

The logo for TJ Cross Engineers features the company name in a bold, black, sans-serif font. A red horizontal line with a small crosshair in the center is superimposed over the letters 'J' and 'C'. Below the main name, the word 'ENGINEERS' is written in a smaller, spaced-out, black, sans-serif font.

**TJ Cross**  
ENGINEERS

The logo for Cal-Valley Insurance Services, Inc. includes a blue outline map of California on the left. To the right of the map, the company name is written in a blue, serif font.

*Cal-Valley Insurance Services, Inc.*

A dark grey rectangular sign with white text is mounted on the side of a light-colored building. The sign displays the address '200 NEW STINE' in a white, sans-serif font.

200 NEW STINE

# Well Testing with High Well Count

Kent E. Halley  
Bakersfield, CA  
May 2010

# Well Performance Measurement

1. Gross Flow
2. Net Oil
3. Gas

# Well Performance Measurement Customers

1. Well Operations Supervisor
2. Production Engineer
3. Reservoir Engineer



# WPM Uses for Well Operations Supervisor

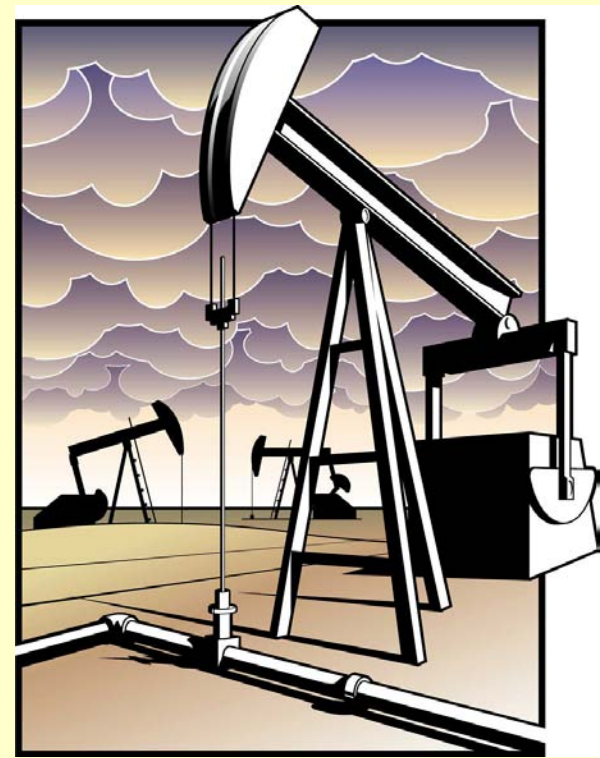
- ◆ Detect physical problems with pump, rods, tubing, etc.
- ◆ Prioritize repair and maintenance (R&M)

# WPM Uses for Production Engineer

1. Detect need for recompletion and reconditioning (R&R)
2. Evaluate R&R
3. Evaluate new technology, stimulation effectiveness, chemical, fracturing, etc.

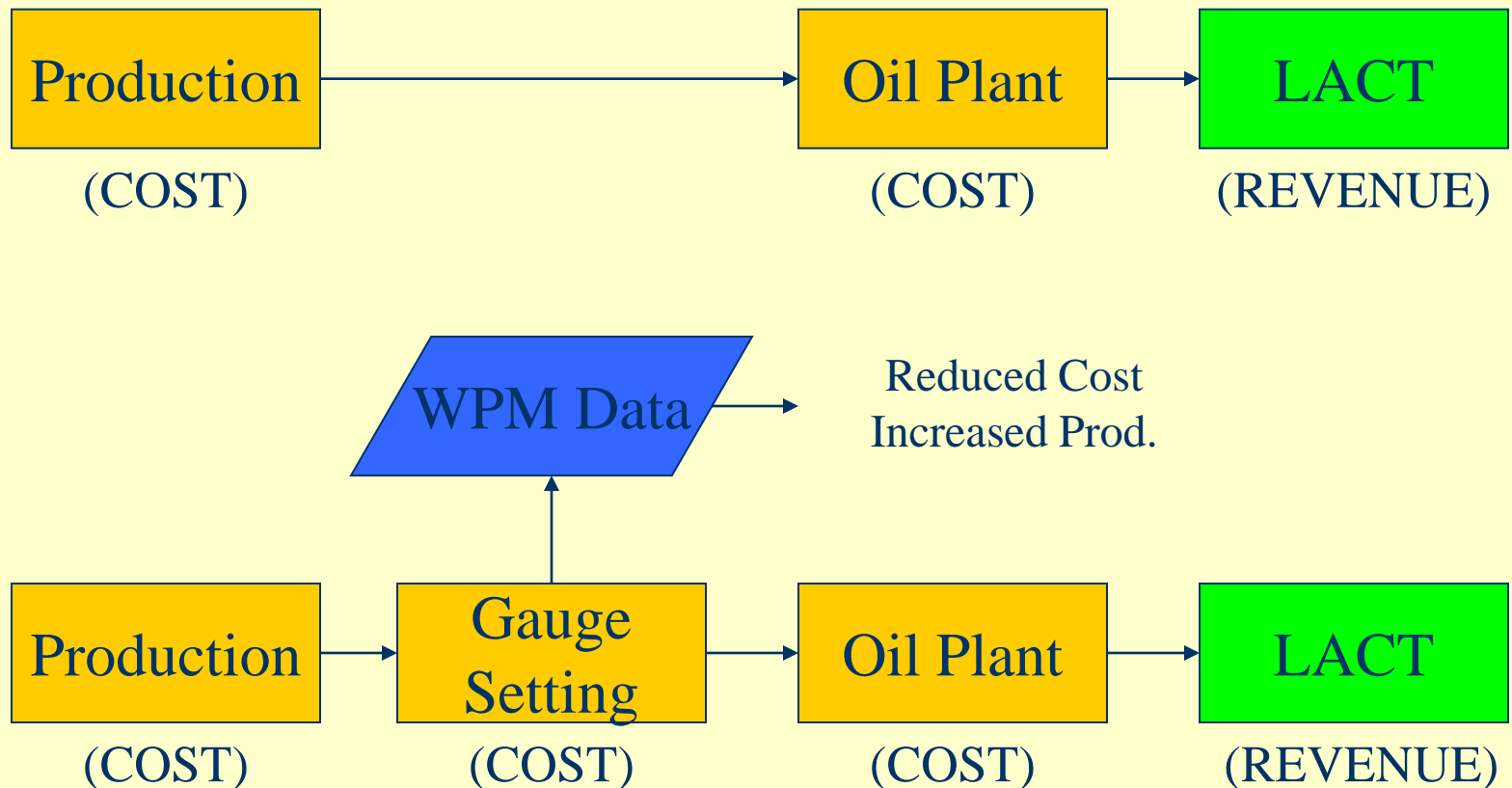
# WPM Uses for Reservoir Engineer

1. Manage water, steam, or CO<sub>2</sub> injection
2. Determine infill and field development opportunities
3. Compare different well types in a reservoir



# Value of Data

## The Gauge Setting is a Data Manufacturing Plant



**Increased production and reduced costs must justify gauge setting investment!**

# Value of Data Quality

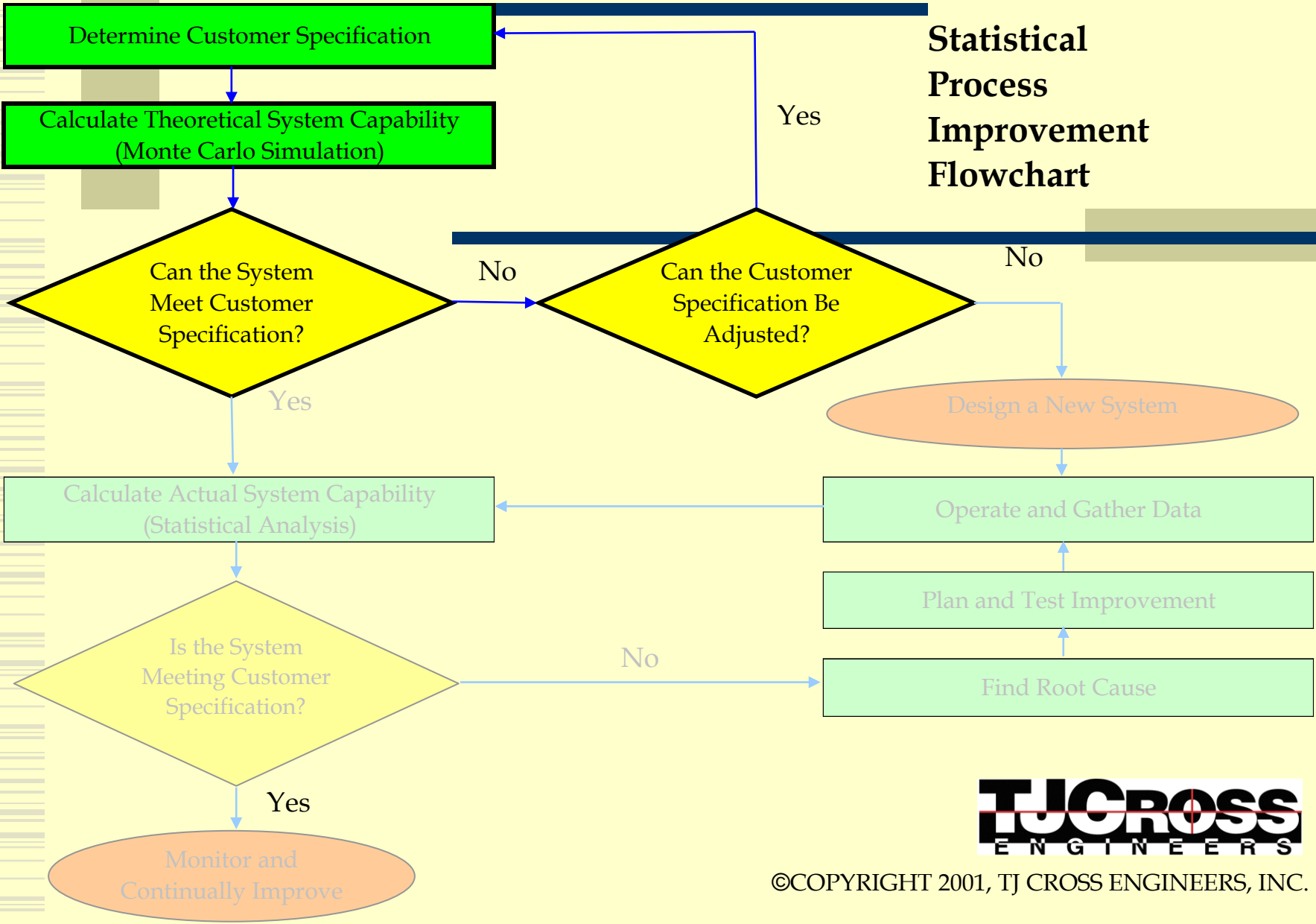
## Three layers of Data Quality

- ◆ **Accurate and Precise – Positive**  
“I know that I am getting good information, and the data is falling within the expected range. I am making good decisions.”
- ◆ **No Data – Neutral**  
“I know that I am not getting data, but I am taking other means to make decisions.”
- ◆ **In-Accurate and In-precise – Negative**  
“Even though I do not know the quality of my data, I am still making decisions, some good and some bad.”

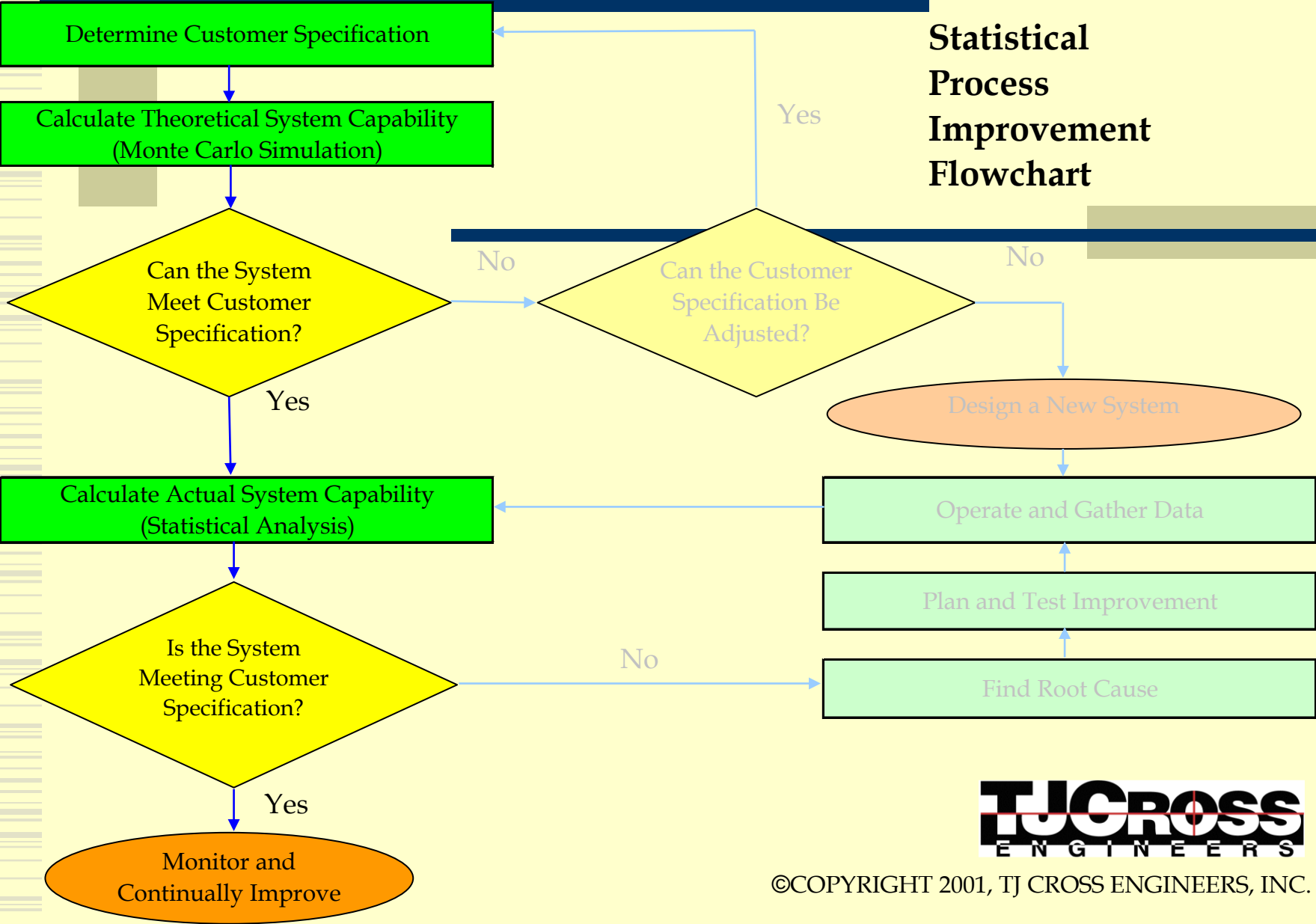




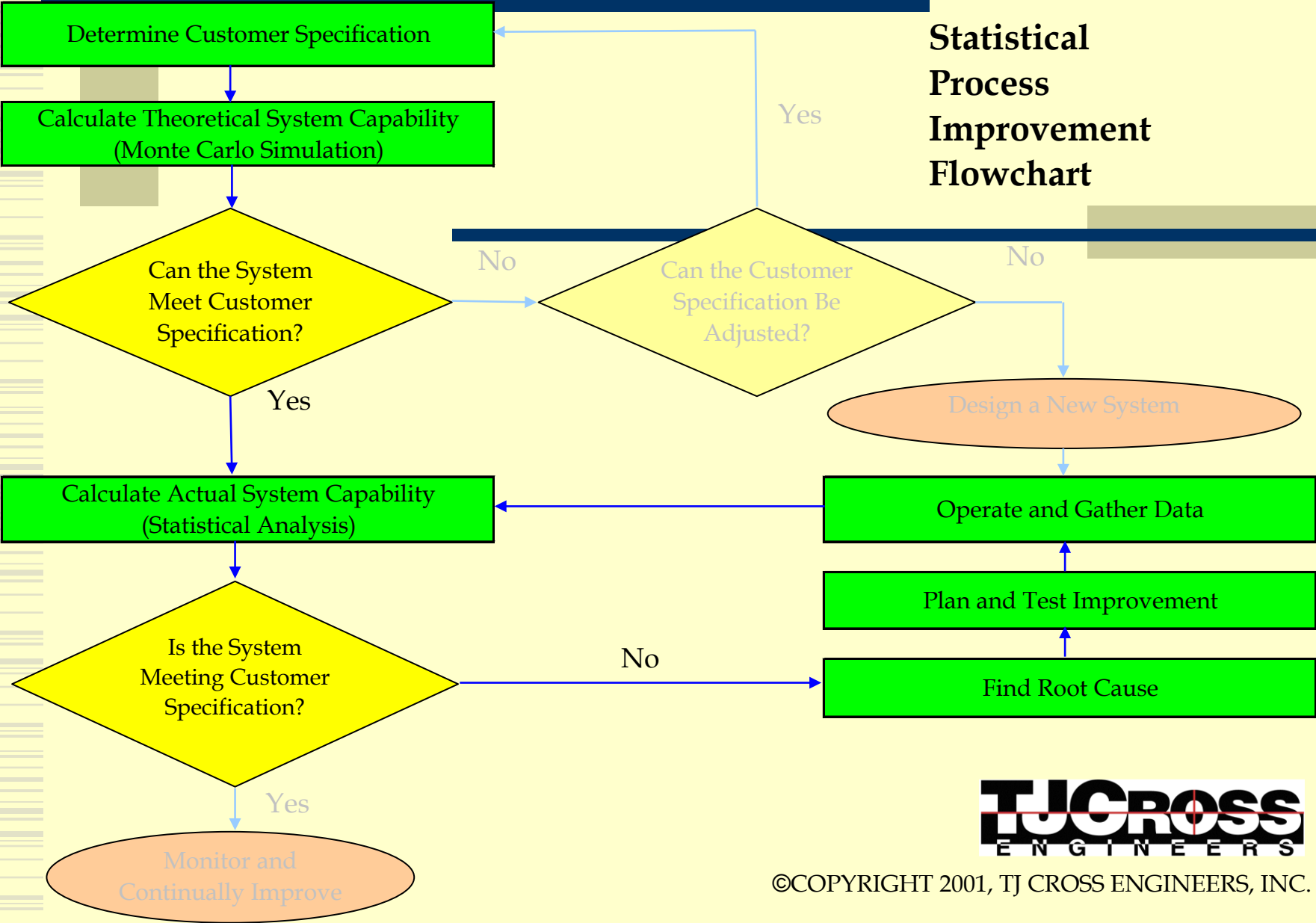
# Statistical Process Improvement Flowchart



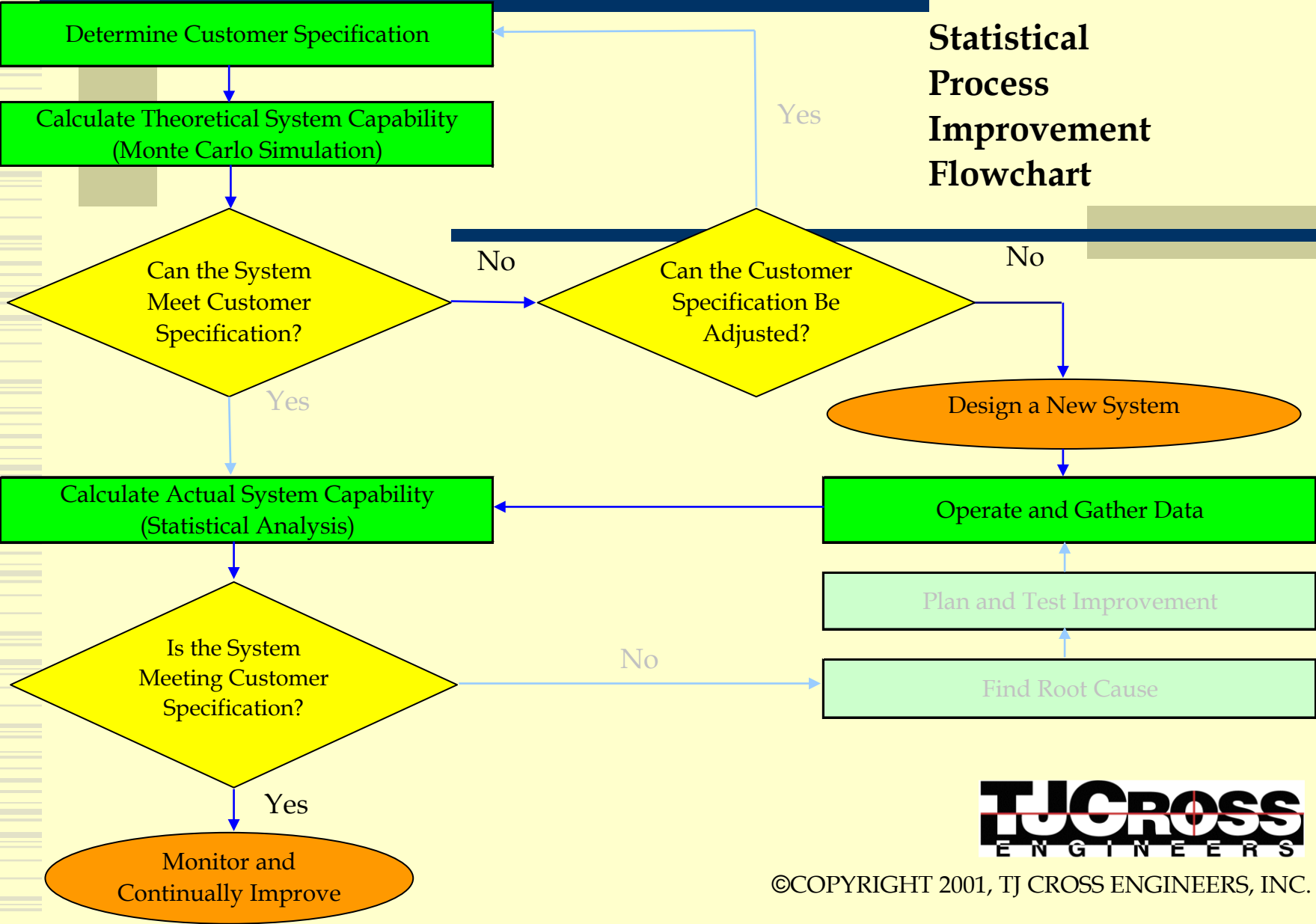
# Statistical Process Improvement Flowchart



# Statistical Process Improvement Flowchart

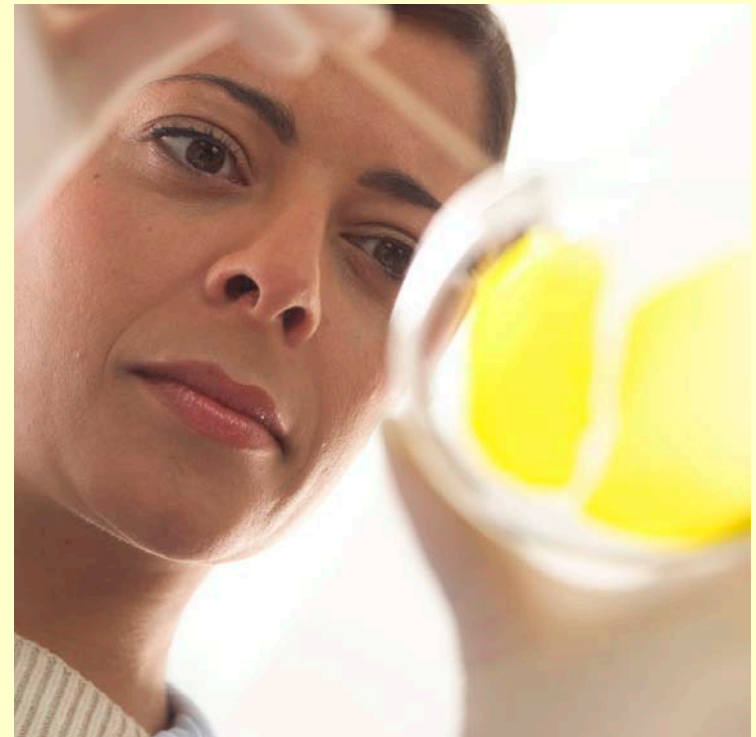


# Statistical Process Improvement Flowchart



# AWT Sources of Error

1. Representative sample
2. Separation of phases
3. Measurement of phase
4. Data conversion



# Representative Sample Error

1. Purge volume – dilution or plug flow
2. Test time
3. Pump-off control coordination
4. Vessel fluid level changes

# Separation of Phases Errors

1. Liquid in gas
2. Gas in liquid
3. Emulsion/free water separation (3 Ph.)

# Measurement of Phases Errors

- ◆ Meter sizing and selection
- ◆ Meter calibration - maintenance
- ◆ Liquid density drift
- ◆ Gas S.G. drift
- ◆ Cut probe calibration - maintenance



# Data Conversion Errors

1. Calibration ranges
2. Meter factors
3. Engineering unit conversions
4. OI vs. SCADA calculations

# Statistical Analysis

## 1. Assumptions

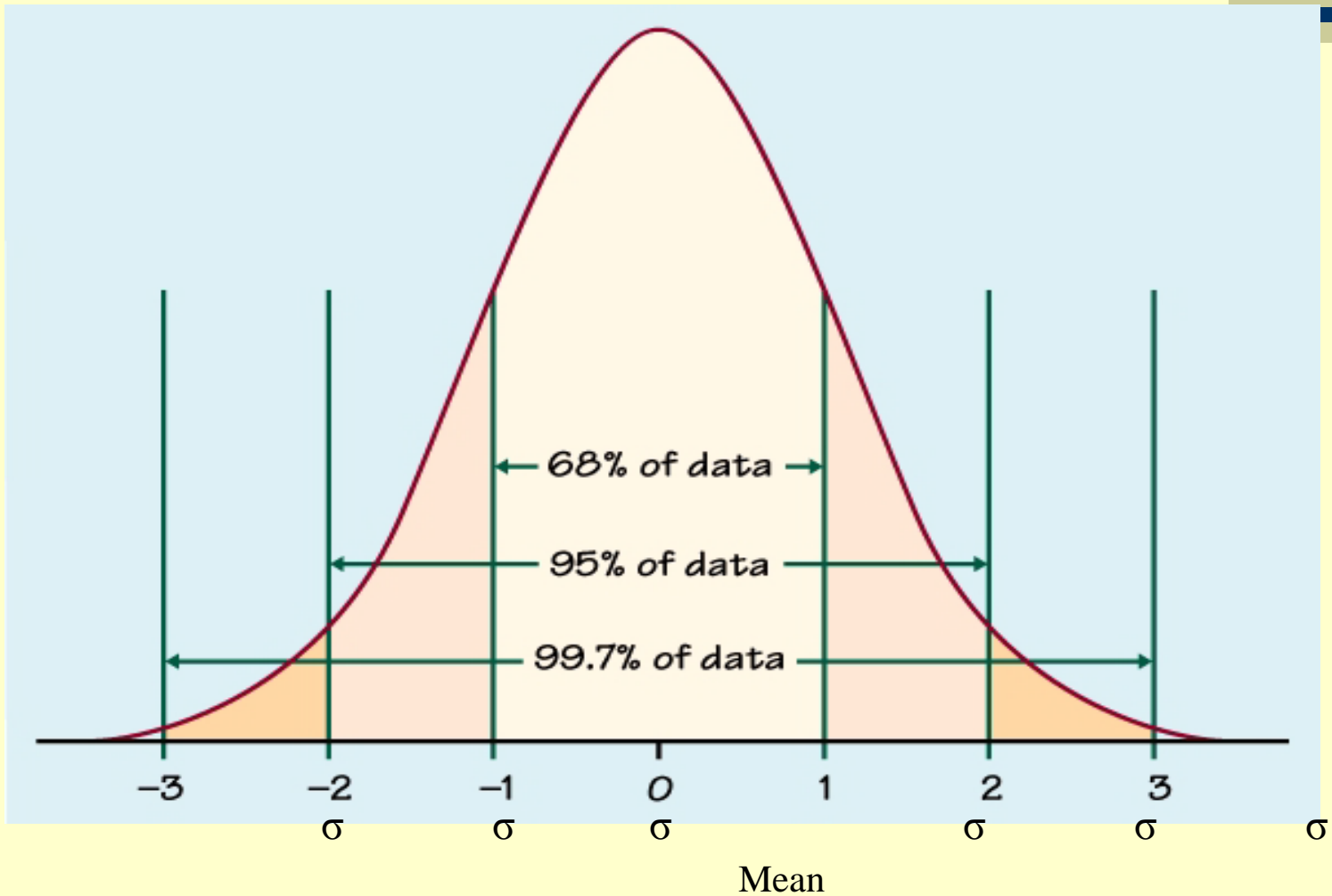
## 2. Normal distribution – standard deviation

## 3. “Stop light” control

# Assumptions

1. Well production is flat, gradually increasing, or gradually decreasing.
2. Measurement errors are normally distributed about the average production.
3. Test are expected to be within the average  $\pm 2\sigma$ . A test outside  $\pm 2\sigma$  is significant. A test outside  $\pm 3\sigma$  is highly significant.

# Normal Distribution and Standard Deviation



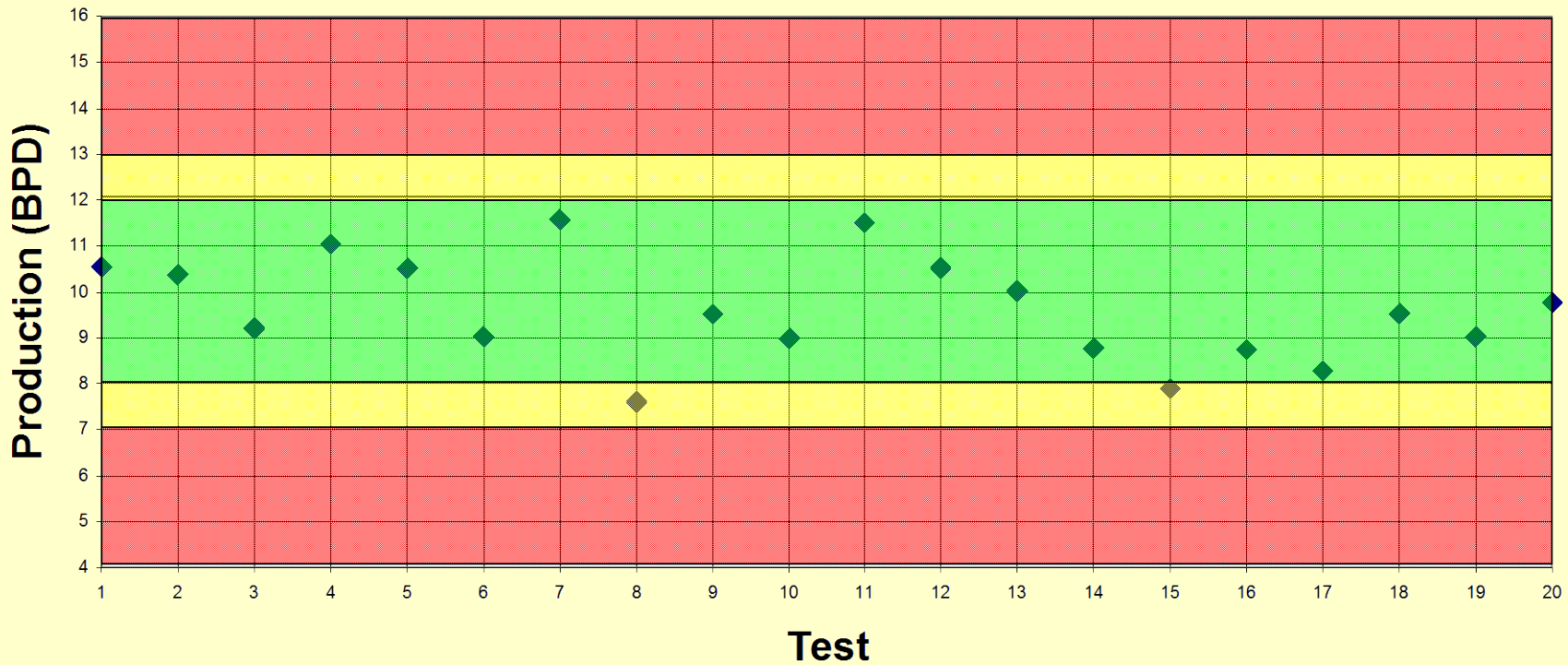
# Stop Light Control



1. Create control chart for last 20 tests (min. 10, max. 30)
2. **Green** ( $\pm 2\sigma$ ) = Go, everything is normal.
3. **Yellow** ( $+2\sigma$  to  $+3\sigma$  or  $-2\sigma$  to  $-3\sigma$ ) = Production may have change or a problem may have occurred with the metering system. Retest well and investigate problem if retest is not in the green region.
4. **Red** (outside  $\pm 3\sigma$ ) = Production has changed, or there is a problem with the well metering system. Investigate the situation.

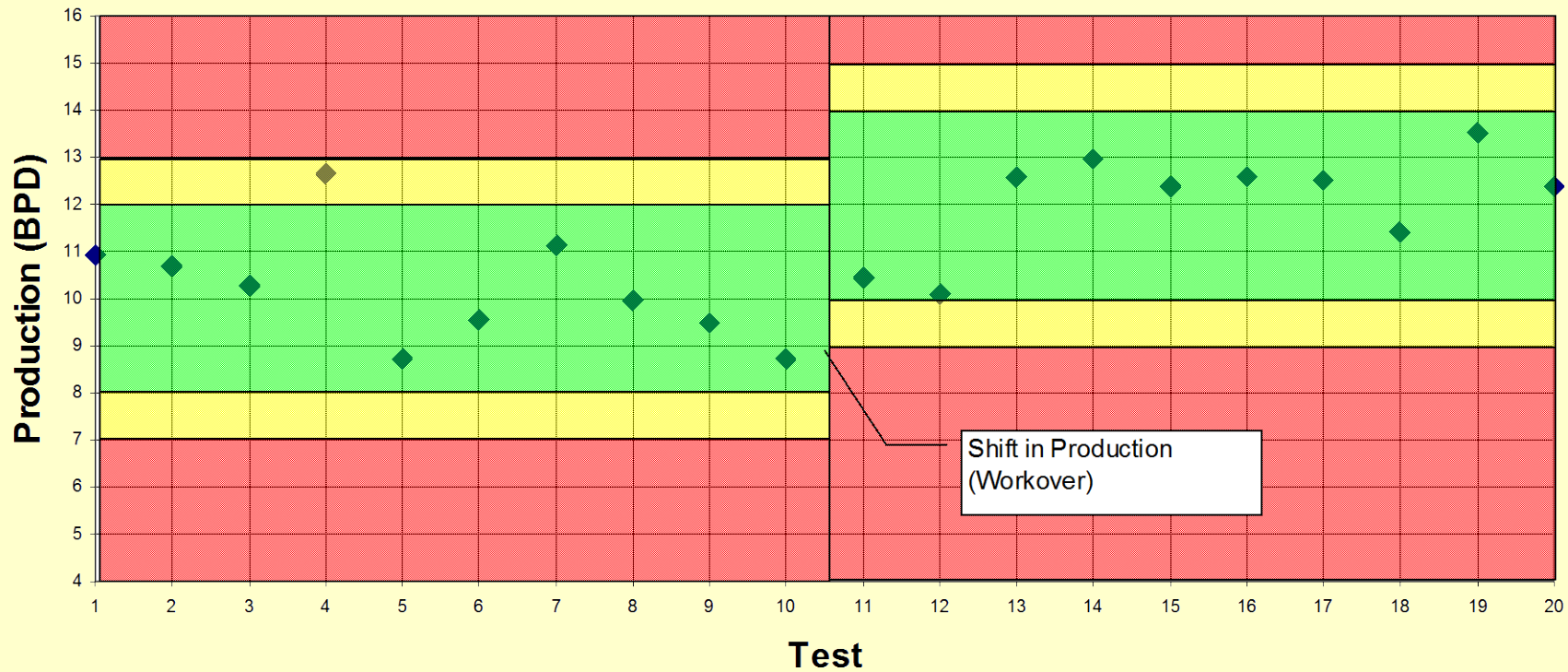
# Stop Light Control Example 1

## Stop Light Control Example

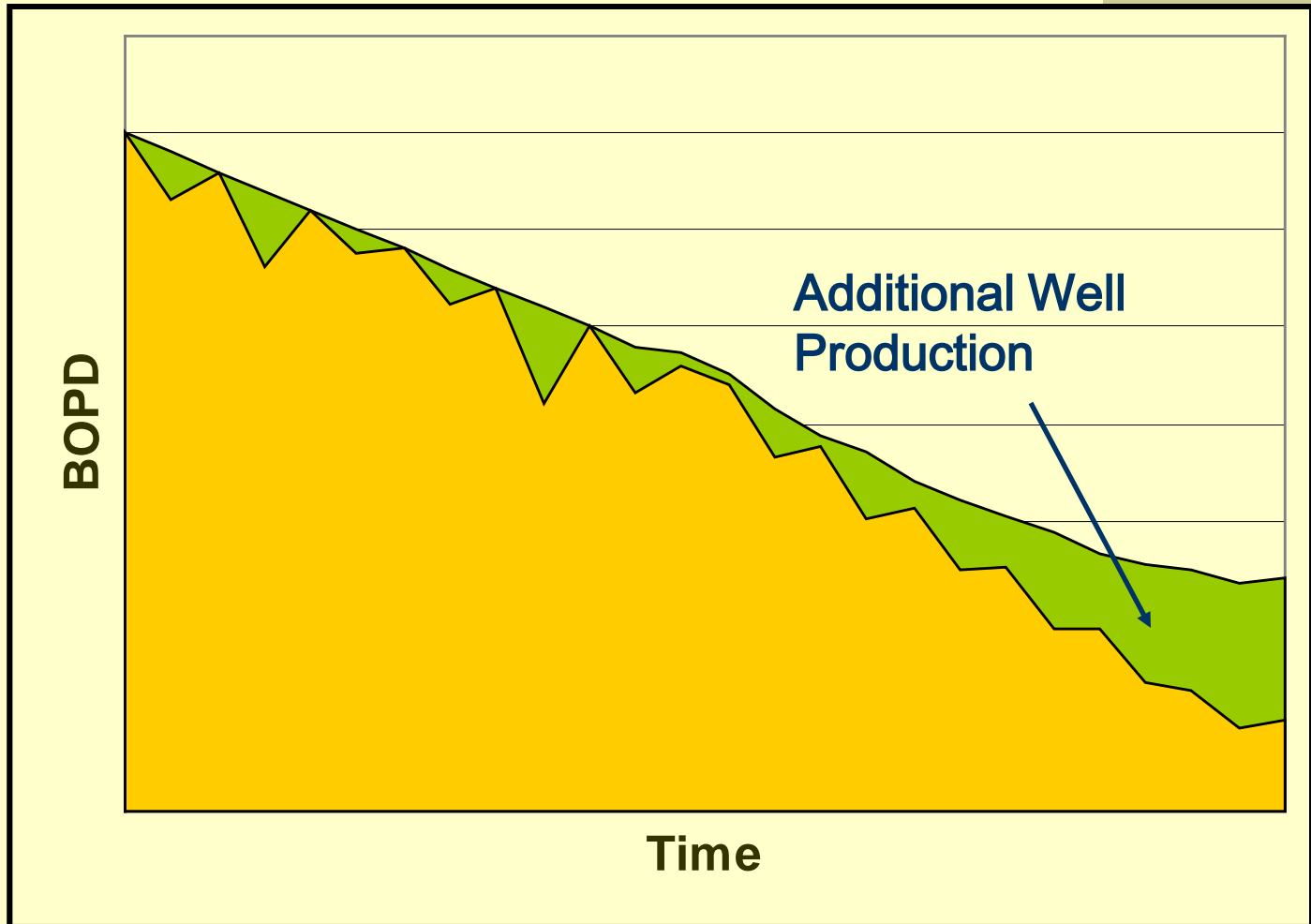


# Stop Light Control Example 2

## Stop Light Control Example



# Potential Production Capture Using Best-in-Class WPM





# WPM Conclusions

**DATA** + **STATISTICAL ANALYSIS** = **INFORMATION**



**INFORMATION** + **SUBJECT MATTER EXPERT** = **KNOWLEDGE**