1	Customer will not notice the adverse effect or it is insignificant	Likelihood of occurrence is remote	Sure that the potential failure will be found or prevented before reaching the next customer
2	Customer will probably experience slight annoyance	Low failure rate with supporting documentation	Almost certain that the potential failure will be found or prevented before reaching the next customer
3	Customer will experience annoyance due to the slight degradation of performance	Low failure rate without supporting documentation	Low likelihood that the potential failure will reach the next customer undetected
4	Customer dissatisfaction due to reduced performance	Occasional failures	Controls may detect or prevent the potential failure from reaching the next customer
5	Customer is made uncomfortable or their productivity is reduced by the continued degradation of the effect	Relatively moderate failure rate with supporting documentation	Moderate likelihood that the potential failure will reach the next customer
6	Warranty repair or significant manufacturing or assembly complaint	Moderate failure rate without supporting documentation	Controls are unlikely to detect or prevent the potential failure from reaching the next customer
7	High degree of customer dissatisfaction due to component failure without complete loss of function. Productivity impacted by high scrap or rework levels.	Relatively high failure rate with supporting documentation	Poor likelihood that the potential failure will be detected or prevented before reaching the next customer
8	Very high degree of dissatisfaction due to the loss of function without a negative impact on safety or governmental regulations	High failure rate without supporting documentation	Very poor likelihood that the potential failure will be detected or prevented before reaching the next customer
9	Customer endangered due to the adverse effect on safe system performance with warning before failure or violation of governmental regulations	Failure is almost certain based on warranty data or significant DV testing	Current controls probably will not even detect the potential failure
10	Customer endangered due to the adverse effect on safe system performance without warning before failure or violation of governmental regulations	Assured of failure based on warranty data or significant DV testing	Absolute certainty that the current controls will not detect the potential failure

Severity Guidelines
Software FMEA Scoring Example

1,2 Cosmetic Error

No loss in product functionality. Includes incorrect documentation

3,4 Product Performance Reduction - Temporary

Through time-out or system load the problem will “go away” after a period of time

5,6 Functional Impairment / Loss

The problem will not resolve itself, but a “work around” can temporarily bypass the problem area until fixed without losing operation

7,8 Functional Impairment / Loss

The problem will not resolve itself and no “work around” can bypass the problem. Functionality has either been impaired or lost but the product can still be used to some extent

9,10 Product Halts / Process Taken Down / Reboot Required

The product is completely hung up, all functionality has been lost and system reboot is required

Rate of Occurrence Scale

Software FMEA Scoring Example

1	1 per 100 units- years (1/50m)
2	1 per 10 unit-years (1/5m)
3	1 per 1 unit-year (1/525k)
4	1 per 1 unit-month (1/43k)
5	1 per week (1/10k)
6	1 per day (1/1440)
7	1 per shift (1/480)
8	1 per hour (1/60)
9	1 per 10 min (1/10)
10	1+ per min (1/1)

Detection Scale

Software FMEA Scoring Example

1,2	Requirements / Design Reviews
3,4	Code Walkthroughs / Unit Testing
5,6	System Integration & Test
7,8	Installation & Start-up
9,10	Detectable only once “on line”

Preparing the FMEA...
Just Like The Other Tools

- **Team Effort:**
  - **Operators, Technicians, Engineers, Managers, Customers, Co-workers, Suppliers, ARMI, etc...**
- **Inputs to Mapping**
  - **Process Map**
  - **C&E Matrix**
  - **Brainstorming**
  - **Engineering Specifications/Operating Manuals**
  - **Employee Experience**
  - **6M's (Fishbone Diagram)**
    - **Man, Machine (Equipment), Method (Procedures), Measurement, Mother Nature (Environment), Materials**

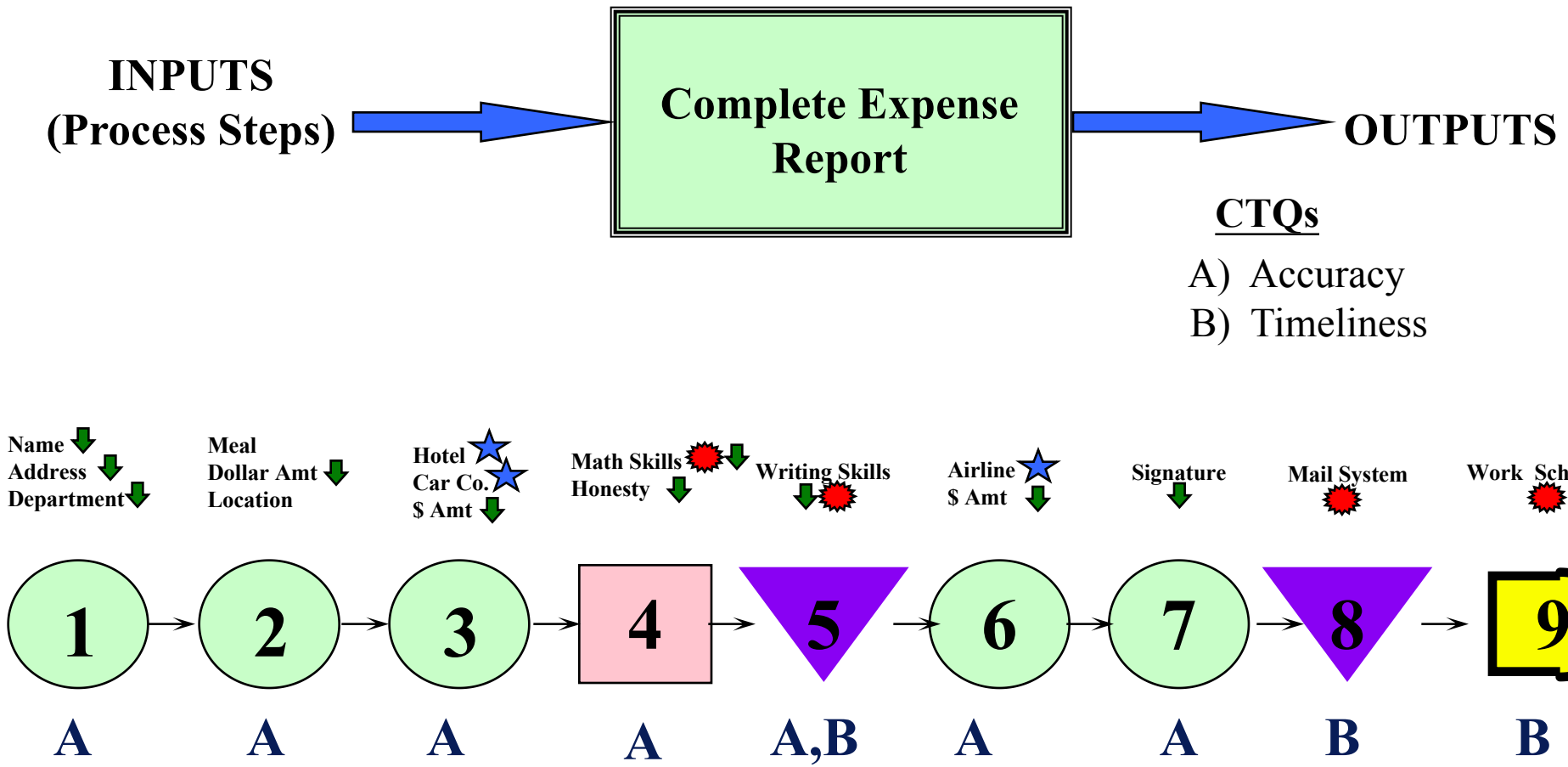
General Steps in the FMEA

These steps were covered in the Process Mapping and C&E modules

- Select the Process FMEA team
- Develop a Process Map and identify all process steps
- List all the Key Process Outputs to satisfy internal and external customer requirements
- For each Process Step, list Key Process Input Variables
- For the Process Define C&E matrix relating Key Outputs to Key Process Input Variables
- Rank the KPIV's according to importance

1. For each KPIV determine ways in which the input can go wrong (Failure Modes)
2. Determine Effects for each
3. Identify potential Causes
4. List the current controls for each Cause
5. Assign Severity, Occurrence and Detection ratings to each cause
6. Calculate RPN
7. Determine recommended actions to reduce *High* RPNs
8. Take appropriate actions
9. Re-calculate all RPNs

Process Map To Be Used In Example



C&E Matrix Example

Cause and Effect Matrix

	Rating of Importance to Customer	10	8														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	Process Inputs	Accuracy	Timeliness		Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Requirement	Total
1	Name	10	10														180
2	Address	10	10														180
3	Department	10	10														180
5	$ Amt	10	10														180
10	Honesty	10	10														180
9	Math Skills	10	8														164
11	Writing Skills	9	4														122
13	Signature	2	10														100
15	Work Sched.	2	10														100
12	Airline Name	8	0														80
14	Mail System	0	10														80
4	Meal Name	6	0														60
7	Hotel Name	6	0														60
8	Car Co.	6	0														60
6	Meal Loc.	4	0														40

1. For each KPIV determine ways in which the input can go wrong (Failure Modes)

The first two highest ranked Key Process Input Variables on the C&E Matrix are **Name & Address**

FMEA Worksheet

Process Step	Key Process Input	Failure Modes - What can go wrong?	Effects	Causes	Current Controls
Personal Information	Name	Missing			
		Unreadable			
	Address	Work or Home Address			

2. For each Failure Mode determine Effects

These effects are internal requirements for the next process.

FMEA Worksheet

Process Step	Key Process Input	Failure Modes - What can go wrong?	Effects	Causes	Current Controls
Personal Information	Name	Missing	Delayed Processing		
		Unreadable	Delayed Processing		
	Address	Work or Home Address	Delayed Delivery		

3. Identify potential Causes of each Failure Mode

In most cases, there will be more than one Cause for a Failure Mode. We'll keep it simple for this exercise.

Worksheet

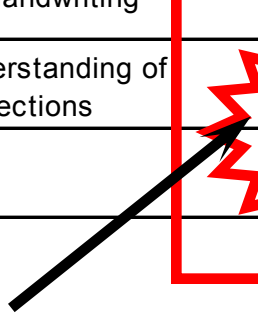
Process Step	Key Process Input	Failure Modes - What can go wrong?	Effects	Causes	Current Controls
Personal Information	Name	Missing	Delayed Processing	Forgot	
		Unreadable	Delayed Processing	Bad Handwriting	
	Address	Work or Home Address	Delayed Delivery	Misunderstanding of Instructions	

4. List the Current Controls for each Cause

For each Cause list how we are either preventing or detecting it.
Record the procedure number wherever there is an SOP.

FMEA Worksheet

Process Step	Key Process Input	Failure Modes - What can go wrong?	Effects	Causes	Current Controls
Personal Information	Name	Missing	Delayed Processing	Forgot	None
		Unreadable	Delayed Processing	Bad Handwriting	Computer generated form
	Address	Home or Work Address	Delayed Delivery	Misunderstanding of directions	None



This is how the FMEA identifies initial holes in the Current Control Plan.
Teams can start working on these holes right away.

5. Assign Severity, Occurrence and Detection ratings to each Cause

Key Process Input	Potential Failure Mode	Potential Failure Effects	S E V	Potential Causes	O C C	Current Controls	D E T	R
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 eith the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect cause or FM?	
Name	Missing Name	Delayed Processing	10	Forgot	2	None	10	
	Unreadable Name	Delayed Processing	9	Bad Hand Writing	8	Computer generated form	6	
Address	Work or home address	Delayed Delivery	4	Misunderstood directions	3	None	10	
								0

Note: If there are no current controls the ability to detect = 10.

If you have developed a scaling matrix, include in your documentation.

6. Calculate RPN

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 eith the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect cause or FM?	RPN
Name	Missing Name	Delayed Processing	10	Forgot	2	None	10	200
	Unreadable Name	Delayed Processing	9	Bad Hand Writing	8	Computer generated form	6	432
Address	Work or home address	Delayed Delivery	4	Misunderstood directions	3	None	10	120

RPN = Severity ∗ Occurrence ∗ Detection

7. Determine Recommended Actions to reduce High RPN's

First, sort all causes by RPN. Notice that you have to fill all cells for each column so you can carry the Failure Modes, Effects, Causes and Current Controls along with the sort.

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 eith the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect [illegible]?	RPN	What are the actions for reducing the occurrance of the Cause, or improving detection? **Should have actions only on high RPN's or easy fixes.**	Whose Responsible for the recommended action?
Delayed Processing	9	Bad Hand Writing	8	Computer generated form	6	432	Revise form, Put on NET	J. M./Prod Desk
Delayed Processing	10	Forgot	2	None	10	200	None	
Delayed Delivery	4	Misunderstood directions	3	None	10	120	None	

Actions are recommended for only the high RPN's. The key is **FOCUS**!

8. Take appropriate Actions and Document

Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken
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 eith 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 occurrance of the Cause, or improving detection? **Should have actions only on high RPN's or easy fixes.**	Whose Responsible for the recommended action?	What are the completed actions taken with the recalculated RPN? **Be sure to include completion month/year**
Delayed Processing	9	Bad Hand Writing	8	Computer generated form	6	432	Revise form, Put on NET	J. M. / Prod desk	Form revised 10/97 On NET 11/97
Delayed Processing	10	Forgot	2	None	10	200	None		
Delayed Delivery	4	Misunderstood Directions	3	None	10	120	None		

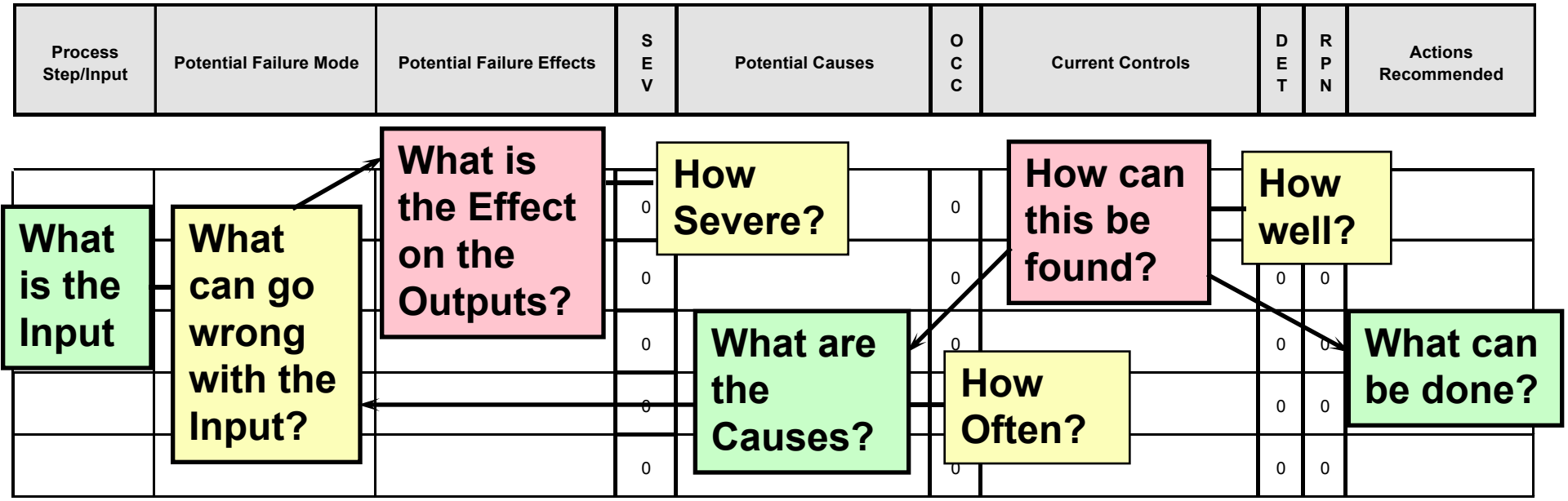
If there is an "easy" fix for low RPN items . . . take action and document

9. Recalculate RPN's

SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken	SEV	OCC	DET	RPN
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 eith 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 occurrance of the Cause, or improving detection? **Should have actions only on high RPN's or easy fixes.**	Whose Responsible for the recommended action?	What are the completed actions taken with the recalculated RPN? **Be sure to include completion month/year**				
9	Bad Hand Writing	8	Computer generated form	6	432	Revise form Put on NET	J. M. / Prod Desk	Revised form 10/97 On NET 11/97	2	8	10	160
10	Forgot	2	None	10	200	None			10	1	10	100
4	Misunderstood Directions	3	None	10	120	None			1	0	0	0

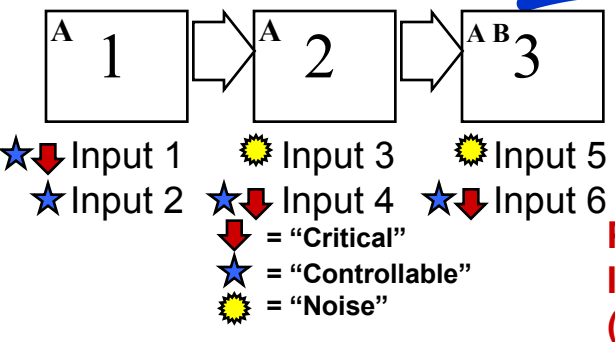
Work on revised highest RPNs

Overview


Process Step/Input
Potential Failure Mode
Potential Failure Effects
S E V
Potential Causes
O C C
Current Controls
D E T
R P N
Actions Recommended
What is the Input
What can go wrong with the Input?
What is the Effect on the Outputs?
How Severe?
What are the Causes?
How Often?
How can this be found?
How well?
What can be done?

Six Sigma Tools Linkage

Step One: Map The Current Process



STEP #1: Process Mapping

a. - Form a team using Subject Matter Experts and Process Owners
b. - Define the current process steps and inputs (X's)
c. - Identify which process steps effect each CTQ
d. - Identify the characteristic of each process input (Controllable, Critical and/or Noise)
Do not proceed until all previous is complete

STEP #2: C&E Matrix

a. - List the controllable and critical inputs vertically in the C&E matrix
b. - List the CTQs horizontally (Use the customer to determine the importance of each CTQ)
c. - Use the same team to correlate and weigh the impact of each input to each CTQ
Do not proceed until all previous is complete

STEP #3: FMEA

a. - List the Key Inputs (which rank high on the C&E) in the "Key Inputs" column of the FMEA
b. - Work through the FMEA with the team
Do not proceed until all previous is complete

STEP #4: Gather Data

a. - Gather data about those potential causes (X's) with the highest RPN Numbers and any unknowns.

CTQ's
A - CTQ 1
B - CTQ 2

Process Inputs (X's)

Cause and Effect

	Rating of Importance to Customer		9	5	
	Outputs		1	2	
			CTQ A	CTQ B	Total
	Process Inputs				
1	Input 1		9	9	126
2	Input 2		9	9	126
3	Input 3		5	1	50
4	Input 4		1	1	14
5	Input 5		9	5	106
6	Input 6		9	1	86
7					0
8					0
9					0
10					0
11					0
12					0
13	Total		42	26	508

Step Two: Cause & Effect Matrix

Suspect Key Inputs (Largest #'s)

Step Three: FMEA

Process/Product Failure Modes and Effects Analysis (FMEA)

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended
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 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?		What are the actions for reducing the occurance of the Cause, or improving detection? Should have actions only on high RPNs or easy fixes.
1	BOM	Poorly Defined	Decrease in OM	10	Inadequate specification	3		5	150	
				10	Inexperienced AE	3		5	150	
			Increase OM	1	Inadequate specification	3		5	15	

Step Four: Data Gathering

Data should then be collected on:
1) The associated Y's (CTQs).
2) The Key Inputs and potential causes of failure related to those Key Inputs with the **highest RPN** numbers and any unknowns.

FMEA
“Real Life Examples”

Process/Product
Failure Modes and Effects Analysis
(FMEA)

Process or Product Name:		Prepared by:	
Responsible:		FMEA Date (Orig) _____ (Rev) __	

Process Step/Part Number	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN
Packaging	Wrong Packaging Mtl	Broken Parts	10	Operator Error	8	Wall Chart of correct material	9	720
			10		8	Whare house audit	5	400
			10	Substitute Cheaper Mtl	2	None	10	200
	Too Many boxes on Pallet	Crushed Boxes	6	Tempory Help	5	None	10	300

Failure Modes and Effect Analysis (FMEA)

Commercial Example

PROJECT **Increase The Number Of Completed Telephone Calls on First Contact**

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Prepared by: **William M. Schramm** **FMEA Date (Orig) _ 6/14/96____ (Rev) 6/21/96_____**

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects (Process)	SEV	Potential Causes (Why)	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.
What is the process step	What is the Key Process Input?	In what ways does the Key Input go wrong?	(1 - 5)	How Severe is the effect to the customer?	What causes the Key Input to go wrong? (1 - 5)	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? (5 - 1)	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 easy fixes.**	Whose Responsible for the recommended action?
Identify Need / Urgency	Part #	Customer doesn't have a Part#	Salesperson can't quote/order	4	Customer doesn't have all information	3	Catalogs, system, disks	1	12		
				4	New application	3	None	1	12		
			Require additional time searching catalogs, systems, etc.	3	Customer doesn't have all information	3	Catalogs, system, disks	1	9		
				3	New application	3	None	1	9		
			Customer will have to find additional information and call back	5	Customer doesn't have all information	3	Catalogs, system, disks	1	15		
				5	New application	3	None	1	15		
		Customer has the wrong part #	Salesperson can't quote/order	4	Customer was given the wrong #	3	Alpha / numeric sequence	4	48		
				4	Looking at wrong information on product	3	Alpha / numeric sequence	4	48		
				4	Customer gives serial # as part#	2	Alpha / numeric sequence	3	24		
				4	Missing nameplate/worn out	3	Alpha / numeric sequence	1	12		
				4	Customer misreads part #	4	Alpha / numeric sequence	3	48		
			Salesperson quote/order wrong part#	5	Customer was given the wrong #	3	Alpha / numeric sequence	4	60		
				5	Looking at wrong information on product	3	Alpha / numeric sequence	4	60		
				5	Customer gives serial # as part#	2	Alpha / numeric sequence	3	30		

Manufacturing Example

Process Step	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	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 eith the cause or the Failure Mode? **Should include an SOP number.**	How well can you detect cause or FM?	
BLOCKING STATION	PREFORM AND BLOCK WDGS	START WIRE DOESN'T SET--END TURNS IN BORE	DAMAGED STATOR(SCRAP)	10	BLOCKER SETUP	3	VISUAL	6	180
CRIMPING STATION	ROUTE LEADS AND CRIMP SWITCH	STRT WIRE PUSHED IN FRT OF LEG	DAMAGED STATOR(SCRAP)	10	BLIND ASSEMBLY, DESIGN ISSUE	5	VISUAL	7	350
		STRT WIRE PULLED IN BORE ON OLE	DAMAGED STATOR(SCRAP)	10	OPERATOR AWARENESS/ MANUFACTURING ISSUE	5	VISUAL	7	350
STATOR TESTER	ELECTRICAL TEST OF STATOR	AUTOMATED TESTER BREAKS SWITCH LEG	DAMAGED STATOR ASSEMBLY(CAN BE REPAIRED)	8	SWITCH LEG NOT IN STATOR SLOT PRIOR TO TEST(MATERIAL HAND. CONVEYER)	6	VISUAL	7	336
MOTOR ASSEMBLY	DROP STATOR ONTO ROTOR	MAGNET WIRE DAMAGED DURING OPERATION	DAMAGED STATOR(SCRAP)	10	PICK-N-PLACE OFF ALIGNMENT	2	VISUAL	3	60

Process/Product Failure Modes and Effects Analysis (FMEA)

Product Manufacturing Example

Process or Product Name:	Clean Sheet Compressor		Prepared by:	Page ____ of ____
Responsible:			FMEA Date (Orig) 10/15/97_____	(Rev) _____

Part Name / Part number	Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.
What is the part?	What is the part's function?	In what ways does the function fail?	What is the impact on the Key Output Variables (Customer Requirements) or internal requirements?	How Severe is the effect to the cusotmer?	What causes the funciton to fail?	How often does cause or F.M occur?	What are the existing controls and procedures (inspection and test) that prevent eith 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 occurrance of the Cause, or improving detection? **Should have actions only on high RPN's or easy fixes.**	Whose Responsible for the recommended action?
Rotor Assembly	Transmit torque	Rotor Slip or spin on shaft	No compressed air		Improper fits (at regular & high temp)				0		
		Effective Rotor resistance incorrect	Blown fuses		Lamination / endring design				0		
					Improper skew specified				0		
		Brg slips in DE endshield	Brg failure		Improper fits (at regular & high temp)				0		
			Failure to start		Improper fits (at regular & high temp)				0		
	Support cust. side load	Shaft break	No compressed air		Improper material spec		Life test, DeVilbiss FEA, GE FEA		0		
					Loads exceed design		Life test, DeVilbiss FEA, GE FEA, Compressor head height requirement		0		
					Effective section properties (high stress areas)		FEA & life test		0		
			Compressor damage		Improper material spec		Life test, DeVilbiss FEA, GE FEA		0		
					Loads exceed design		Life test, DeVilbiss FEA, GE FEA, Compressor head height requirement		0		
					Effective section properties (high stress areas)		FEA & life test		0		
			Rotor Locked up		Improper material spec		Life test, DeVilbiss FEA, GE FEA		0		
					Loads exceed design		Life test, DeVilbiss FEA, GE FEA, Compressor head height requirement		0		
					Effective section properties (high stress areas)		FEA & life test		0		
		Brg fails	Bearing seize / Rotor locks up		Mis-application of brg		Customer Spec, Life test		0		
					Wrong grease for ambient temp		Customer Spec, Life test		0		
		Excessive shaft dellection	Rotor Striking		Insufficient shaft stiffness		Life test, FEA		0		

FMEA

Class Exercise

With Your Team . . .

Perform An FMEA On The Top 2 Inputs From The C&E

Note: Watch your Time 30 Min.

Present Results On Flip Chart

Summary

- Link FMEA To Measure-Analyze-Improve-Control
- Introduce The Steps To Create A FMEA
- Show Examples
- Perform An Exercise