A Statistical Approach to Product Quality Assurance

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Topics to be covered

- Purpose of Quality Assurance
- Classical Approach to Quality Assurance
  - How It Works
  - Deficiencies of Classical Approach
- Defect Model Approach to Quality Assurance
  - Premise
  - How It Works
  - Types of Defects
  - Benefits of this Quantitative Approach
- Conclusion

Purpose of Quality Assurance

- To provide staff & management insight into processes being used and work products being built
  - Determine process adherence
  - Evaluate work products during development and prior to delivery

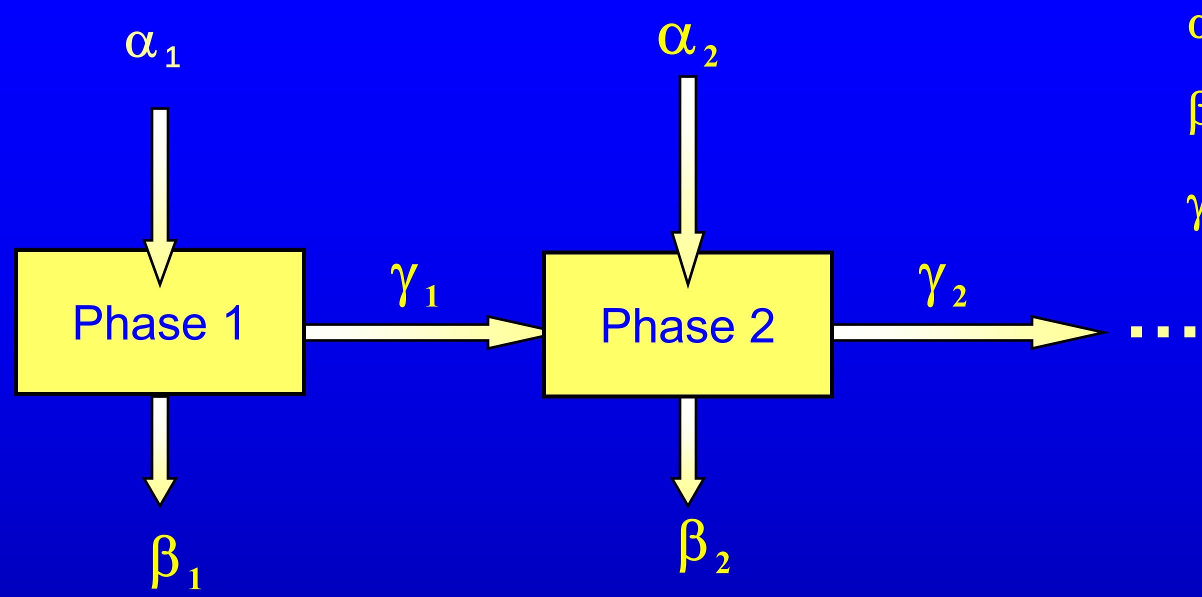
Classical Approach to Quality Assurance

- Separate group from developers
  - A way of insuring independence
- QA group examines/reads the work product to be evaluated
  - Often after the work product is completed
  - Defects found are costly to correct
- QA group typically does not have the domain knowledge to judge technical quality
  - Technical quality not determined
  - Determine if formatted properly
  - Meets standards imposed

Premise

- Products are created by executing processes
- In a mature organization, process performance is known, repeatable and controlled
- Defects are inserted at statistically known rates
- Therefore by monitoring defects detected
  - Estimate of defects remaining in product can be made
  - A statement of the product quality can be quantitatively made
  - Corrective action can be taken early in the life cycle
    - Least costly to correct

Defect Modeling



α = Defects In

β = Defects Out

γ = Remaining Defects

$\alpha_1 = \beta_1 + \gamma_1$

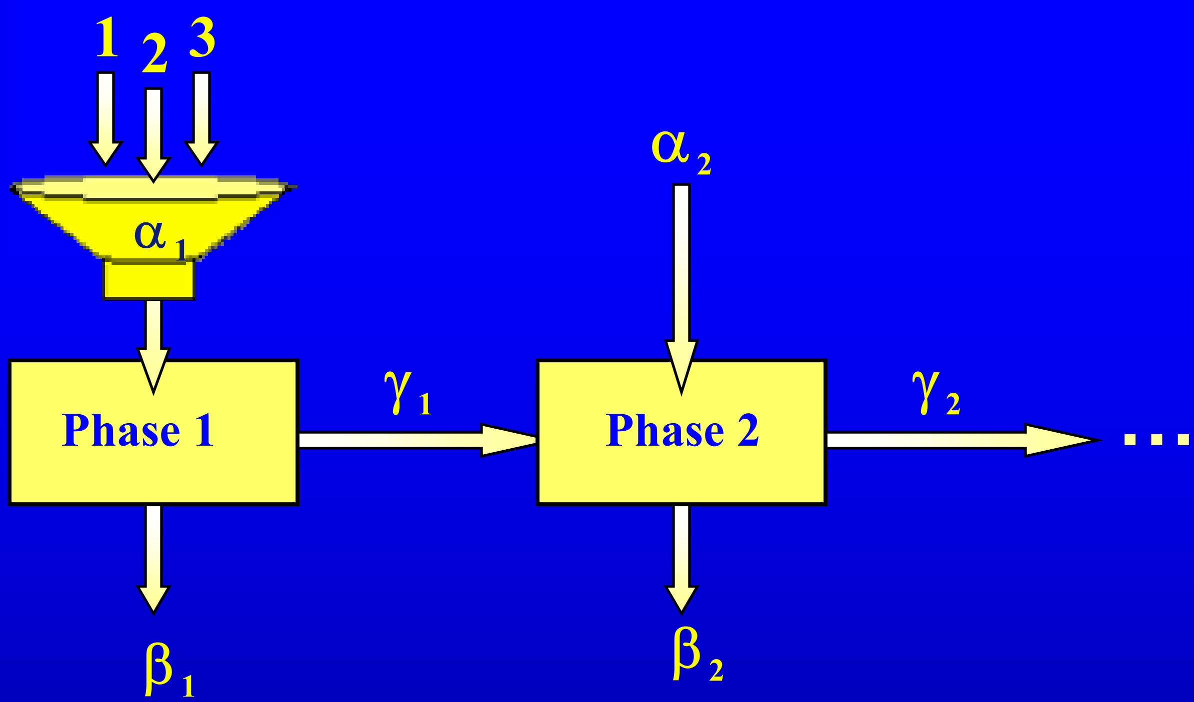
$\gamma_1 = \alpha_1 - \beta_1$

$\alpha_2 + \gamma_1 = \beta_2 + \gamma_2$

$\gamma_2 = \alpha_2 + \gamma_1 - \beta_2$

"Defects In" is known, "Defects Out" is monitored --> Therefore "Remaining Defects" left in product can be determined

Defect Modeling



1 = New

2 = Mod

3 = Revised

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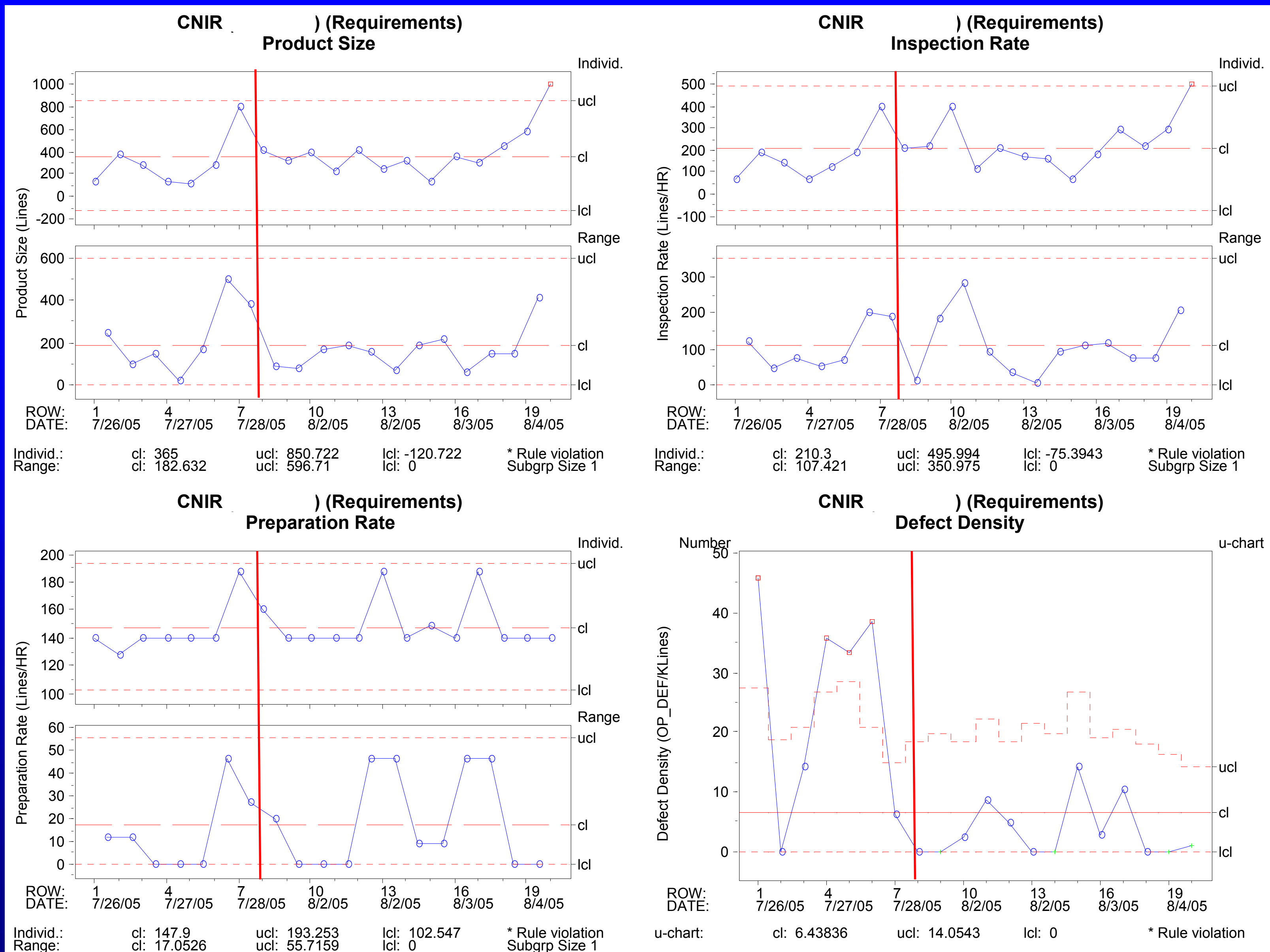
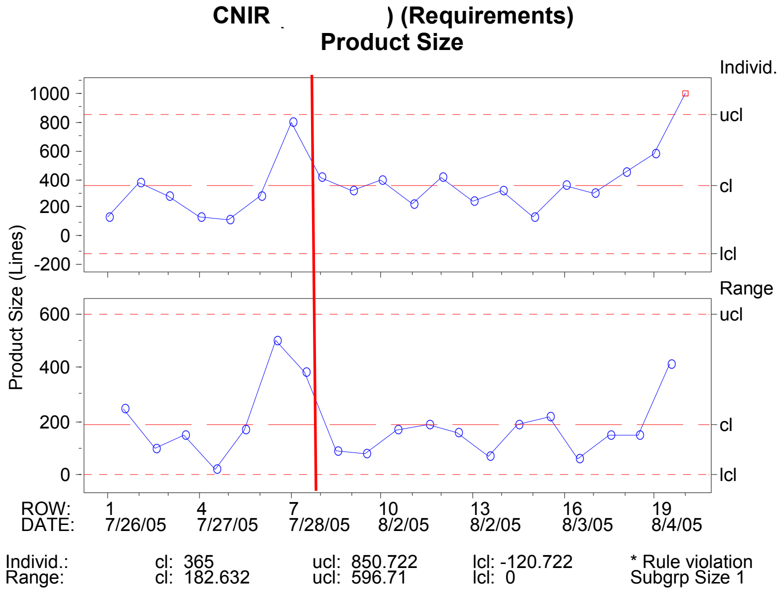
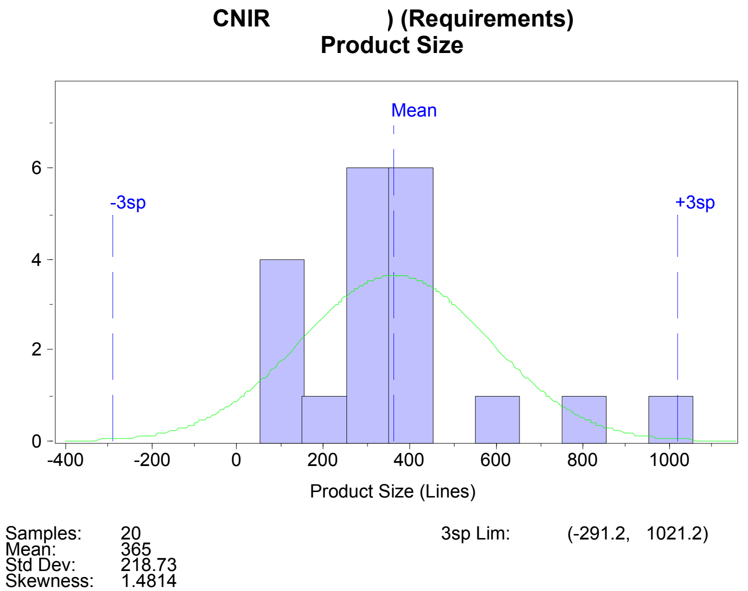


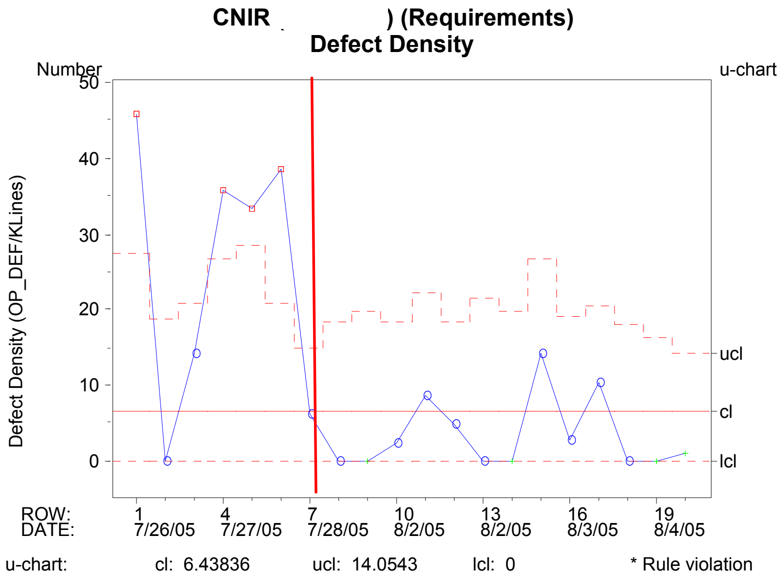
CNIR) (Requirements)
Product Size
Product Size (Lines)
Individ.
Range
ucl
cl
lcl
ROW:
DATE:
Individ.: cl: 365 ucl: 850.722 lcl: -120.722 * Rule violation
Range: cl: 182.632 ucl: 596.71 lcl: 0 Subgrp Size 1
CNIR) (Requirements)
Inspection Rate
Inspection Rate (Lines/HR)
Individ.: cl: 210.3 ucl: 495.994 lcl: -75.3943 * Rule violation
Range: cl: 107.421 ucl: 350.975 lcl: 0 Subgrp Size 1
CNIR) (Requirements)
Preparation Rate
Preparation Rate (Lines/HR)
Individ.: cl: 147.9 ucl: 193.253 lcl: 102.547 * Rule violation
Range: cl: 17.0526 ucl: 55.7159 lcl: 0 Subgrp Size 1
CNIR) (Requirements)
Defect Density
Number
u-chart
Defect Density (OP_DEF/KLines)
u-chart: cl: 6.43836 ucl: 14.0543 lcl: 0 * Rule violation

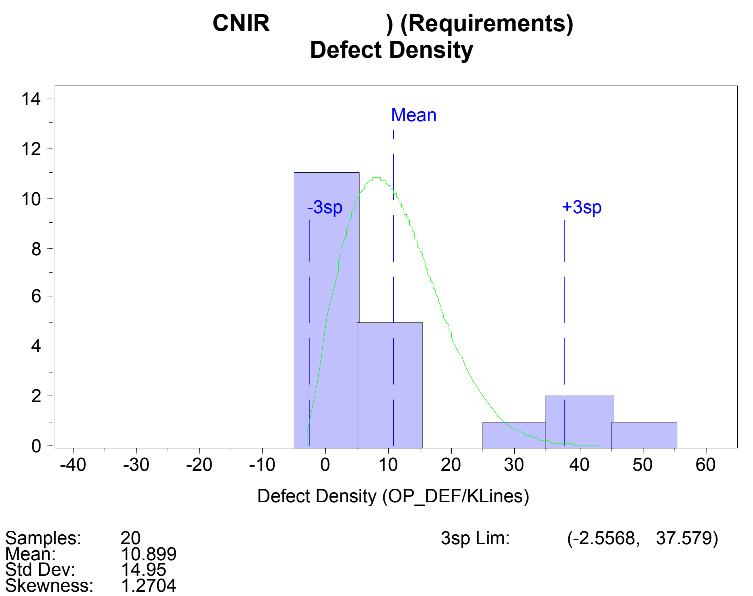
Causal Analysis



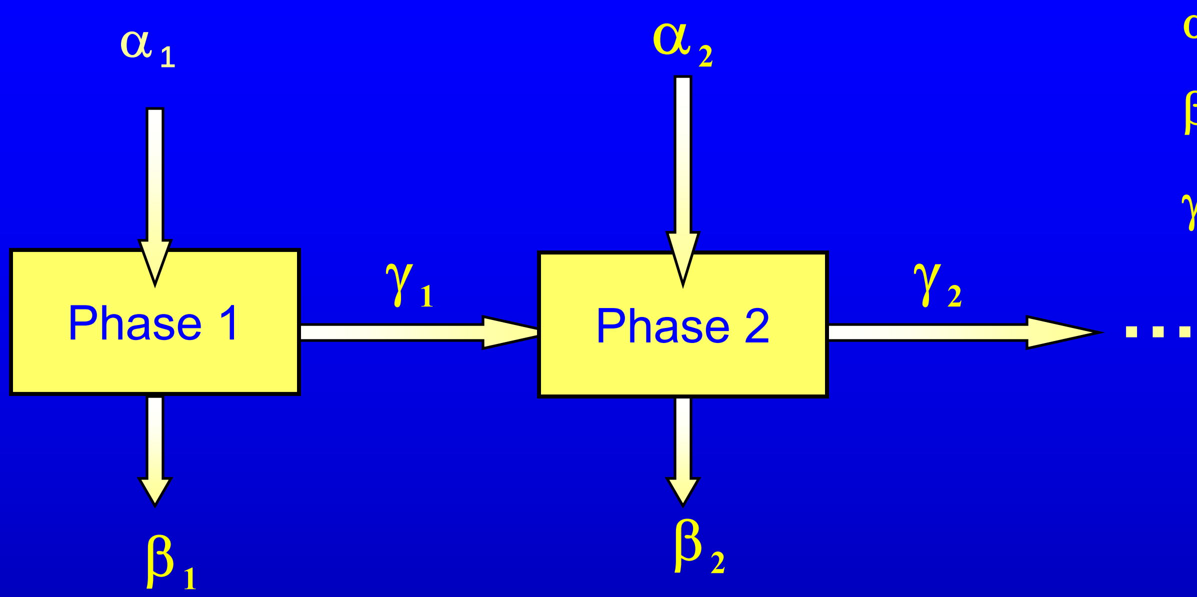


Causal Analysis





Defect Modeling



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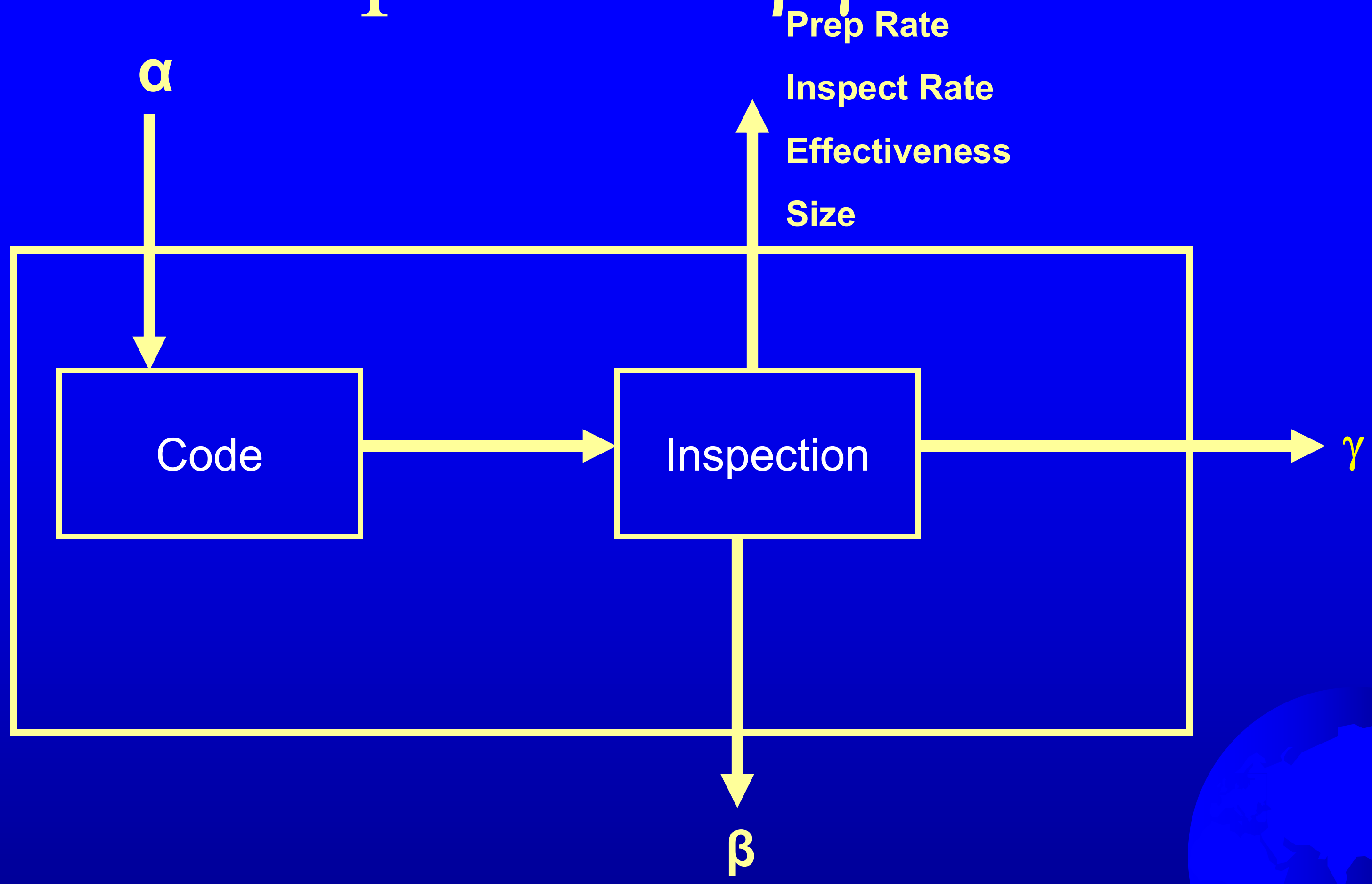
Expanded αβγ Chart



Defect Detection Methods

- “Peer Reviews”
  - Inspections (Fagan)
  - Structured Walk-Through
  - Active Reviews
- Modeling and Simulation
- Testing
  - Unit
  - Integration
  - Formal/ Sell-off
- Various Effectiveness in Methods

Sources of Defect

- Ambiguous Requirements
- Incomplete Analysis of Requirements
- Misunderstood Requirements
- Poor Design
  - No Flexibility
  - Too General
- Error in Coding
- Complexity
- Miss-execution
- COTS
- Open Source

Types of Defects

- Logic (Most Prevalent)
- Computation
- Interface
  - External
  - Internal
- Data

Acceptable Defect Levels

- Categories of Software:
  - Demonstration (Proof of Concept)
  - Windows
  - Military
  - DO-178B
    - 5 Categories f (affect of failure)
  - Manned Space Flight

- Level of latent defects permissible varies (Do not want to overkill; Too costly)

Defect Model (By the Numbers)

Know the Pedigree of Reused Code

Reused (Fielded)
Reused (Not Fielded)
Modified
New

0.2 Defects/ KSLOC

⋮

25 Defects/ KSLOC

What is the Defect Density? **Not Simple**

CNIR Defect Model

New Functionality

Phase	Insert	Detect
Requirements	46	37
Design	21	17
Coding	8	15
Test	0.2	≤4.6
FQT	0.1	≤2.5

CNIR #'s

CNIR Defect Model

Mod Functionality

Phase	Insert	Detect
Requirements	20	16
Design	21	17
Coding	5.8	10
Test	0.2	≤4.6
FQT	0.1	≤2.5

CNIR #'s

Defect Cost Example

10 K	**Reused** @ 0.2 Defects/ KSLOC	→	0.2 Defects
9 K	**Reused Prototype** @ 15 Defects/ KSLOC	→	30 Defects
7 K	**Modified Significant** @ 20 Defects/ KSLOC	→	40 Defects
5 K	**New** @ 25 Defects/ KSLOC	→	125 Defects

= 195.2 Total Defects

Therefore, 19.5 Defects/ KSLOC

Defect Cost Example (continued)

- 195 Defects in 9 KSLOC
  - @ 100% Fagan Coverage
    - ➔ 45 Fagan Inspections
  - @ 20 Man Hours/ Inspection
    - ➔ 900 Man Hours
  - Removing 156 Defects
    - 39 Defects Remaining
- 39 Defects
  - @ 20 Man Hours/ Defect
    - ➔ 780 Man Hours
  - @ 40 Man Hours/ Defect
    - ➔ 1,560 Man Hours

Total Cost: 1,880 – 2,460 Man Hour

Code/ Unit Test/ Integration

At 2 SLOC/ Man Hour, Total Cost = 4,500 Man Hours

Defect Cost Example (continued)

- 195 Defects in 9 KSLOC
  - @ 50% Fagan Coverage
    - ➔ 23 Fagan Inspections
  - @ 20 Man Hours/ Inspection
    - ➔ 460 Man Hours
  - Removing 62 Defects
    - 133 Defects Remaining

- 133 Defects
  - @ 20 Man Hours/ Defect
    - ➔ 2,660 Man Hours
  - @ 40 Man Hours/ Defect
    - ➔ 5,320 Man Hours

Total Cost: 3,120 - 5,780 Man Hours

Benefits of Method

- Quality of product is estimated quantitatively as components are created
  - Defects least costly to correct
- Systemic problems identified and steps taken to prevent repeating defects
- Additional defect detection activities can be added if deemed necessary

Conclusion

- Defect Modeling and Statistical Control of Quality provides the following advantages over the classical method
  - Technical Product Quality is objectively evaluated by personnel with domain knowledge using a formal proven approach
  - Estimate of defects remaining in product can be made throughout the product lifecycle
    - Corrective action can be taken early in the life cycle
      - Least costly to correct
  - The quality of the end product is known
    - Additional defect detection activities can be added if deemed necessary
  - Trend analysis of defects and root cause analysis can lead to proactively preventing future defects not only on the project, but throughout the organization

Contacts

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