Process Performance Baselines and models

Data collection
Kappa
Sampling
Hypothesis testing
Baselines
Models

Which Control Chart Should Be Used?

Individuals and Moving Range (XmR or ImR) Charts

Use the short term variation between adjacent observed values to estimate the natural (inherent) variation of the process. This leads to a pair of charts, one for the individual values (X or sometimes reffered to as I) and another for the successive two point moving ranges (mR)

Note: XmR charts are sometimes referred to as ImR charts with the “I” representing Individual data points

mR = moving Range = the absolute difference between successive individual values

X-Bar and R Charts

- When the measurements of product or process characteristics are collected under basically the same conditions, the data may be grouped into self-consistent sets (subgroups of size = n)

- The results of the groupings are used to calculate process control limits, which, in turn, are used to examine stability and process capability

Detecting Process Instabilities -1

- To test for instabilities in processes, examine all control charts for instances and patterns that signal process anomalies

- Look for values that
  - Fall outside the control limits
  - Have unusual (non random) patterns within the running record
  - Suggest that assignable causes exist

Detecting Process Instabilities -2

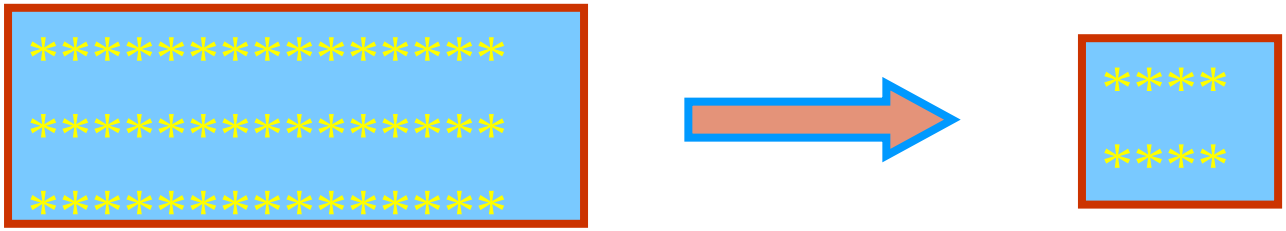
- The following four tests are used to detect instabilities:

Test 1: A single point falls outside the 3-sigma control limits
Test 2: At least two of three successive values fall on the same side of, and more than two sigma units away from, the center line.
Test 3: At least four out of five successive values fall on the same side of, and more than one sigma unit away from, the center line.
Test 4: At least eight successive values fall on the same side of the center line

What is SAMPLING?

- If the total data set has "N" data points and is called the population.
- Sampling is the process of selecting a portion of subset of the total data that may be available. This is usually represented as "n".
- The purpose of sampling is to be able to make judgment for the total population based on the "n" data points sampled

What is SAMPLING?....



Population of "N"

What is the average tenure of agent

Using a sample "n", We make a judgment that the average tenure is 8(say) months

For sampling ask yourself

- Why do you need to sample?
- What are the benefits of sampling?
- What are the sampling techniques and which one we use when?
- What should be the sample size

Considerations while sampling:

- **Why do you need to sample?**
  - Collecting complete data is too costly, is cumbersome
  - Collecting data may be a destructive process
  - The process has high volume output
- **When should I not sample?**
  - When the data subset does not depict the true process. E.g. Venture capital funding deals
- **That the sample is representative**
  - It is representative if it accurately represents the target population.

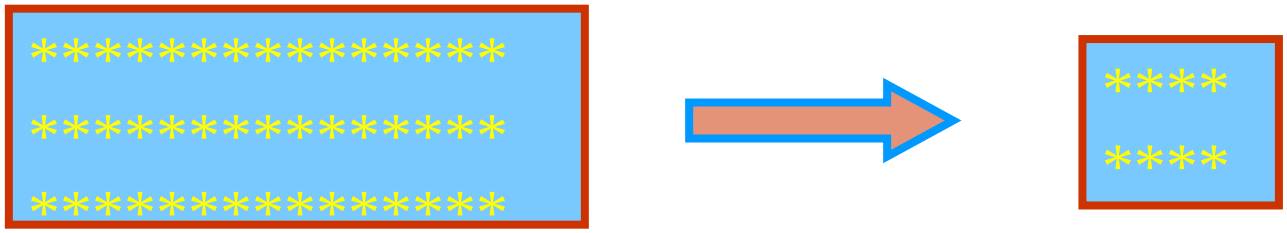
Sampling Approaches

- Population approach:
  - Random Sampling
  - Random Stratified sampling
- Process Approach:
  - Systematic sampling
  - Sampling by Rational sub grouping

Sampling Approach-Population

- **Random Sampling**
  - Each unit has the same probability to be selected in the sample.

E.g. draw of lots in a game show



Sampling Approach- Population..

- **Random Stratified sampling**
  - Stratify the data into different groups
  - Then randomly select sample from each of the stratified groups
  - The sample size of the stratified groups is in proportion of the relative size of the group

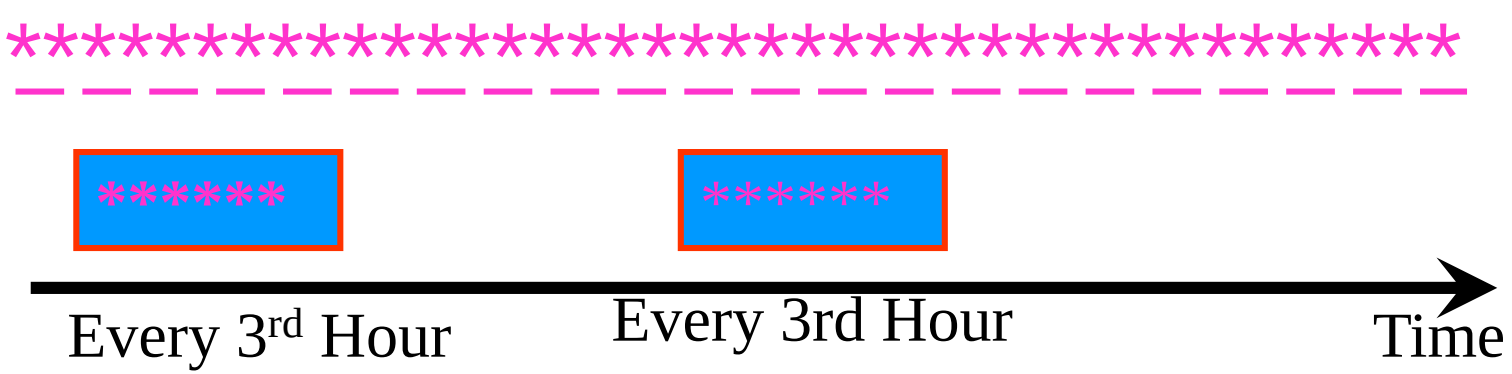
E.g. Average loan application processing time in days stratified

By loan amount (large, medium, small)

Sampling Approach-Process

- **Systematic sampling**
  - Used in continuous process situations
  - Frequency of sampling is chosen ie. every nth hour so many samples will be drawn

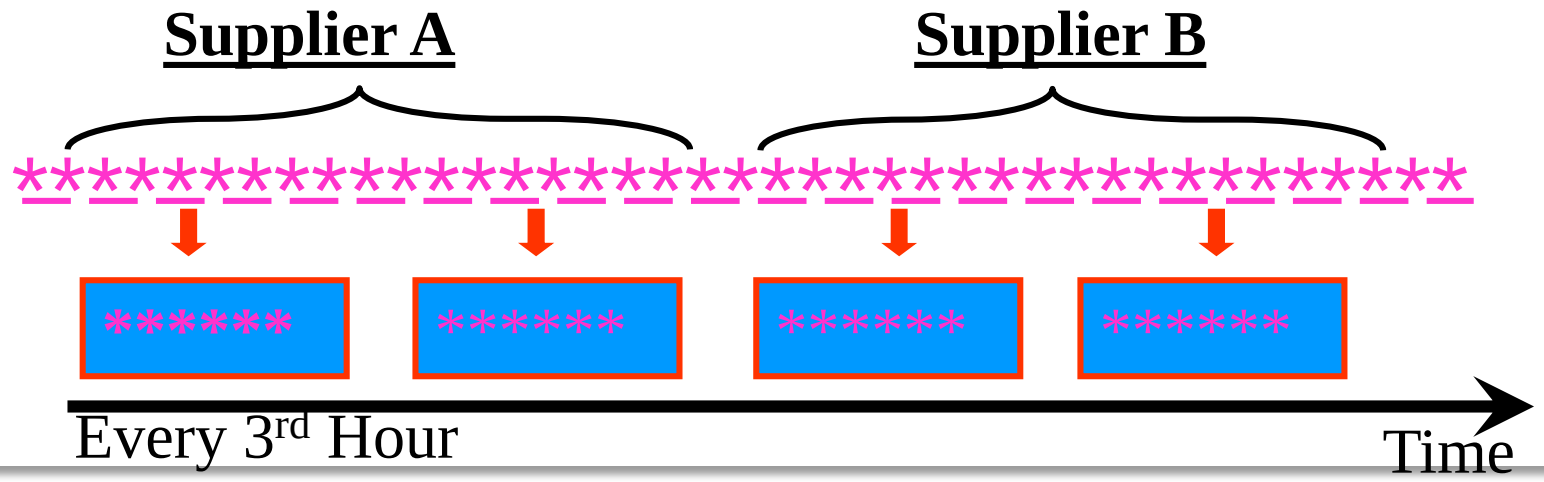
E.g. every 3rd hour a group of consecutive cash vouchers are sampled for accuracy of the time stamp at the stock booking terminal.



Sampling Approach-Process..

- **Rational sub grouping**
  - Used in continuous process situations
  - Sample drawn from groups produced under similar conditions
  - Base the subgroups so as to avoid capturing "Special Causes" of variation in the subgroup

E.g. sample every 3rd hour by each batch of supplier materials



Sampling Approach-Process..

Considerations

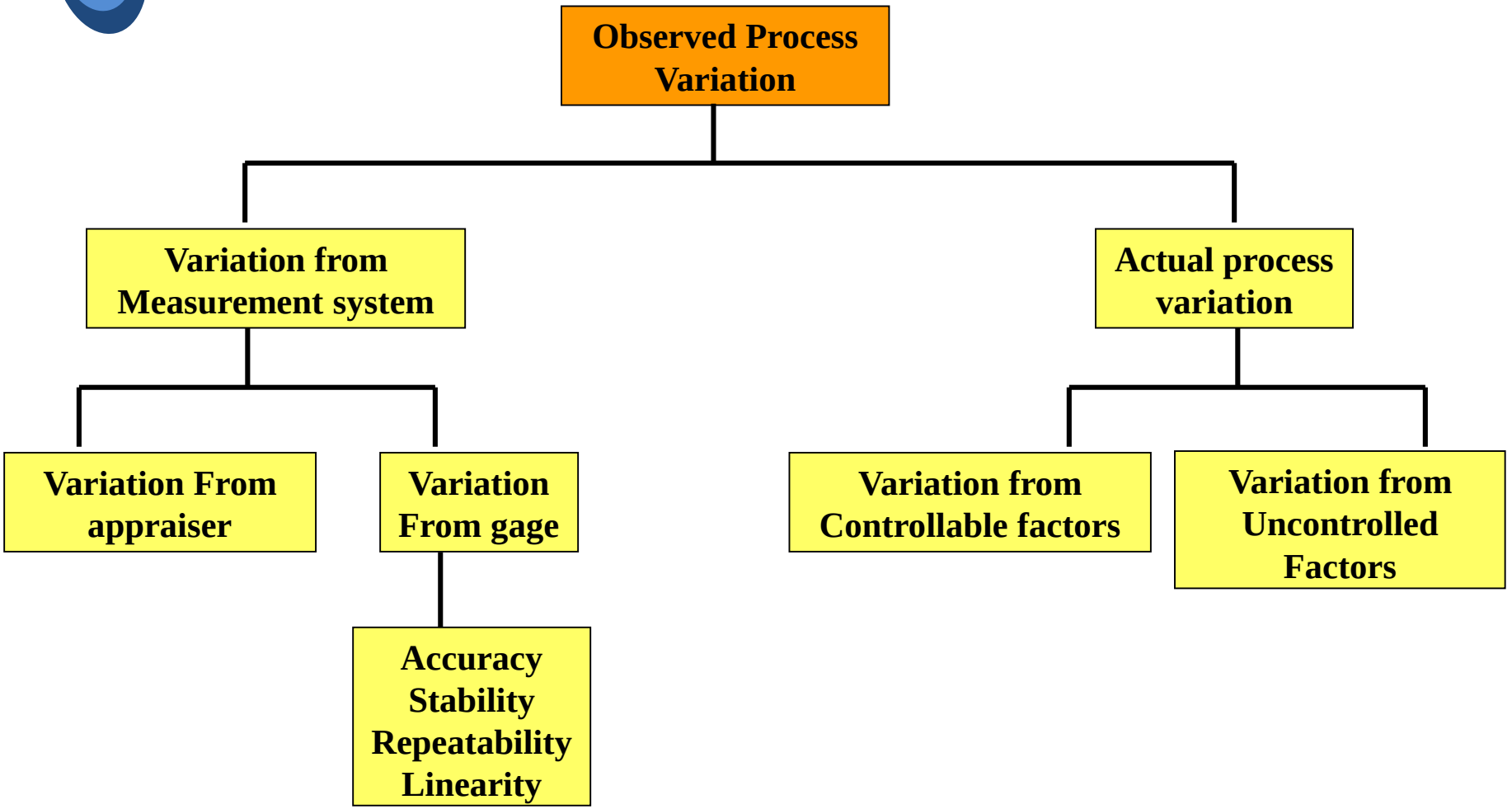
- Sample frequency enough to catch the shift in the process from the good to the bad
- More useful to capture frequent samples of smaller size than one large sample once.
- If the process has
  - Larger the variation the more frequent the sampling
  - Lower the variation the less frequent the sampling
  - Higher the volume production the more frequent the sampling
  - Lower the volume production less frequent the sampling

Sampling Exercise.

Measurement System Analysis

- **Repeatability**
  - Variation in measurement when a person measures the same unit repeatedly with the same measuring gage (Equipment)
- **Reproducibility**
  - Variation in measurement when two or more persons measure the same unit using the same measuring gage (Appraiser)

Components of Variation



Measurement System Errors

- **Accuracy**
  - The difference between the average of observed of values and the standard
- **Repeatability**
  - Variation in measurement when a person measures the same unit repeatedly with the same measuring gage (or tool)
- **Reproducibility**
  - Variation in measurement when two or more persons measure the same unit using the same measuring gage (or tool)

Measurement System Errors…

- **Stability**
  - Variation in measurement when the same person measures the same unit using the same measuring gage over an extended period of time.
- **Linearity**
  - The consistency of the measurement across the entire range of the measuring gage.

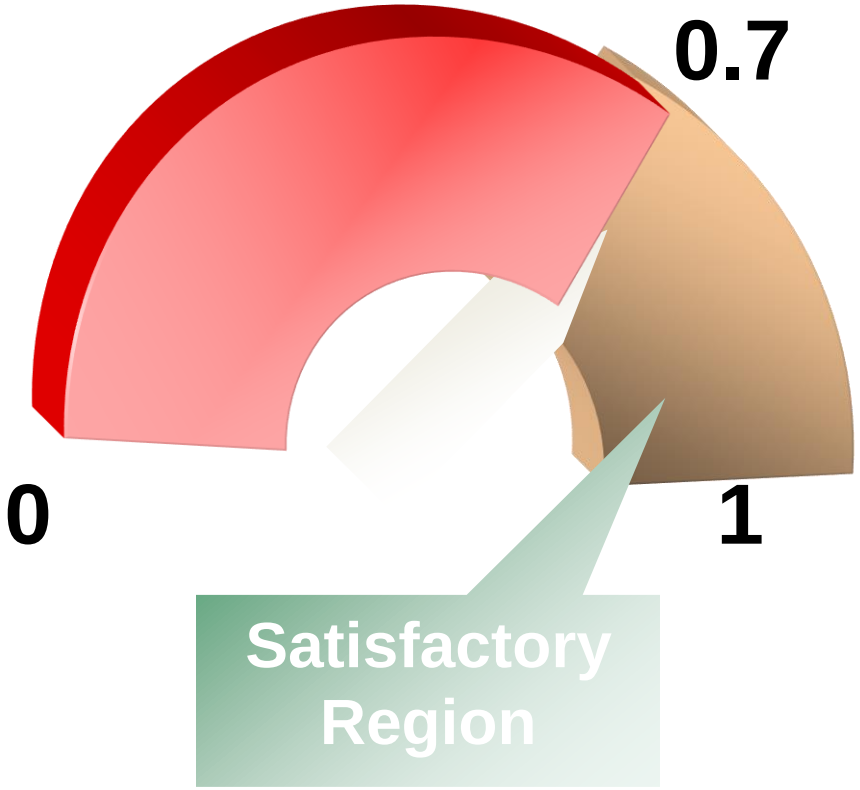
Acceptable level of Management system variation

- For Gage R & R studies
  - Ideally less than 10% of the process variation
  - Between 10 &30 % of total process variation is tolerable
  - Greater than 30% is unacceptable

Cohen's Kappa

Cohen's Kappa

- Assess inter-rater reliability
- Better than % agreement.
- Range from 0-1.00, with larger values indicating better reliability
- Kappa > .70 deemed Satisfactory

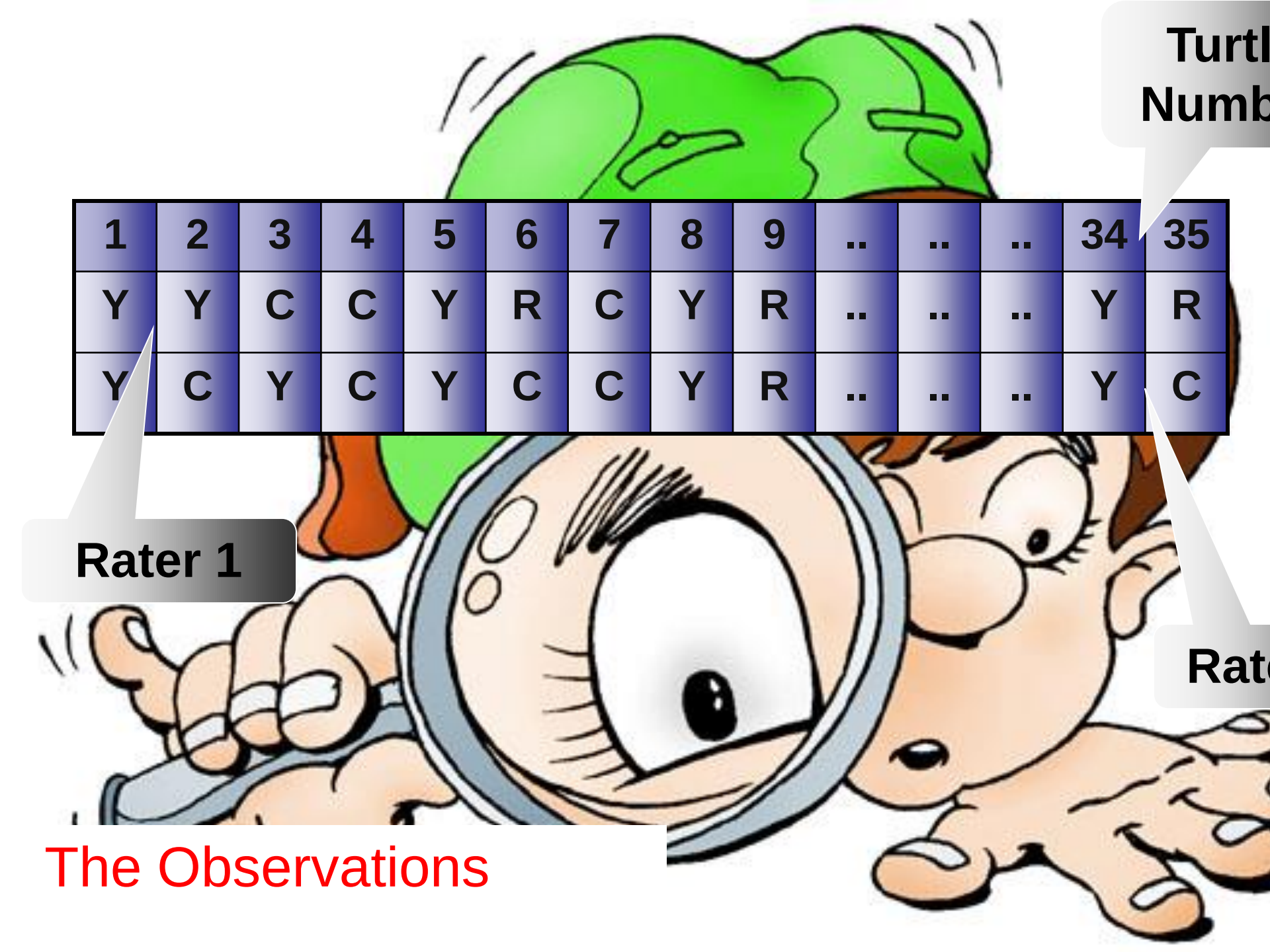


Calculating Kappa: Solving the Turtle Mystery

- The case required that the species of each juvenile turtle being observed to be identified.
- It can be difficult to correctly discriminate between juvenile Yellow-bellied turtles, Red-bellied turtles, and River Cooters.

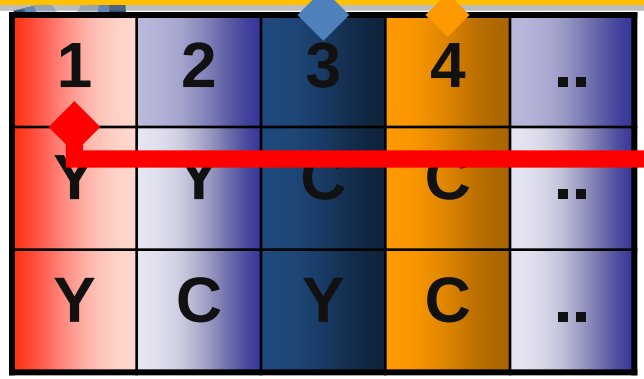
How to Index Kappa: Solving the Turtle Mystery

- Working with videos of the target behaviors, two raters identified the species of each turtle. Kappa will be used to assess the inter-rater reliability of this identification process.
- The species will be abbreviated Yellow-bellied = "y", Red-bellied = "r", and Cooters = "c".

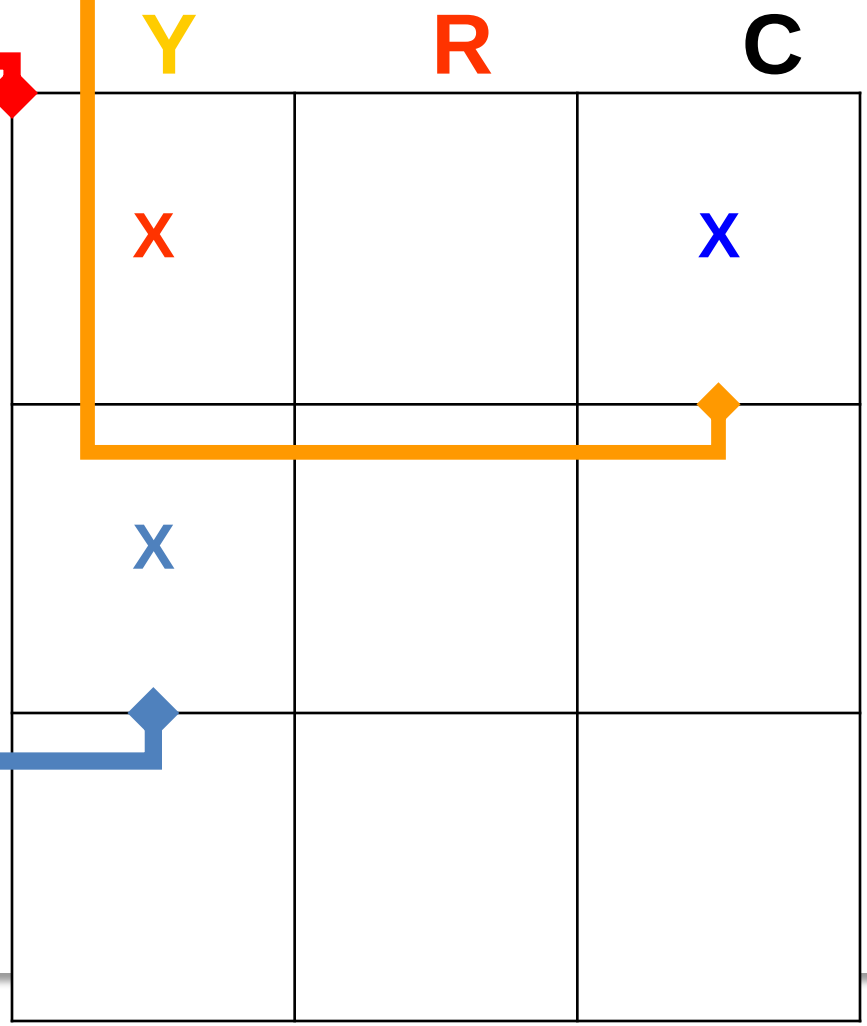


The Observations

Step 1



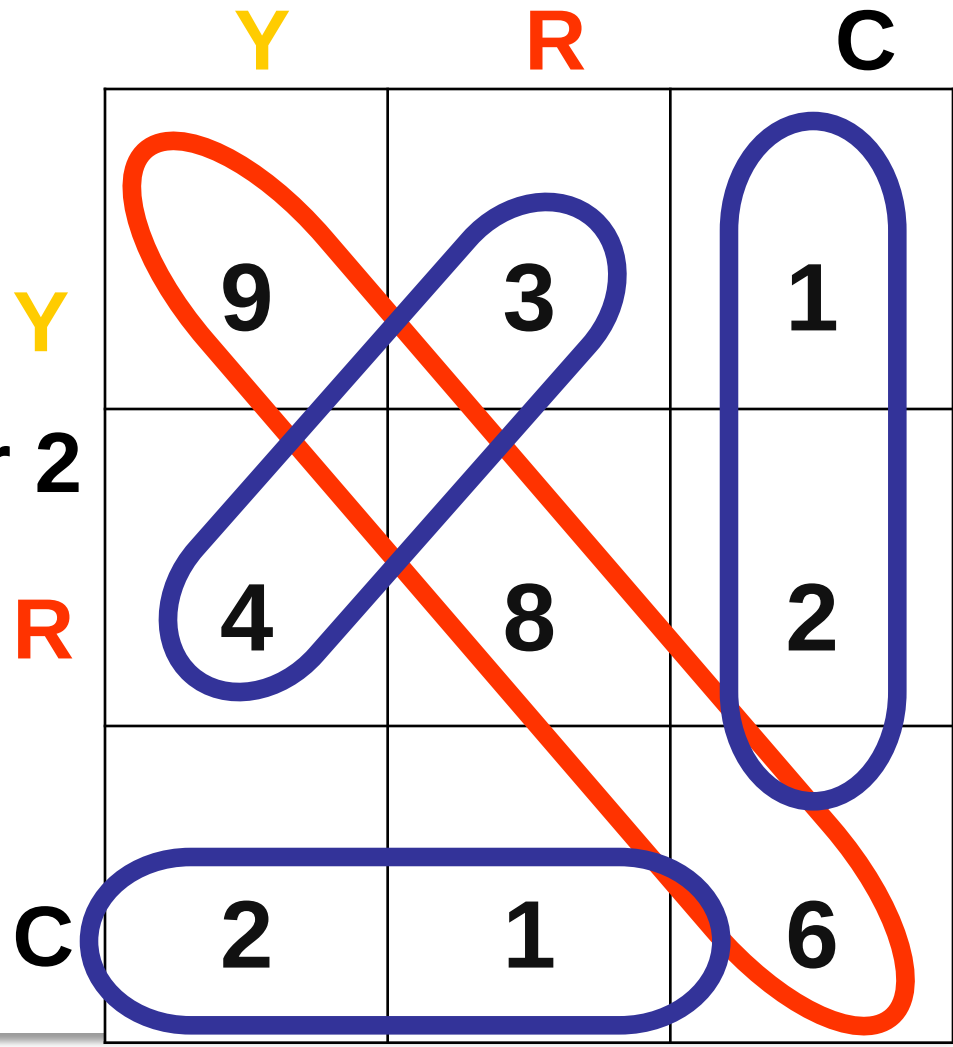
Organize the scores into a contingency table. Since the variable rated has three categories, the contingency matrix will be 3x3 table.



Contingency Matrix

Agreements between the two raters will be placed in one of the diagonal cells.

Disagreements between the raters will be placed in one of the off-diagonal cells.



Step 2

Compute row totals (sum across the values on the same row) and column totals (sum across the values on the same row)

Row Totals

Rater 1

Rater 2	R	C	Y	Row Totals
R	4	8	2	14
C	2	1	6	9
Y	9	3	1	13
Column Totals	15	12	9	36

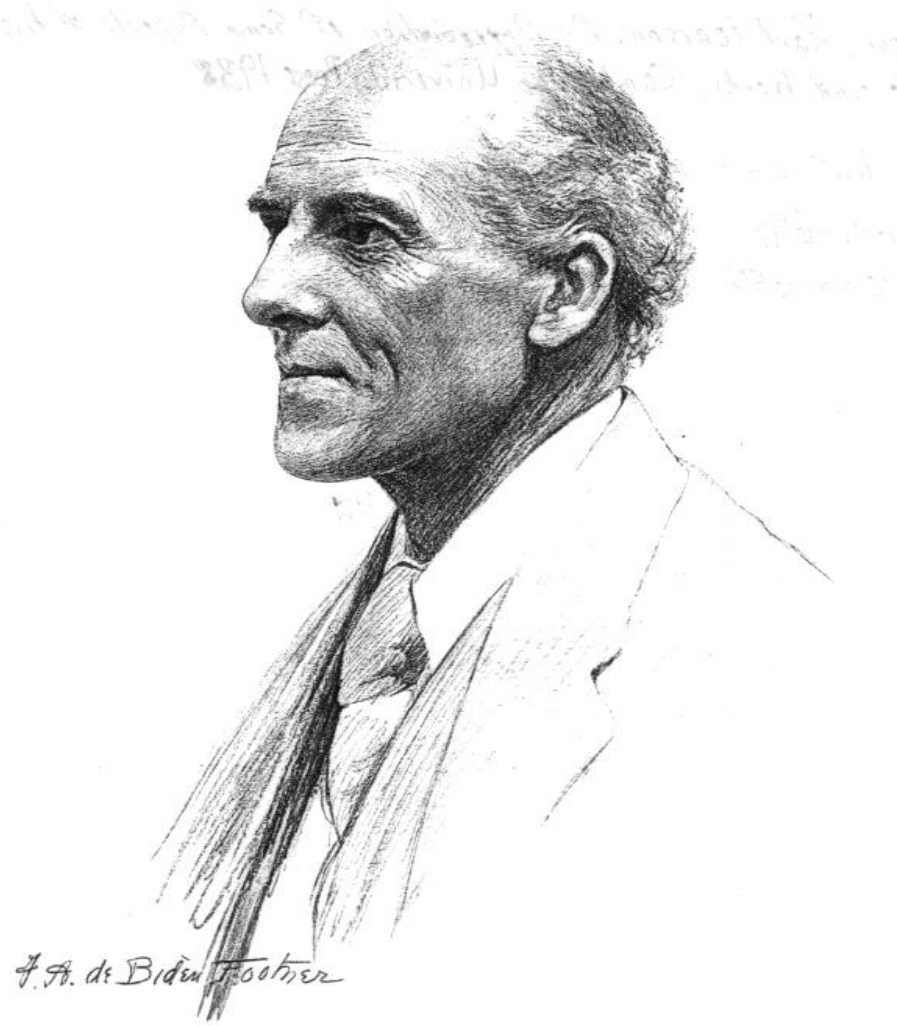
Step 3

- **Compute the total number of agreements by summing the values in the diagonal cells.**

  $\sum a = 9 + 8 + 6 = 23$
- **Based on this, the % agreement would be 23/36 = 64%.**
- **But, the value is an <u>inflated index of agreement</u>, because it does not take into account the agreements that would have agreed by chance.**

Step 4

- Compute the frequency or the agreements that would have been expected by chance for each coding category.
- Done by expected frequencies for Pearson's X^2, but now the formula is applied only to the diagonal cells.



Step 4

- Computation of the expected frequency of agreements by chance for the yellow-bellied turtles:-

$$EF = \frac{\text{Row total X Col total}}{\text{Overall total}} = \frac{13 \text{ X } 15}{36}$$

$= 5.42$

Step 5

- Compute the sum of the expected frequencies of agreement by chance.
- ∑EF = 5.42 + 4.67 + 2.25 = 12.34

Rater 2	Rater 1: Y	Rater 1: R	Rater 1: C
Y	9 (5.42)	3	1
R	4	8 (4.67)	2
C	2	1	6 (2.25)

Step 6: Calculate Kappa

$$\frac{\sum a - \sum EF}{N - \sum EF} \qquad \frac{23 - 12.34}{36 - 12.34} = .45$$

K < 0.70 - conclude that the inter-rater reliability is not satisfactory.

K >0 .70 - conclude that the inter-rater reliability is satisfactory

Kappa Exercise

Hypothesis Testing

Terms and Definitions

- A population consists of the total possible observations with which you are concerned but to which you do not necessarily have access (X1 thru X15)
- A sample is a set of observations selected from a population that you can access
- Different samples may have their own central tendencies and variation.
- Statistics (specifically hypothesis testing) enable you to place a confidence interval on the central tendency and variation of the population and on future samples

Process Understanding via Segmentation and Stratification

- Segmentation (nominal data) is grouping data according to one of the data Elements e.g.
  - types of customers, projects or domains
  - Types of quality checks

- Stratification (ordinal data) is grouping data according to the value range of one of the data elements,. E.g.
  - An ordered scale involved with the data element
  - criticality, severity or priority (e.g. high medium or low)

- You will use hypothesis tests to compare different segments or strata to further understand process behavior

Hypothesis Testing: To Understand and Compare Performance

- A formal way of making a comparison and deciding whether or not the difference is significant is based on statistical analysis.

- Hypothesis testing consists of a null and alternative hypothesis:
  - The null hypothesis states that the members of the comparison are equal; There is no difference (a concrete, default position)
  - The alternative hypothesis states that there is a difference; it is supported When the null hypothesis is rejected.

- The conclusion either rejects or fails to reject the null hypothesis

Formally Stating a Hypothesis

- Average productivity equals 100 kg/mahour
  - Null: average productivity is equal to 100 kg/manhour
  - Alternative: Average productivity is not equal to 100 kg/manhour

- Generally the alternative hypothesis is the difference (e.g. improvement or performance problem) that you seek to learn about

- The null hypothesis holds the conservative position that apparent differences can be explained by chance alone. The phrase “is equal to” will generally appear In the null hypothesis

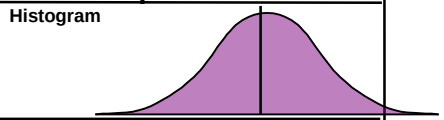
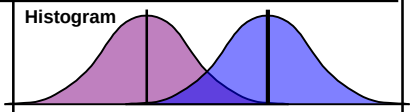
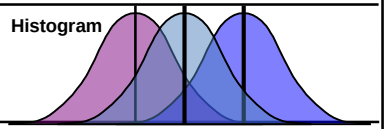
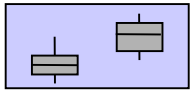
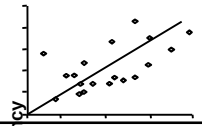
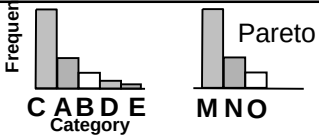
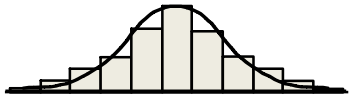
Slogan to Remember p Interpretation

- When the p is low, the null must go
- When the p is high, the null must fly

- Note: The p value is the key output in statistical analysis that students are taught to identify and use to draw a conclusion regarding the hypothesis Test comparison or regarding the significance of a statistical model

Statistical Tests

Some basic statistical tests are shown below with the command for running each test in Minitab.

What The Tool Tests	Statistical Test	Graphical Test
Mean of population data is different from an established target.	**1-Sample t-test** Stat > Basic Statistics > 1-Sample t	
Mean of population 1 is different from mean of population 2.	**2-Sample t-test** Stat > Basic Statistics > 2-Sample t	
The means of two or more populations is different.	**1-Way ANOVA** Stat > ANOVA > One-Way	
Variance among two or more populations is different.	**Homogeneity of Variance** Stat > ANOVA > Homogeneity of Variance	 Box Plots
Output (Y) changes as the input (X) changes.	**Linear Regression** Stat > Regression >Fitted Line Plot	 Scatter Plots
Output counts from two two or more subgroups differ.	**Chi-Square Test of Independence** Stat > Tables > Cross Tabulation OR Chi-Square Test	 Pareto
Data is normally distributed	**Normality Test** Stat > Basic Statistics	

Establish Performance Baselines and Models

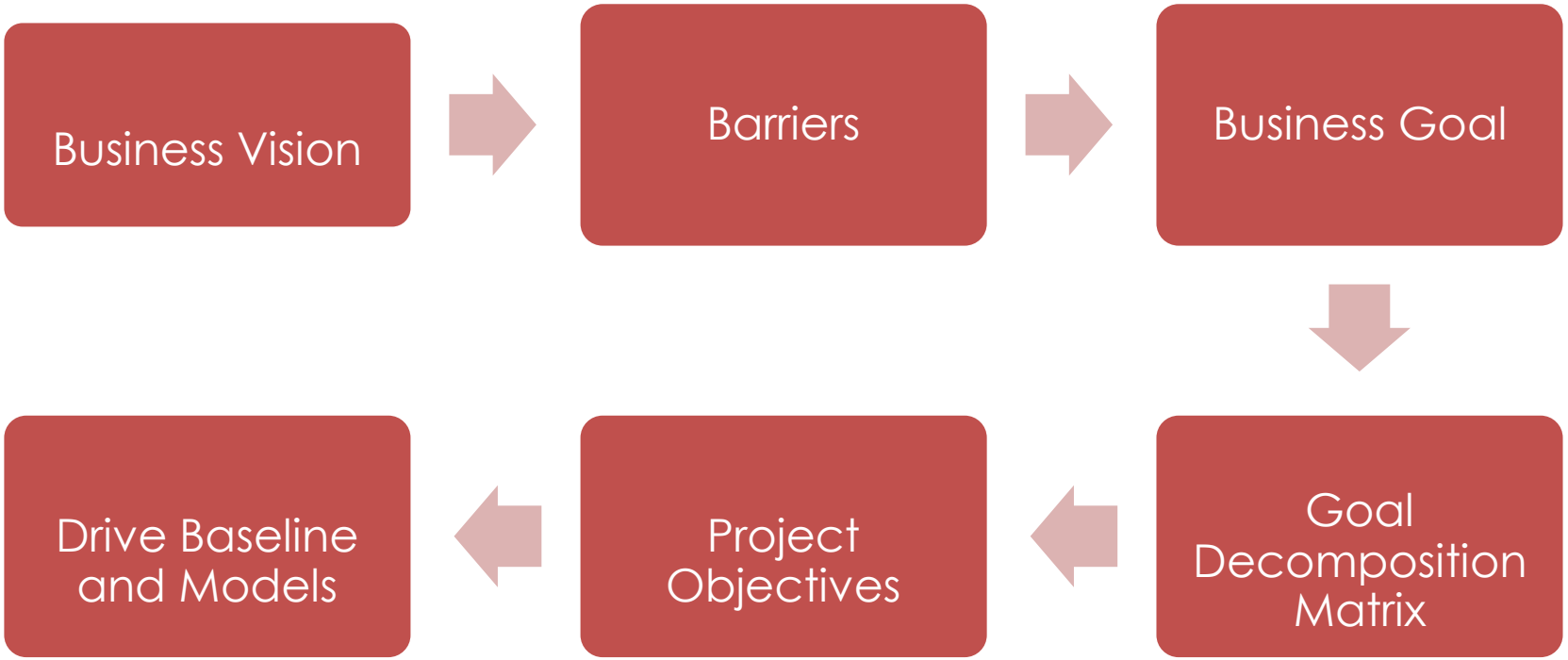
Baselines and models, which characterize the expected process performance of the organization's set of standard processes, are established and maintained.

Select Processes

Select the processes or sub-processes in the organization's set of standard processes that are to be included in the organization's process-performance analyses.

Select processes/sub-processes that will help us understand our ability to meet the objectives of the organization and projects, and the need to understand quality and process performance.

These sub-processes will typically be the major contributors and/or their measures will be the leading indicators.


Business Vision
Barriers
Business Goal
Goal Decomposition Matrix
Project Objectives
Drive Baseline and Models

Establish Quality and Process-Performance Objectives

Establish and maintain quantitative objectives for quality and process performance for the organization.

These objectives will be derived from the organization's business objectives and will typically be specific to the organization, group, or function.

These objectives will take into account what is realistically achievable based upon a quantitative understanding (knowledge of variation) of the organization's historic quality and process performance.

Typically they will be SMART and revised as needed.

Typical Process Performance Objectives for a segment

PPO1

To reduce mean and standard deviation of cycle time.

PPO2

Achieving Productivity of 1.0 wt. point per day with the standard deviation of .05

PPO3

Increase QC Effectiveness to 85% with Standard Deviation of 2%

PPO4

To reduce the delivered defect to customer to NIL critical defect with targeted Delivered Defect Density for Medium and Low Defects with average of 0.8 defects per wt. point with standard deviation of 0.1

Establish Process-Performance Baselines

Establish and maintain the organization's process-performance baselines.

Baselines will be established by analyzing the distribution of the data to establish the central tendency and dispersion that characterize the expected performance and variation for the selected process/sub-process.

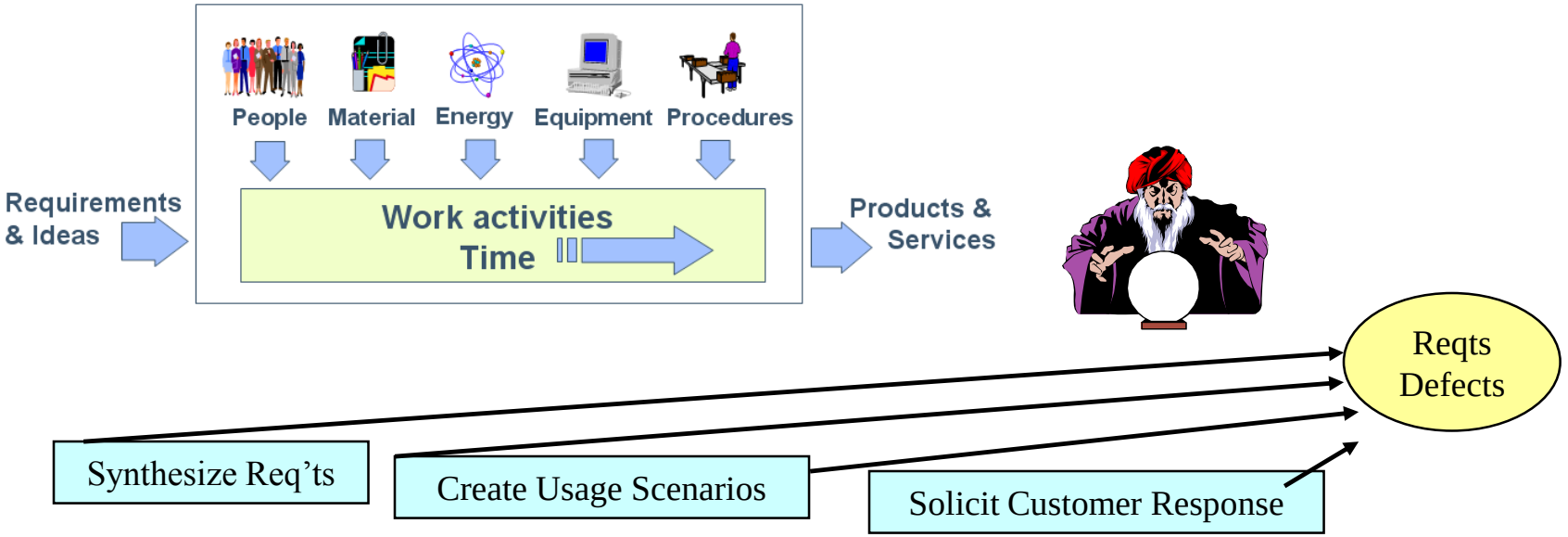
These baselines may be established for single processes, for a sequence of processes, etc.

When baselines are created based on data from unstable processes, it should be clearly documented so the consumers of the data will have insight into the risk of using the baseline.

Tailoring may affect comparability between baselines.

Essential Ingredients of Process Performance Models - 1

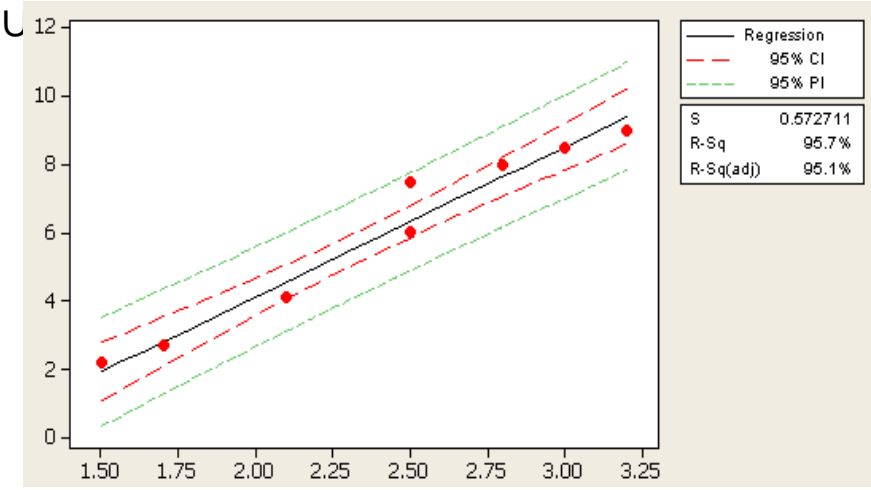
- They relate the behavior or circumstance of a process or sub-process to an outcome.
- They predict future outcomes based on possible or actual changes to factors (e.g. support "what-if" analysis).
- They use factors from one or more sub-processes to conduct the prediction.



Essential Ingredients of Process Performance Models - 2

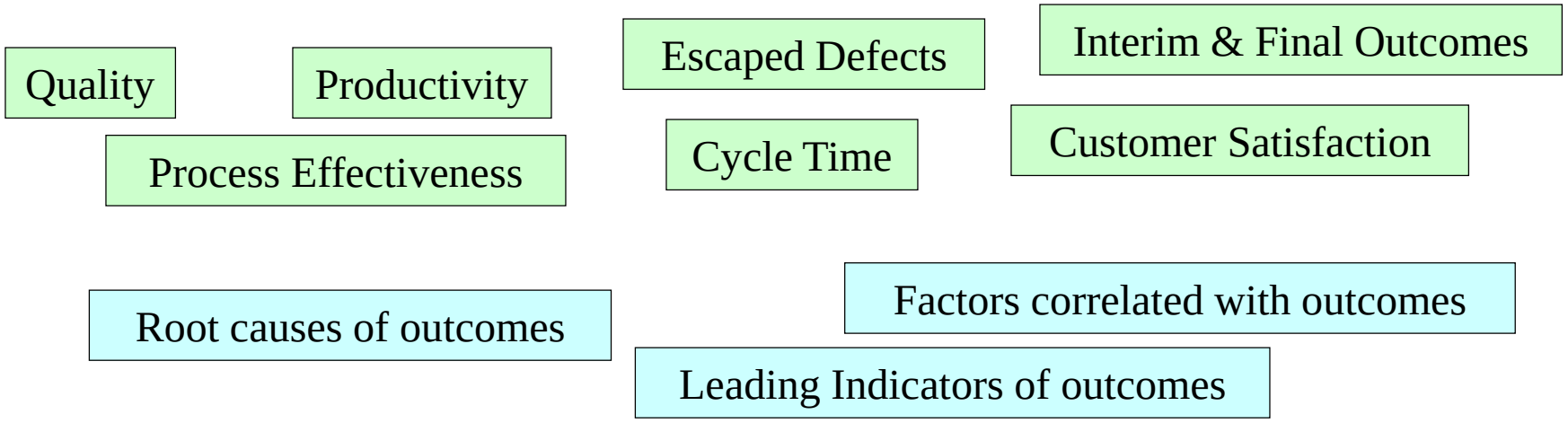
- **The factors used are preferably controllable** so that projects may take action to influence outcomes.

- **They are statistical or probabilistic** in nature rather than deterministic (e.g. they account for variation in a similar way that QPM statistically accounts for variation; they model uncertainty in the factors and predict the uncertainty or range of valu in the outcome).

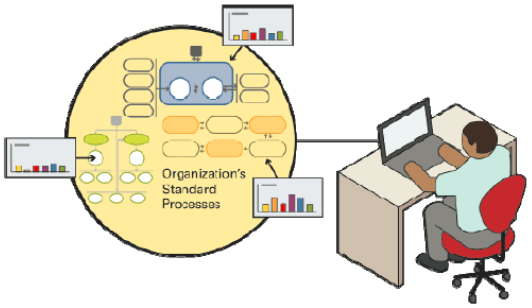


Essential Ingredients of Process Performance Models - 3

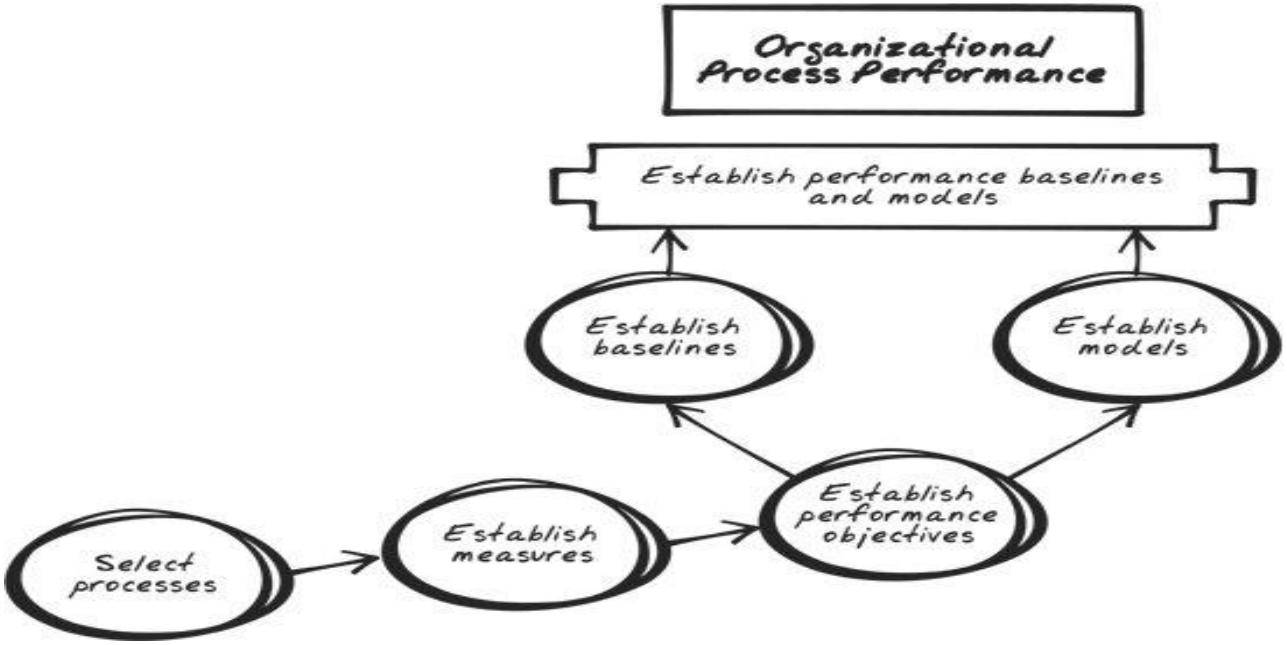
- High maturity organizations generally possess **a collection of process-performance models** that go beyond predicting cost and schedule variance, based on Earned Value measures, to include other performance outcomes.
- Specifically, the models predict quality and performance outcomes **from factors related to one or more sub-processes** involved in the development, maintenance, service, or acquisition processes.



Summarizing High Maturity Process Area



- **ORGANISATION PROCESS PERFORMANCE**
  - *A Process Management Process Area at Maturity Level 4*
  -
  -



Here, the organization establishes baselines and models of process performance based on detailed measures of past process performance. The baselines and models can then be used to predict future project performance.