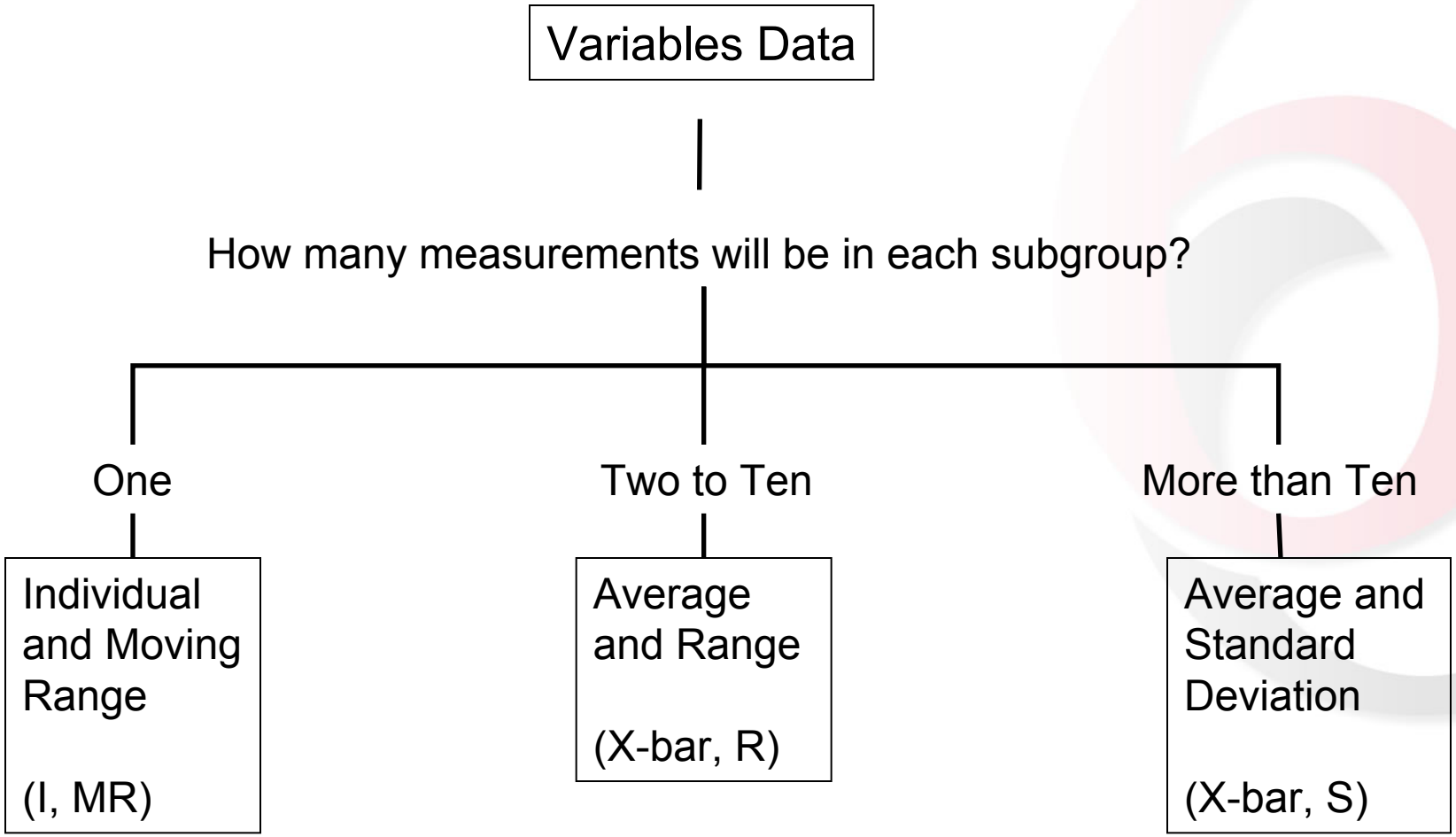
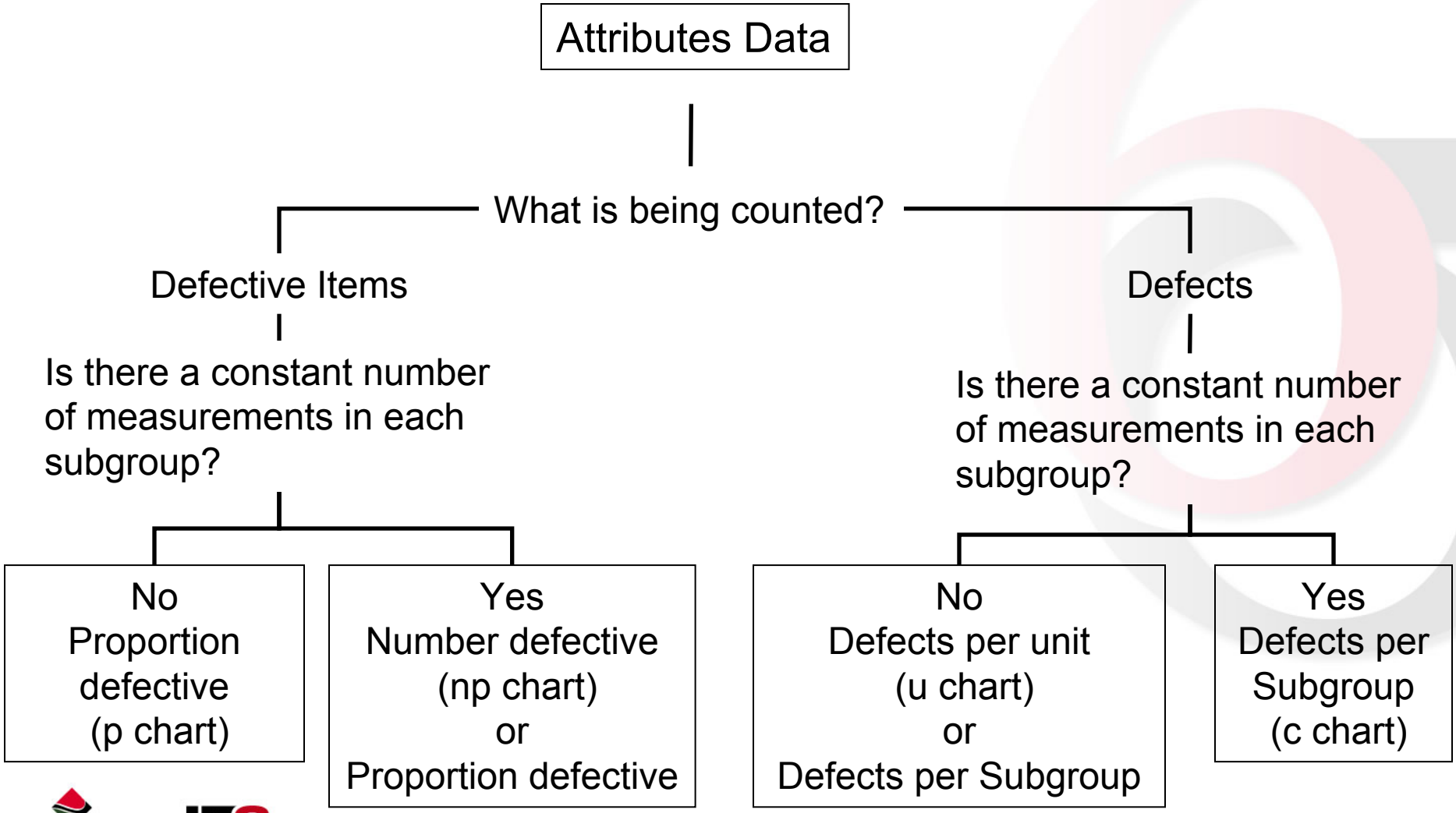
Variables Control Charts



Attributes Control Charts



VARIABLES CONTROL CHARTS

Average and Standard Deviation Charts

$\overline{X}$ and s

- Data are recorded and or charted by computer on a real-time basis so a calculation routine for s is easily integrated.
- Ready availability of a pocket calculator makes computation of a s simple on a routine basis.
- Large subgroup sample sizes are used, and the more efficient measure of variation is appropriate.

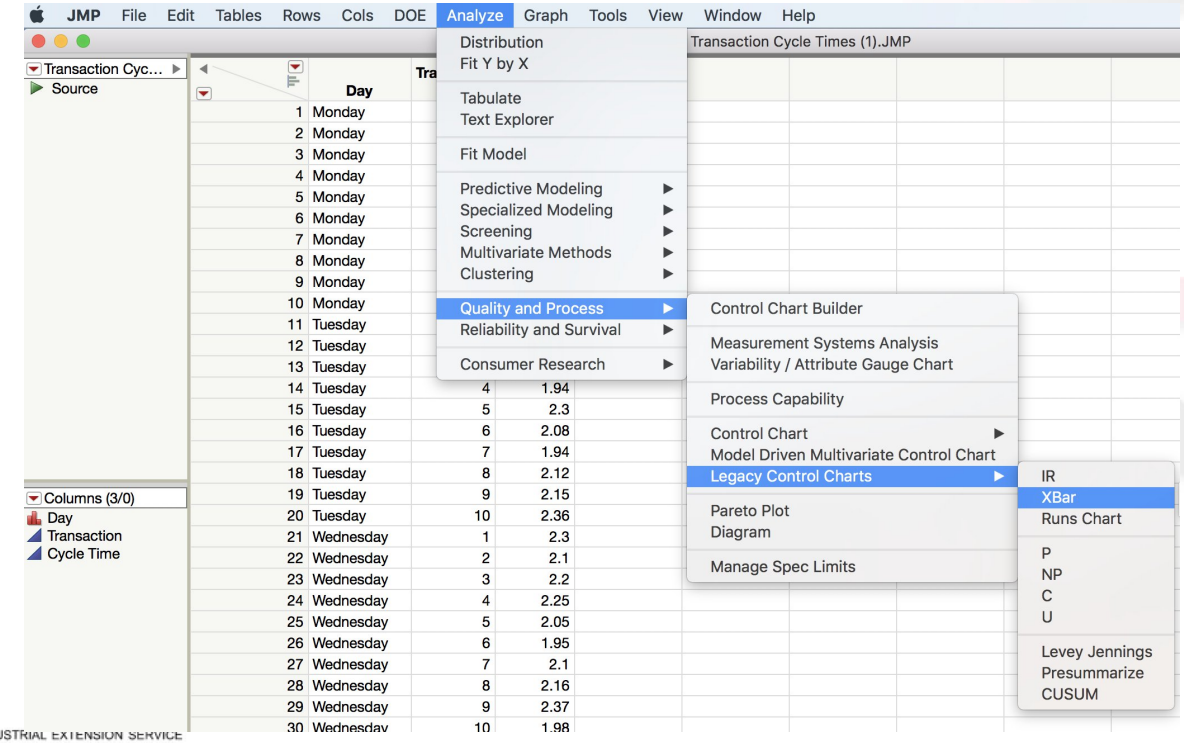
Invoice Cycle Time

After implementing the recommendations of a Lean Six Sigma team, the accounts payable department began control charting the amount of time required to enter the invoice information into the accounting system.

They randomly selected and recorded the processing time for 10 invoices a day. The data collected over a 2-week period is recorded in **Transaction Cycle Times.jmp.**

Invoice Cycle Time

1. Open **JMP**.
2. open **Transaction Cycle Times.jmp**.
3. Select **Analyze → Quality and Process → Legacy Control Chart → Xbar**

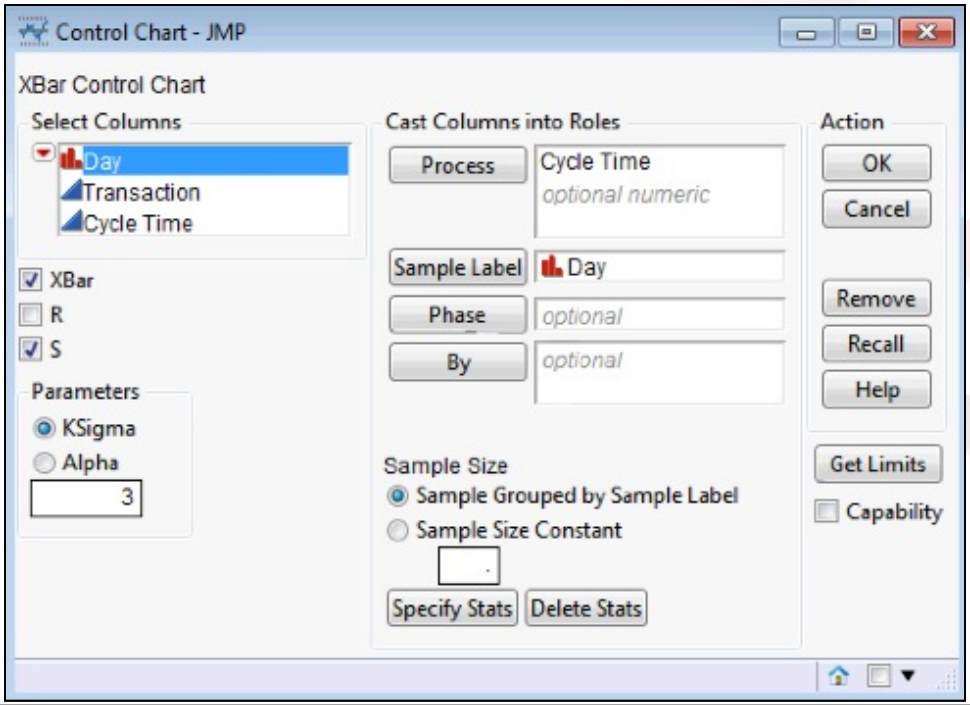


Invoice Cycle Time

4. Select **Cycle Time → Process.**

5. Select **Day → Sample Label**.

6. Check the box next to **S**.



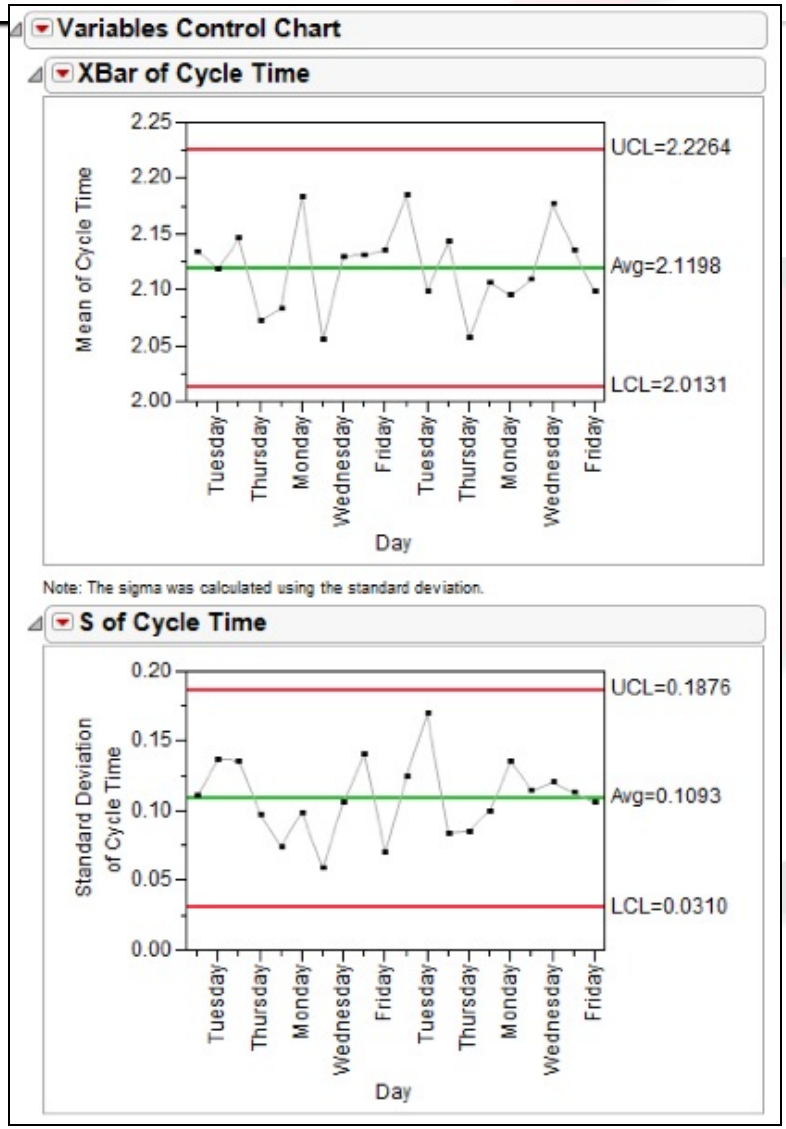
Invoice Cycle Time

7. Select **OK.**

The process appears to be in control but use JMP to double-check.

1. Click the red triangle next to **XBar of Cycle Time** and select **Tests → All Tests**.

If any points, or series of points, indicated the process was out of control, the points would have been marked on the control chart.



8 Tests

Test 1	One point beyond Zone A	Detects a shift in the mean, an increase in the standard deviation, or a single aberration in the process. For interpreting Test 1, any dispersion chart (R-, S-, or MR-) can be used to rule out increases in variation.
Test 2	Nine points in a row in a single (upper or lower) side of Zone C or beyond	Detects a shift in the process mean.
Test 3	Six points in a row steadily increasing or decreasing	Detects a trend or drift in the process mean.
Test 4	Fourteen points in a row alternating up and down	Detects systematic effects such as two alternately used machines, vendors, or operators.
Test 5	Two out of three points in a row in Zone A or beyond and the point itself is in Zone A or beyond.	Detects a shift in the process average or increase in the standard deviation. Any two out of three points provide a positive test.
Test 6	Four out of five points in a row in Zone B or beyond and the point itself is in Zone B or beyond.	Detects a shift in the process mean. Any four out of five points provide a positive test.
Test 7	Fifteen points in a row in Zone C, above and below the center line	Detects stratification of subgroups when the observations in a single subgroup come from various sources with different means. Also detects a reduction in variation.
Test 8	Eight points in a row on both sides of the center line with none in Zones C	Detects stratification of subgroups when the observations in one subgroup come from a single source, but subgroups come from different sources with different means.

Charts for Individual and Moving Range (I-MR)

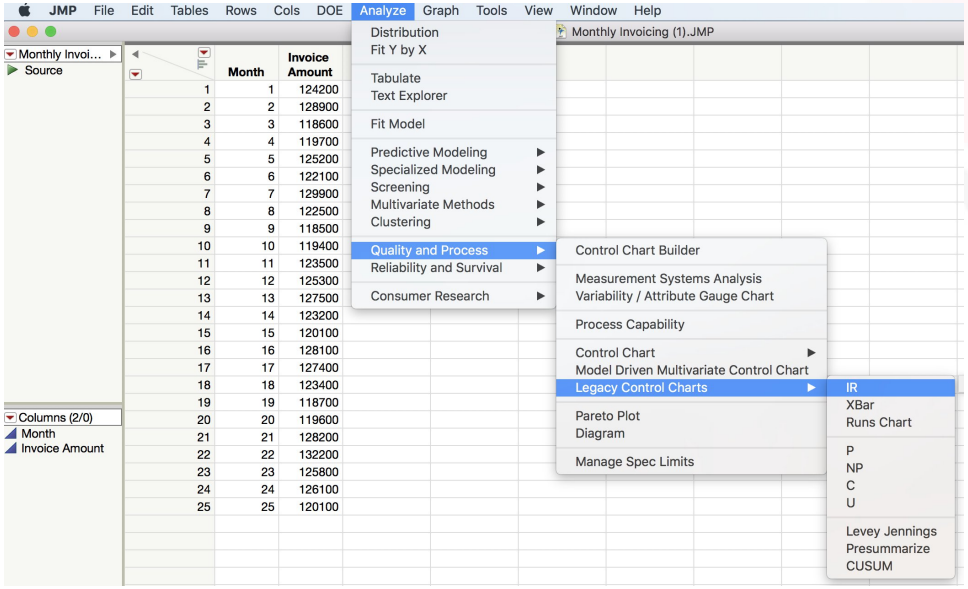
- Charts for individuals are not as sensitive in detecting process changes as $\bar{X}$ and R charts.
- Care must be taken in interpretation if process distribution is not symmetrical.
- Charts for individuals do not isolate the piece-to-piece repeatability; therefore, it might be better to use an $\bar{X}$ bar and R with small subgroup sample sizes.
- Since only one item per subgroup, values of $\bar{X}$ and σ can have substantial variability (even if the process is stable) until the number of subgroups is 100 or more.

Monthly Invoicing

One of the CTQs measured by an accounting department is the total amount invoiced each month. The invoicing data for the last thirty months is stored in Monthly Invoicing.jmp.

1. Select **File → Open → Monthly Invoicing.jmp**.

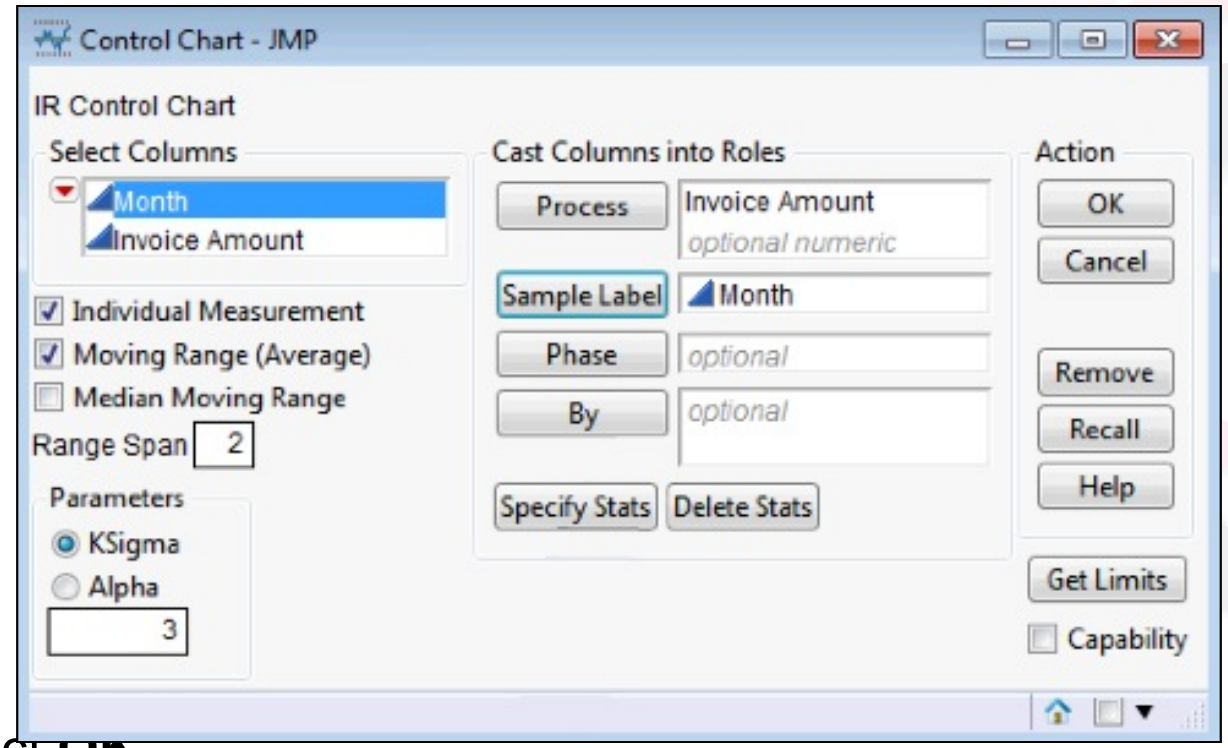
2. Select **Analyze → Quality and Process → Legacy Control Chart → IR**.



Monthly Invoicing

3. Select **Invoice Amount → Process**.

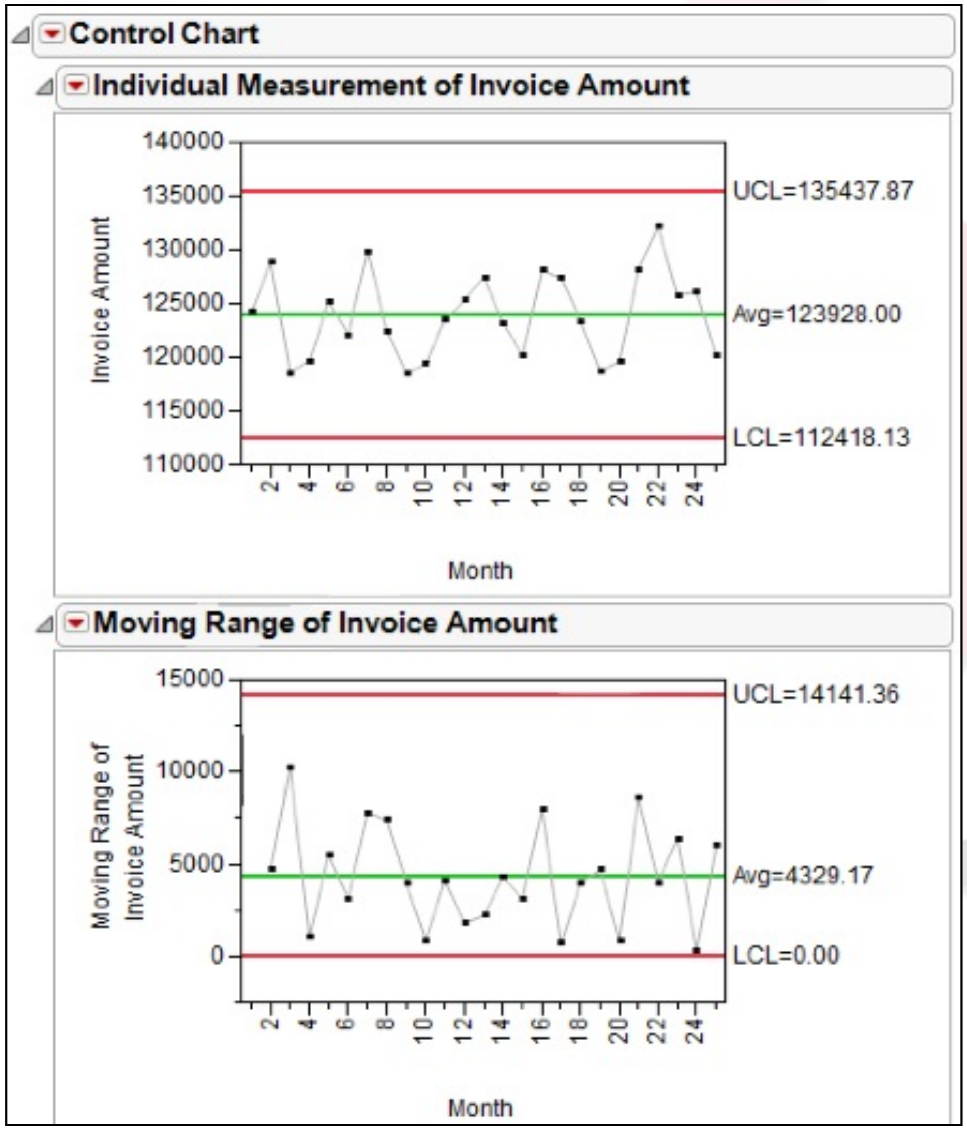
4. Select **Month → Sample Label**.



5. Select **OK**.

Monthly Invoicing

The process appears to be stable and predictable.



ATTRIBUTES CONTROL CHARTS

Control Charts for Attributes

Chart Type	Description of Data on Chart
p Chart np Chart	Proportion of non-conforming or defective units. Examples include the number of insurance claim forms completed incorrectly each month or the number of customer questions not resolved during the first call to the help desk. A p-chart is used when the sample size is not constant.
u Chart c Chart	Defects or imperfections that do not render an entire item defective. Examples include the number of scratches on a computer case or the number of complaints of poor customer service received in a retail store. A u-chart is used when the sample size varies.

Insurance Claims

A large metropolitan healthcare center initiated a six sigma project to investigate why insurance payments had declined in the previous fiscal years. One of the critical Xs identified during the project was completeness of information on claims forms. During the control phase of the project, the team and process owner implemented control charts to chart the number of forms completed incorrectly. They randomly pull 100 claims forms each week and count the number of incomplete forms. The data for the last thirty weeks is stored in Insurance Claims.jmp.

1.Select **File → Open → Insurance Claims.jmp**.

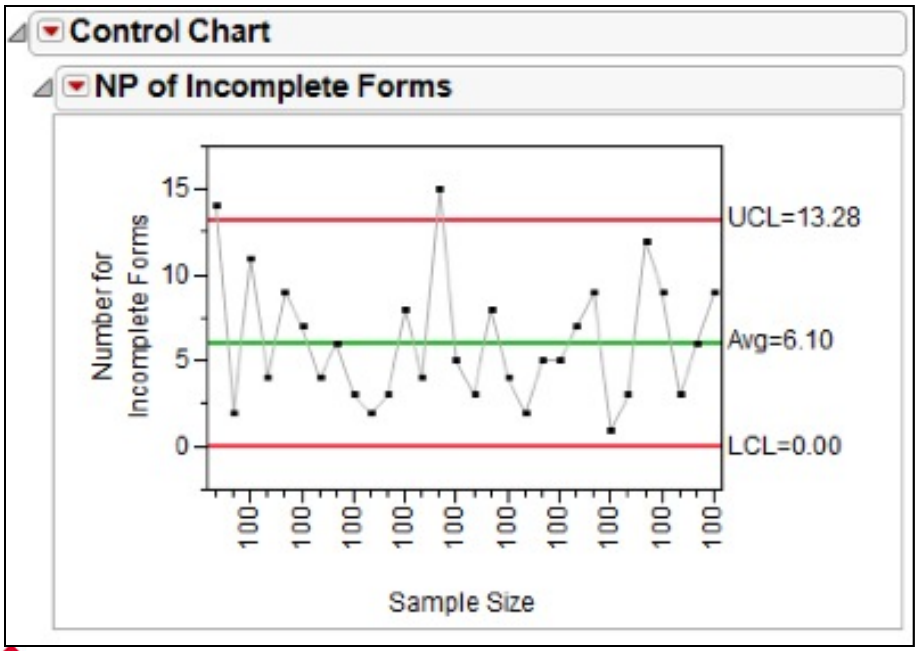
2.Select **Analyze → Quality and Process → Legacy Control Chart → NP**.

Insurance Claims

3. Select **Incomplete Forms → Process**.

4. Select **Sample Size → Sample Label**.

5. Select **OK**.



The process is not in statistical control. Two weeks had an unusually high number of incomplete forms.

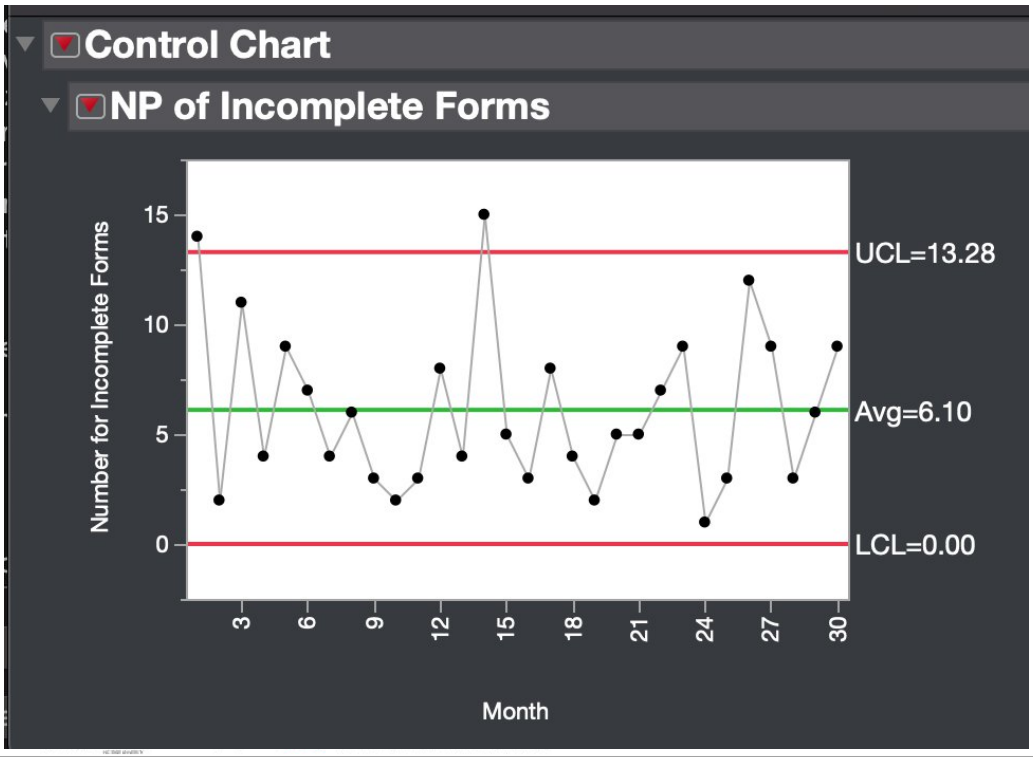
Using the process management plan created by the Lean Six Sigma team, the process owner determined that the high number of incomplete forms was due to new hires who had not been properly trained. Corrective action was taken immediately.

Insurance Claims

3. Select **Incomplete Forms → Process**.

4. Select **Month → Sample Label**.

5. Select **OK**.



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LEAN SIX SIGMA
February 9, 2024

A. Blanton Godfrey, Ph.D.
Joseph D. Moore
Distinguished University Professor
NORTH CAROLINA STATE UNIVERSITY

NC STATE UNIVERSITY COLLEGE OF TEXTILES

TODAY'S OBJECTIVES

Discussion of assignments:

- Mayo
- Sandholm
- Tata

Quiz

Finish Intro to Probability & Statistics

Measurement System Analysis

Introduction to Process Capability Analysis

TATA

In how many countries does Tata provide products and services?

How many employees does Tata have?

What is the five-pronged approach in Tata Steel?

In the Tata Group journey to excellence, what were added in 2006, 2007 and 2010?

TATA

What services does the Tata Business Excellence Group provide?

The Tata Business Excellence Model is based on the Malcolm Baldrige National Quality Award criteria. What is different?

What did they add to the TBEM in 2019?

Who were Sunil's inspirations?

MAYO CLINIC

What concept did Henry Plummer bring to Mayo Clinic in the early 1900's?

What was the catalyst that made Mayo Clinic rethink its quality management approach?

What are sentinel events?

What was Mayo's first step in creating their Value Creation System?

MAYO CLINIC

What are the four main parts of Mayo's "Quality Construct?"

What does transparency mean at Mayo?

What did the former secretary of the U.S. Treasury (and former CEO of Alcoa), Paul O'Neil, estimate the percentage of waste is in healthcare in the United States?

SANDHOLM

What are the three competencies that give results?

The knowledge to achieve success in quality and improvement work includes what three areas?

The knowledge needed to implement systematic improvement work comes from what concepts?

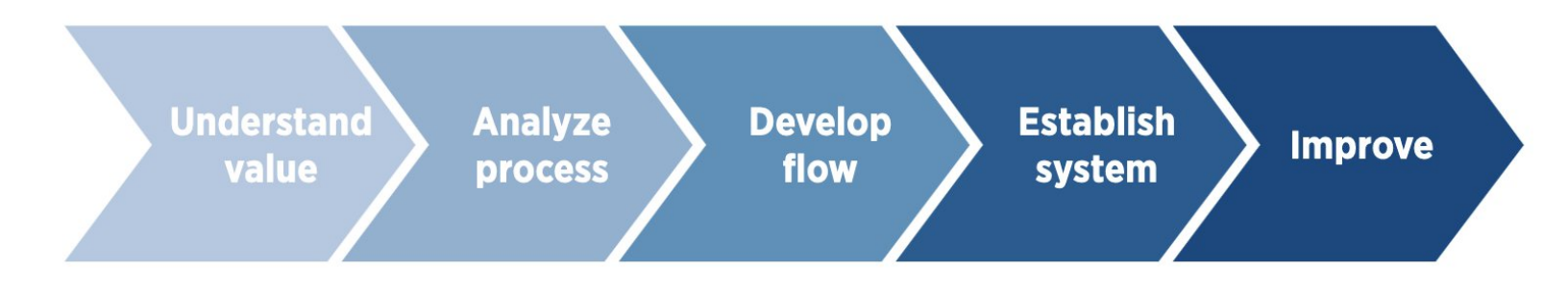
SANDHOLM

What is the role of a Master Black Belt?

What are the steps he describes for process development based on Lean Tools?

SANDHOLM

What are the steps he describes for process development based on Lean Tools?



ASSIGNMENTS FOR FEB 16

Do reading assignment on Process Capability.

COURSE OBJECTIVES

1. Explain and apply statistical engineering using multiple graphical and statistical tools using state-of-the art graphical and statistical software to improve business and manufacturing processes.
2. Formulate problem statements that identify critical quality improvement opportunities.

COURSE OBJECTIVES

3. Deploy Lean Six Sigma methodology to solve challenging engineering and business management problems using graphical statistics , measurement systems analysis, process capability studies, hypothesis testing, the elements of Design of Experiments, and Statistical Process Control.

COURSE OBJECTIVES

4. Interpret and explain graphical and statistical results from state-of-the-art statistical software (JMP Pro 16) for making engineering and business decisions, and
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IN-CLASS EXERCISES

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HAVE FUN!

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Raleigh, North Carolina 27626
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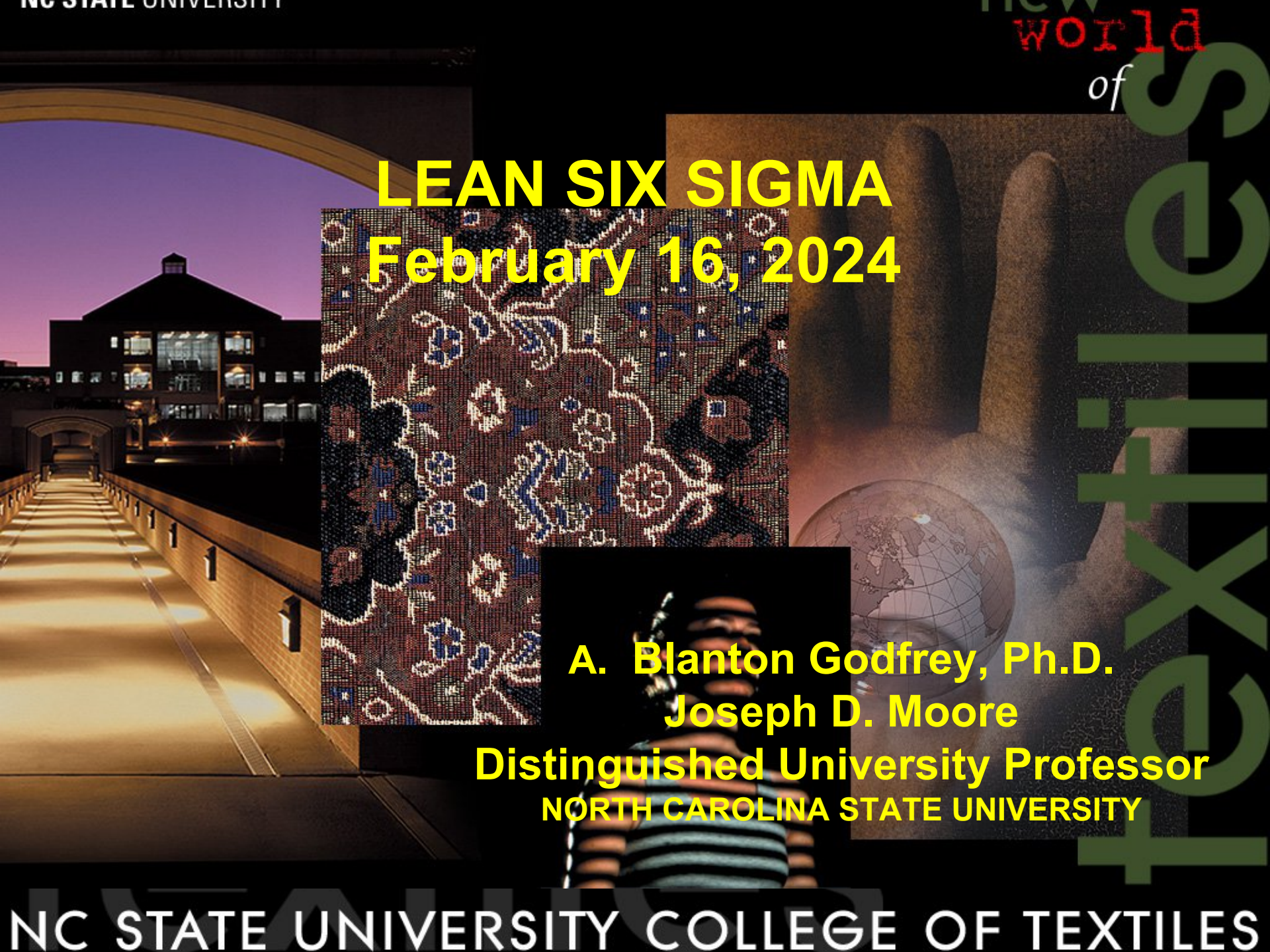
Phone: 1-919-523-3819
http://www.tx.ncsu.edu
E-mail: blanton_godfrey@ncsu.edu

Slides are posted each week.



LEAN SIX SIGMA
February 16, 2024

A. Blanton Godfrey, Ph.D.
Joseph D. Moore
Distinguished University Professor
NORTH CAROLINA STATE UNIVERSITY

TODAY'S OBJECTIVES

Discussion of assignments:
Process Capability Paper

Continue Process Capability Introduction

Quiz

In class MSA exercises

PROCESS CAPABILITY PAPER

Who was Bonnie Small?

What are the two methods suggested for measuring process capability?

Which method does JMP 17 use?

Who was Vic Kane?

Who created the method for real time applications of process capability analysis using digital monitoring of time series performance?

PROCESS CAPABILITY PAPER

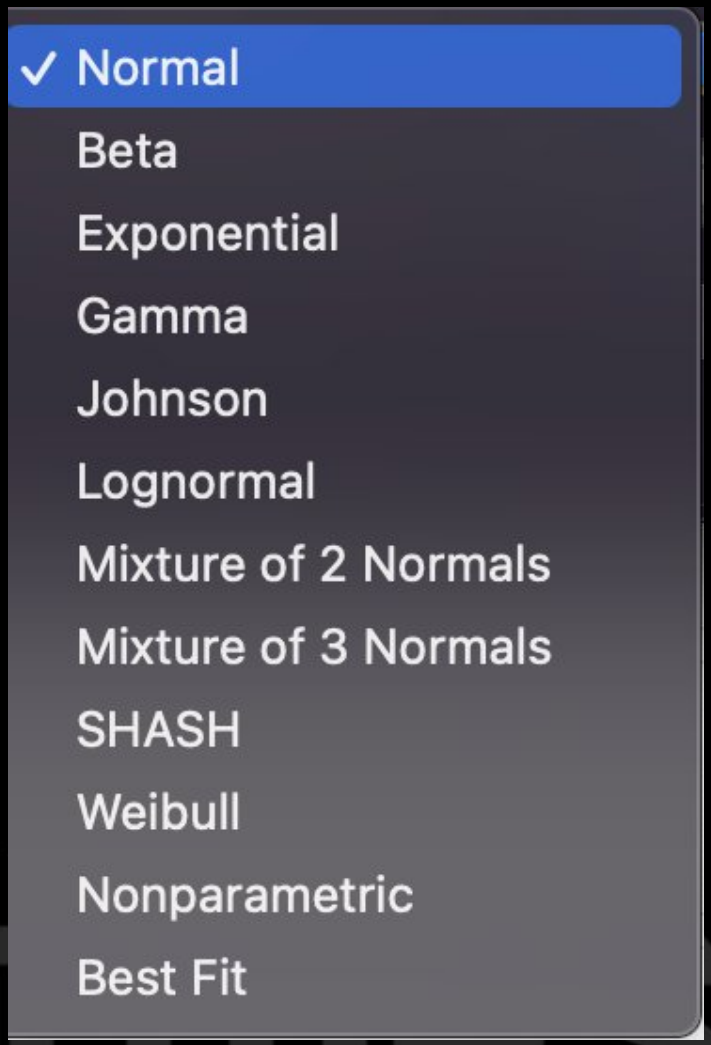
What were the two methods for analyzing productive processes suggested by Bell Labs?

Why do Watson and Turunen think the way we calculate process capability needs to be updated?

Does JMP 17 calculate process capability indices for non-normal data?

Do the infinite tails of a normal distribution really bother you?

JMP 17 PROCESS CAPABILITY DISTRIBUTIONS



SHASH DISTRIBUTION

The Sinh-Arcsinh (SHASH) distribution for fitting a GAMLSS

Description

The Sinh-Arcsinh (SHASH) distribution is a four-parameter distribution, for a gamlss family object to be used for a GAMLSS fitting using the function gamlss(). The functions dSHASH, pSHASH, qSHASH and rSHASH define the density, distribution function, quantile function and random generation for the Sinh-Arcsinh (SHASH) distribution

GAMLSS

From Wikipedia, the free encyclopedia

The **Generalized Additive Model for Location, Scale and Shape (GAMLSS)** is an approach to statistical modelling and learning. GAMLSS is a modern distribution-based approach to (semiparametric) regression. A parametric distribution is assumed for the response (target) variable, but the parameters of this distribution can vary according to explanatory variables using linear, nonlinear or smooth functions. In machine learning parlance, GAMLSS is a form of supervised machine learning.

THE PARAMETERS

$$g_1(\mu) = \eta_1 = X_1\beta_1 + \sum_{j=1}^{J_1} h_{j1}(x_{j1})$$

$$g_2(\sigma) = \eta_2 = X_2\beta_2 + \sum_{j=1}^{J_2} h_{j2}(x_{j2})$$

$$g_3(\nu) = \eta_3 = X_3\beta_3 + \sum_{j=1}^{J_3} h_{j3}(x_{j3})$$

$$g_4(\tau) = \eta_4 = X_4\beta_4 + \sum_{j=1}^{J_4} h_{j4}(x_{j4})$$

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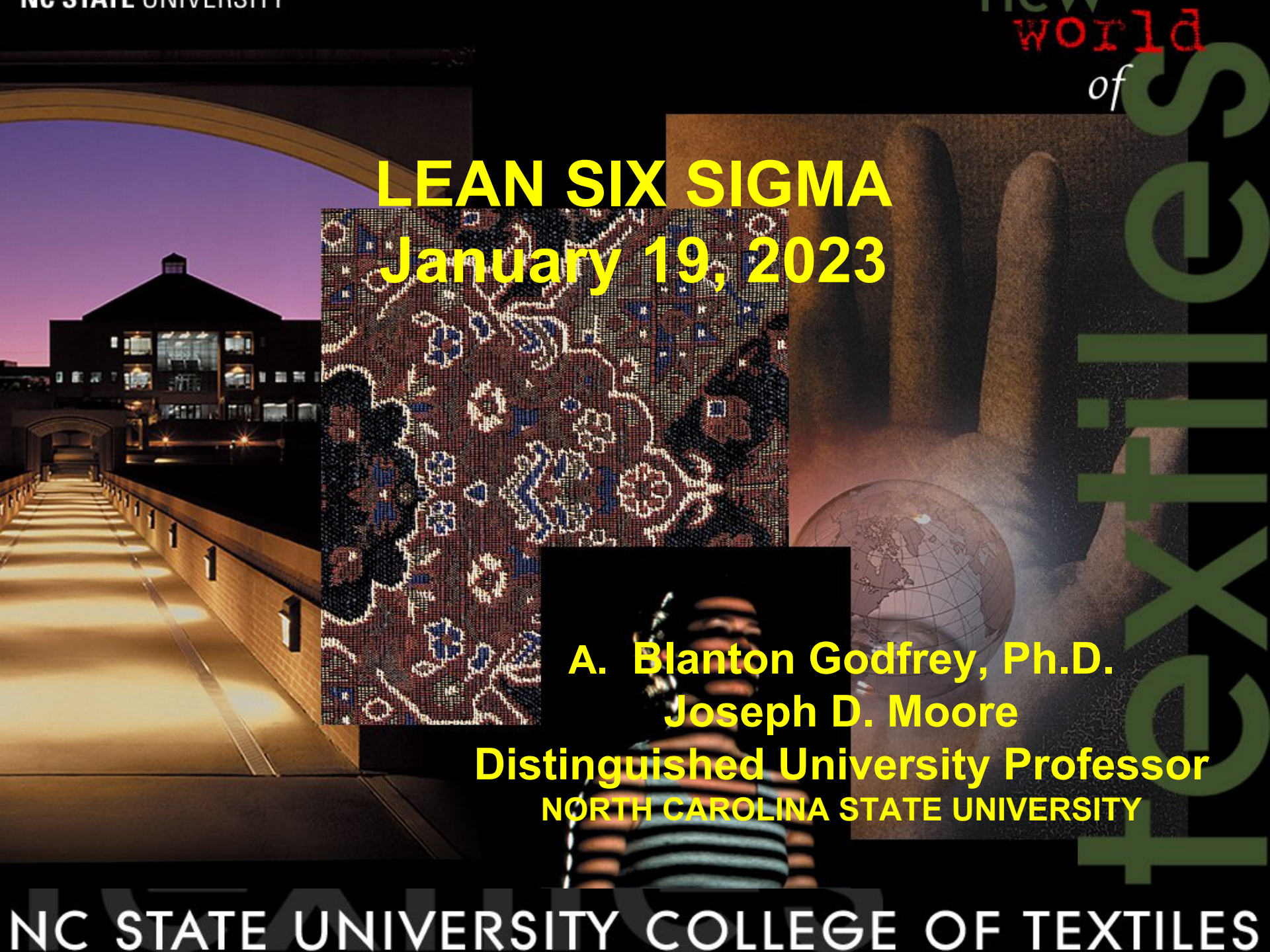

LEAN SIX SIGMA
January 19, 2023

A. Blanton Godfrey, Ph.D.
Joseph D. Moore
Distinguished University Professor
NORTH CAROLINA STATE UNIVERSITY

TODAY'S OBJECTIVES

Discussion of assignments
- Marshmallows
- Heart Attacks
- Problem Framing

Finish Introduction Slides

Introduction to DEFINE & Rethinking DEFINE

TODAY'S OBJECTIVES

Cost of Quality, Voice of Customer, LSS Teams

Quiz

Planning for projects with company

COURSE OBJECTIVES

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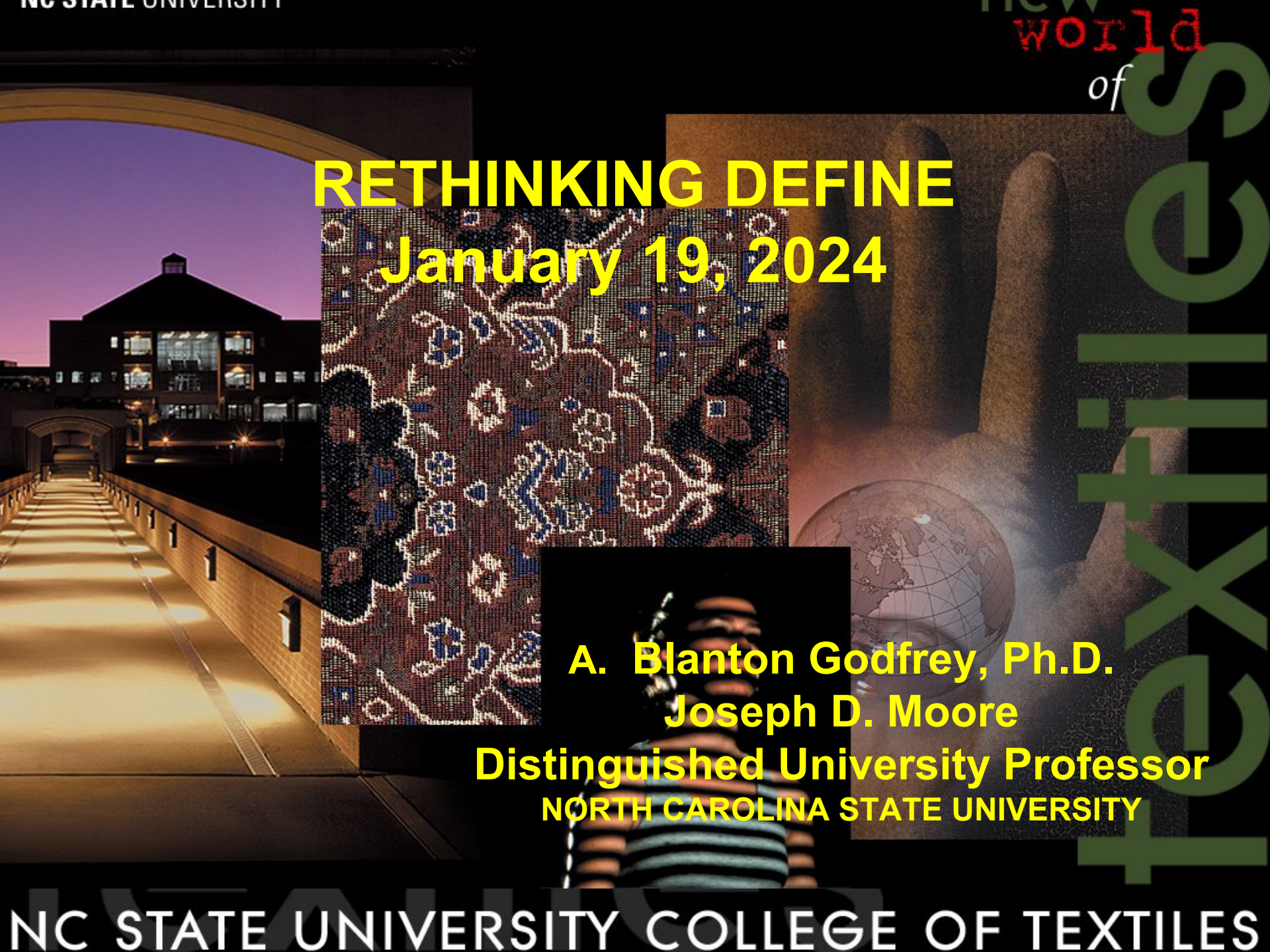


RETHINKING DEFINE

January 19, 2024

A. Blanton Godfrey, Ph.D.
Joseph D. Moore
Distinguished University Professor
NORTH CAROLINA STATE UNIVERSITY

TODAY'S OBJECTIVES

An introduction to DEFINE.

Based on Hoerl, Kuonen, and Redman's work on Problem Framing.

New ideas on how to define problems.

Roger W. Hoerl, Diego Kuonen, and Thomas C. Redman (2022), "Problem framing: Essential to successful statistical engineering Applications," *Quality Engineering*, Special Edition on Statistical Engineering, Vol. 34, Issue 4.

INTERNATIONAL STATISTICAL ENGINEERING ASSOCIATION

https://isea-change.org/

ISEA is free to join, now has over 1,000 members.

Special Edition of Statistical Engineering

MOTIVATION

- Weinberg (1986): “Unless and until all members of a team have a common understanding of the problem, attempts to solve the problem are just so much wasted energy.”

- Holtz (2021): “Ever started a project with a fuzzy idea of the goal? Or alternatively, a project with a clearly defined goal that is not realistic or that does not add any meaningful value? You’re not alone. We’ve all been there.”

Roger Hoerl, “Problem Framing,” Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

MOTIVATION

- Former Indian Prime Minister Jawaharlal Nehru: “It is an extraordinary thing, of course, that everybody is answering questions without knowing what the questions are. In other words, everybody is finding some remedy without knowing what the malady is.” (Jugulum 2022).

- Attributed to Albert Einstein: “If I were given one hour to save the planet, I would spend 59 minutes defining the problem, and one minute solving it.”

Roger Hoerl, “Problem Framing,” Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

WHAT'S THE PROBLEM?

One of the most common causes of failure in improvement projects is poor problem framing (identifying and structuring the problem)

- Different understandings of the problem
- Fuzzy goals
- Unrealistic goals or timeline
- Unstated constraints
- Proposed solution embedded into problem statement
- Confusion over roles
- Wrong team for the problem
- Etc.

If you have ever served on a faculty committee, you understand!

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

WHAT'S THE PROBLEM?

People in virtually all environments are anxious to get into solving the problem; just do it!

Frequently, people feel that the problem is "obvious"

Political issues and constraints, almost always present in team projects, are left unstated

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

WHAT'S THE PROBLEM?

Some team participants may have hidden agendas

Problem statements may be written by people residing in the same "silo," and therefore represent a narrow view

It is often much easier to work on the symptoms than the root causes

- "Cleaning" datasets versus addressing the root causes of bad data

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

POLYA'S APPROACH

Polya's problem-solving method is deceptively simple:

1. Understand: Understand the problem, to carefully define it and see what is required. (what Hoerl calls "framing")

2. Plan: See how the problem elements are connected, in order to make a plan to solve it.

3. Do: Carry out the plan.

4. Check: Look back at the solution, to review and discuss it. Reloop if necessary.

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

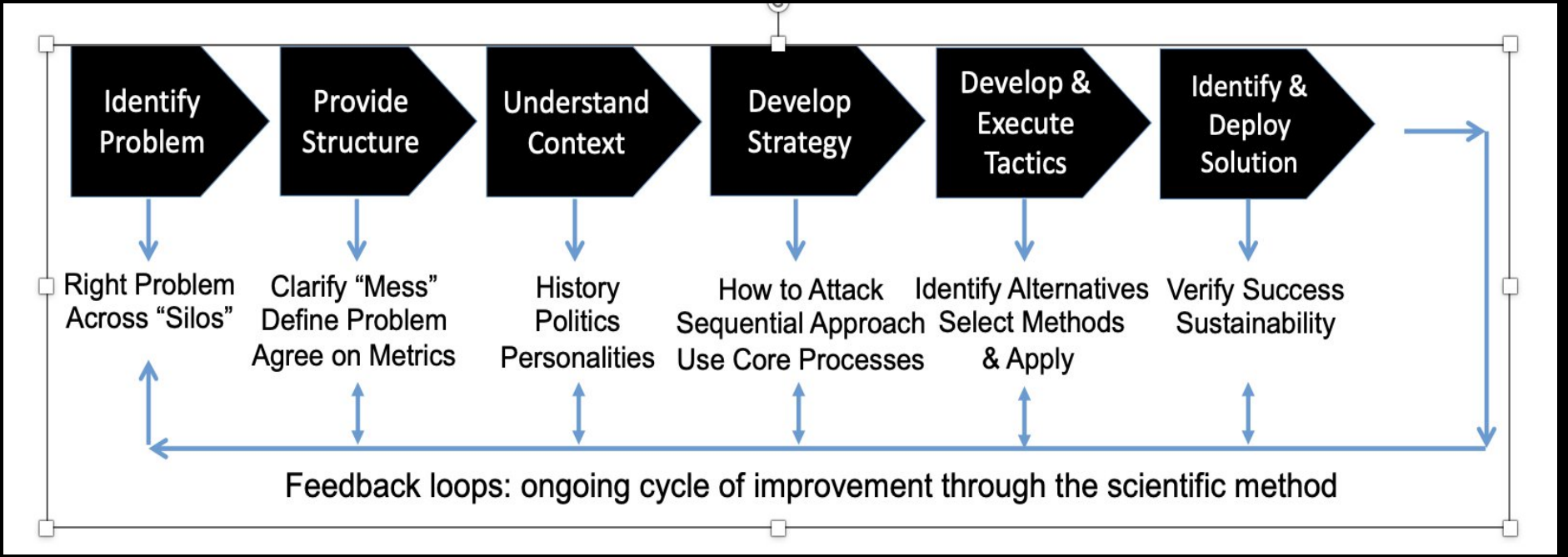
BUILDING ON POLYA'S APPROACH

Based on cognition theory and neuroscience, Robertson (2017) goes on to break each of Polya's steps into two, resulting in eight individual steps:

- Understand – (1) Identify problem, then (2) define problem succinctly
- Plan - (3) Analyze data, then (4) form overall strategy
- Do – (5) Organize information, then (6) allocate resources
- Check – (7) Monitor progress, then (8) evaluate results

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

STATISTICAL ENGINEERING



Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

FRAMING PROBLEMS FOR SUCCESS

1. Recognize that rigorously defining the problem is hard work
   - Resist the temptation to jump into problem-solving mode
   - Negotiate time for properly framing the problem

2. Get the right people involved and urge them to cooperate
   - Broad perspective of entire problem
   - Moving from "Storming" to "Norming" phase of teamwork is critical

3. Establish a common language
   - Statisticians are from Venus, computer scientists are from Mars
   - Buzzwords can create a "Tower of Babel"

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

FRAMING PROBLEMS FOR SUCCESS

4. Don't confuse the problem with its proposed solution
   – Pre-selecting a solution stifles the scientific method and creativity. These "solutions" are typically driven by politics (and don't work!)

5. Understand the distinction between a symptom and a deeper root cause.

6. Apply systems thinking – projects often move problems from one silo to another

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

FRAMING PROBLEMS FOR SUCCESS

7. To the degree that makes sense, quantify the problem and what makes and effective solution.
   Avoids fuzzy projects – but not always possible

8. Questions to ask next.

1. Will solving the stated problem clearly lead to a consequential positive result?
2. Have necessary constraints been clarified ($, people, time, etc.)?
3. Has accountability been clearly established?
4. Have all key stakeholders bought into the problem statement?

Roger Hoerl, "Problem Framing," Presentation at Fall Technical Conference, Quality Engineering Session, October 6, 2023.

HAVE FUN!

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