Big Data, Statistical Engineering, and the Future

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TÍTULO

Outline

- Understanding Big Data
- Big Data: Opportunities and Cautions
- Large, Unstructured, Complex Problems
- Statistical Engineering
- The Science for Solving Problems with Data
- The Future

Understanding Big Data

- Several Talks on Big Data:
  - Roger Hoerl
  - Alberto Ferrer
  - Lluis Marco-Almagro

Understanding Big Data

- Current Abilities:
  - 100% Inspection via Sensors
  - Ability to Sample at Very High Rates
  - Image Data
  - Scrapping Data Bases
  - Internet of Things

Understanding Big Data

- Challenges:
  - Extreme oversampling (sometimes for a reason!)
  - Looking for a needle in a haystack
  - Large n, large p often produces sparse data
  - Complex variance structures
- The Issue: How to Distill the Information?

Understanding Big Data

- Must Consider the Fundamental Nature of the Data:
  - Information rich
  - Information poor.
    - Very few, very small needles in a massive haystack.
    - Often suffer from significant oversampling
    - Modeling Noise!

Understanding Big Data

- Most informative data points: outliers!
- An important issue: What is an outlier?
- Big Data Dominated by Computer Scientists
  - Data Quality
  - Data Cleansing
  - Populations versus Samples

Understanding Big Data

- Standard Statistical Approaches Viewed as Obstructions
  - What Do Power and ARLs Mean with Very Frequent Sampling?
  - Standard Statistical Approaches Require too Much Computation
  - Ultimately, Not Valid, Not Informative.

Understanding Big Data

- Irony: "Needle in the Haystack" Is a Statistical Process Monitoring Problem!
- Proper Solution Requires Going Back to Basics

Understanding Big Data

- NASA Example:
  - Sampling Rate: 100 Times a Second!
  - Test Duration: 168 Hours (One Week)
  - More than 60,000,000 Observations!
  - Actually, 32 Test Stands (Almost 2,000,000,000 Observations a Week!)

Understanding Big Data

- Key insight: Data Buffering
- Can Calculate Simple Statistics in Real Time over Specified Period of Time
- Challenge Remains: How to Use the Data?

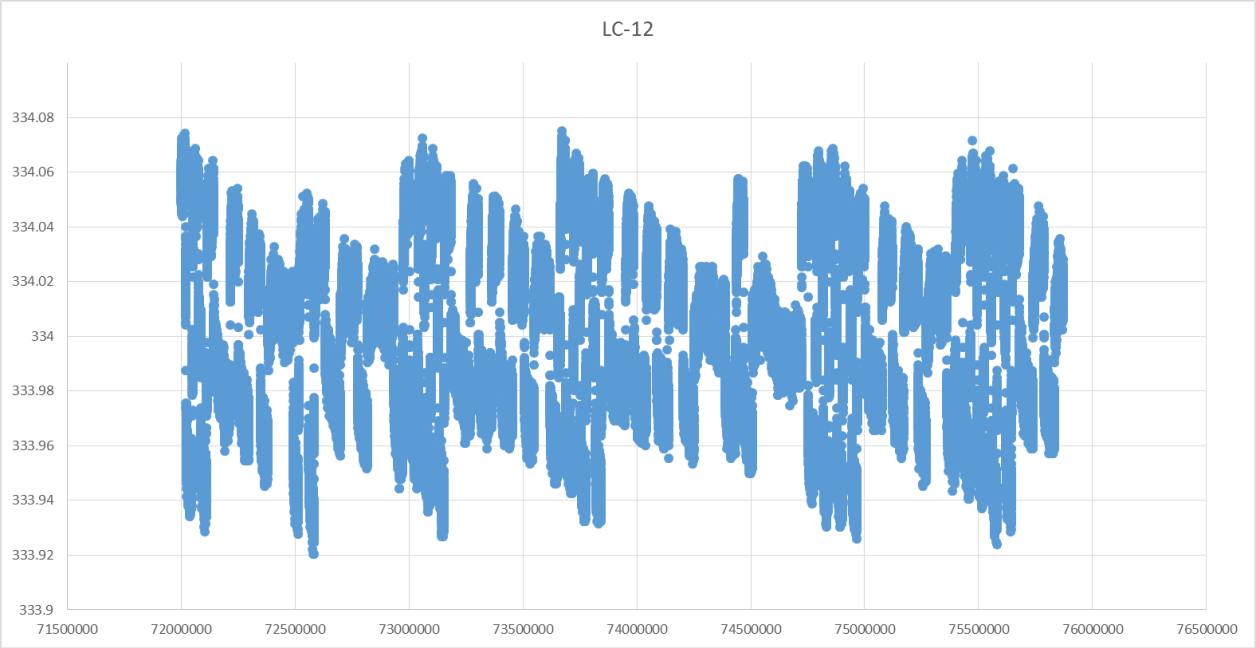
Understanding Big Data

- 5 serial numbers were selected
- Approximately 1 hour, 100 Hz data
- Minor excursions: deviation from target outside approx. +/- 0.085 lbs.
- Major excursions outside +/- 2 lbs.

Understanding Big Data

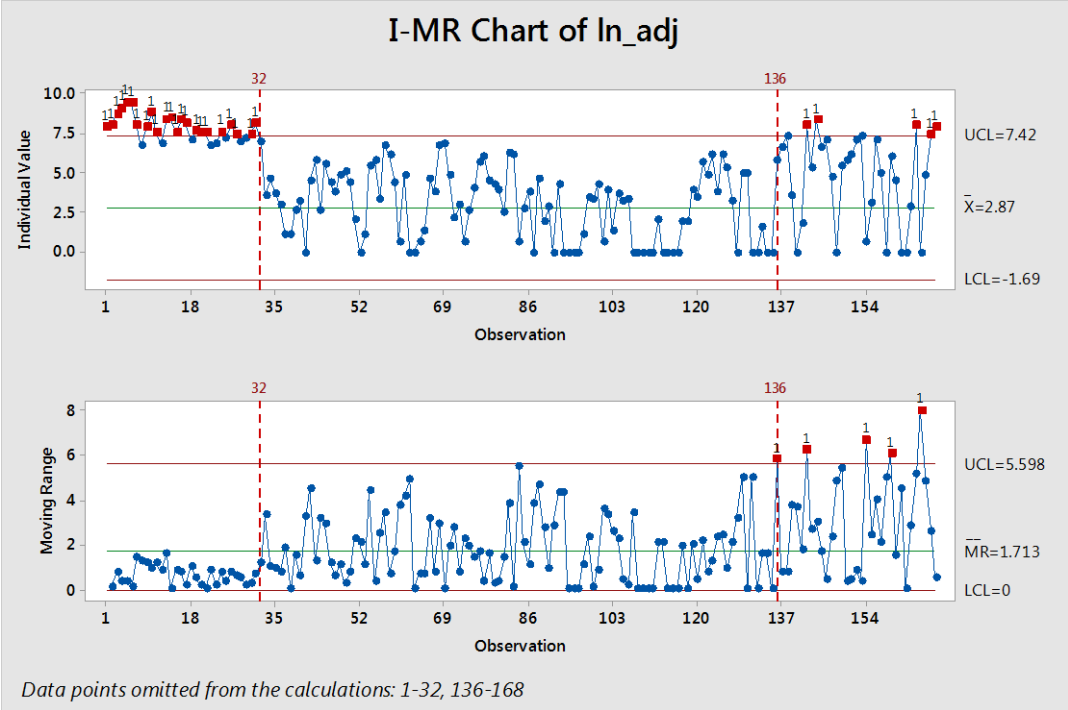
- Counted minor and major excursions for each period of test data
- Specific Goal: Determine Reasonable Engineering Definition of Minor
- Final Definition of Minor: .0075 lbs.

SN 00604

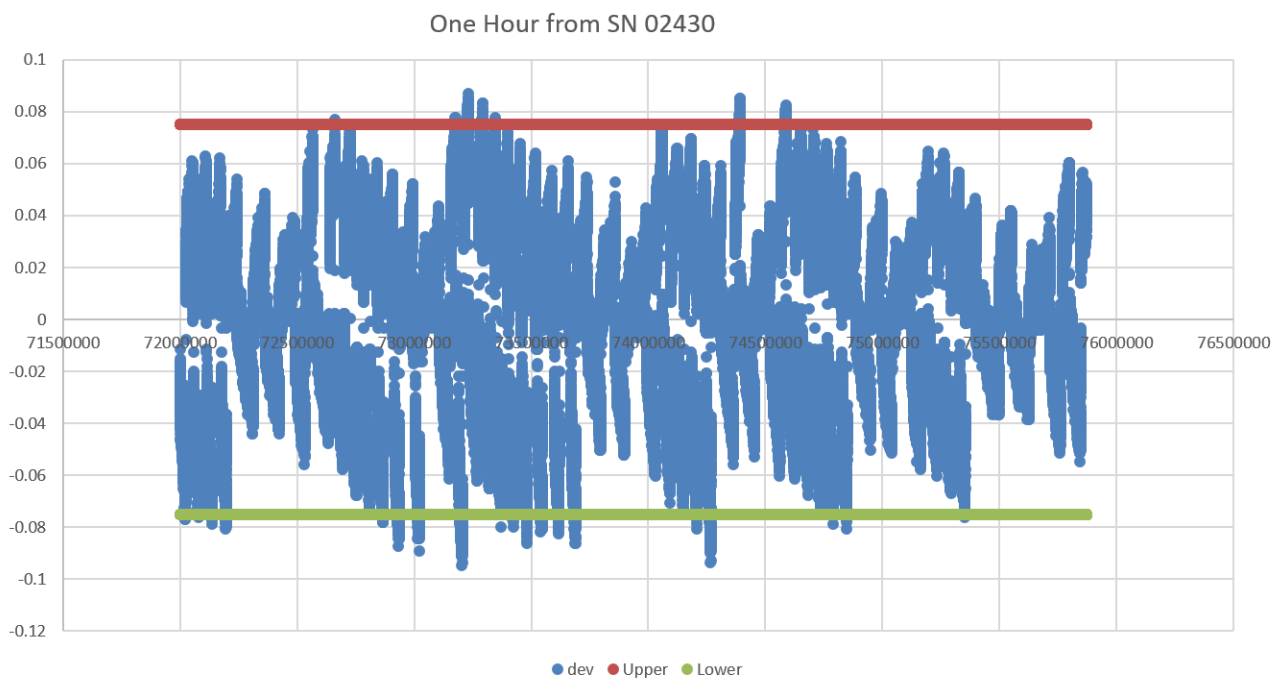


16	Total Excursions +/- Control Limits
0	Major Excursions
334	Set Point
0.075	Upper Control Limit Minor
0.075	Lower Control Limit Minor
2	Upper Control Limit Major
2	Lower Control Limit Major

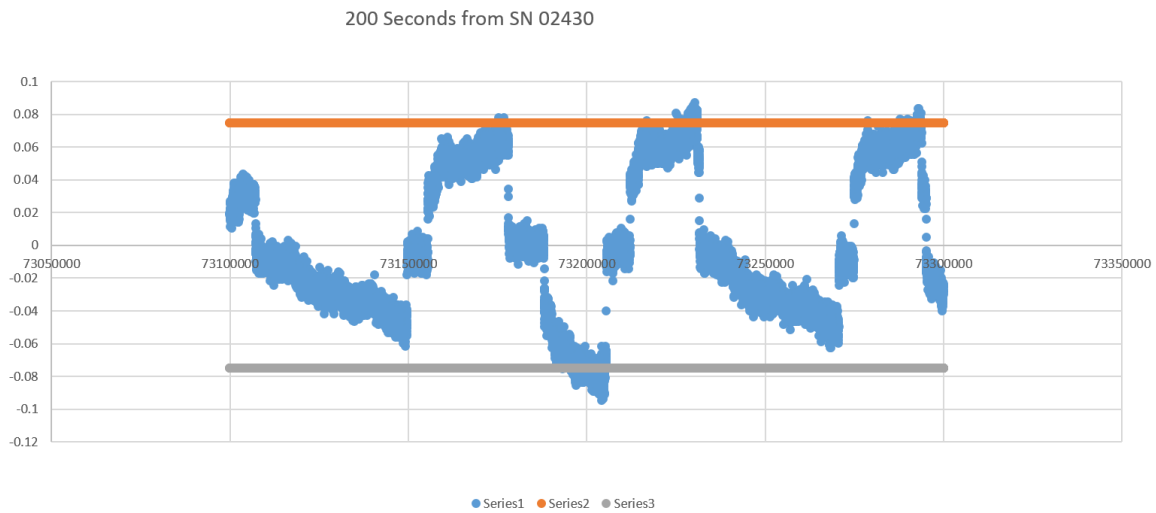
Proposed Phase I I-Chart



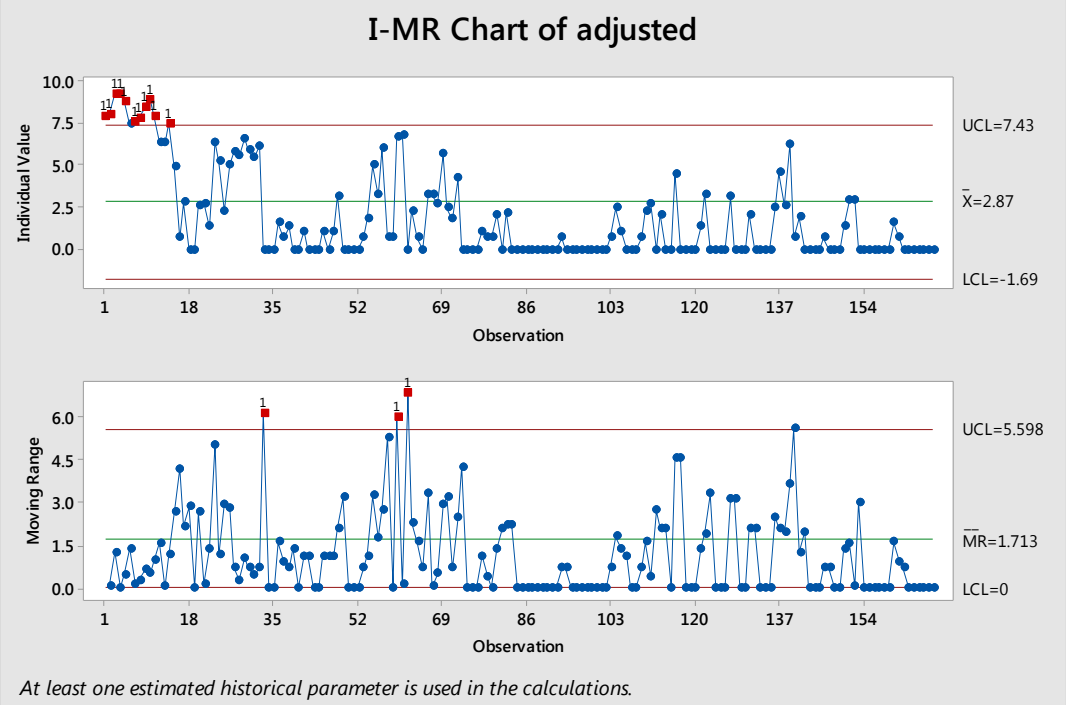
One Hour Problem



Approximately 200 Seconds



Phase I Limits Applied to SN 00604



Opportunities and Cautions

- Massive data are an important opportunity.
- Challenge to explain to management:
  - Management believes that the data set must contain all the answers to its questions.
  - Management rarely understands the fundamental issues with observational studies.

Opportunities and Cautions

- Massive data are vulnerable to misuse.
- Must Manage Expectations!
- As a community,
  - Must address this issue in greater detail
  - Warn our practitioners about making improper conclusions.

Large, Unstructured, Complex Problems

- Problems that Keep Your CEO Awake at Night
- Solutions Are Extremely Valuable!
- These Problems Are:
  - Large
  - Unstructured
  - Complex

Large, Unstructured, Complex Problems

- Require the Proper Data!
  - Properly Collected
  - Properly Analyzed
  - Properly Interpreted
- Proper Solutions Must Be Sustainable

Large, Unstructured, Complex Problems

- Examples:
  - Roger Hoerl's Talk
  - Pete Parker's Talk
- Solutions Combine
  - Academic – Basic Tools
  - Practical Experience – How to Apply the Tools

Large, Unstructured, Complex Problems

- Currently, No Text Discusses Large, Unstructured, Complex Problems!
- Emerging New Discipline: Statistical Engineering

Solutions

- Interdisciplinary Teams
  - Technical – Engineering/Scientific
  - Statistical/Analytical
  - Organizational Psychology/Anthropology
  - Project Management
- Strong Leadership

Statistical Engineering

- The heart of Statistical Engineering is the scientific method.
- Most theories underlying statistical engineering involve the scientific method.
  - Deming-Shewhart PDCA
  - Six Sigma's DMAIC

Statistical Engineering

- The Scientific Method Is
  - Fundamental Approach for Discovery and Problem Solving
  - Inductive/deductive problem solving process

Strategy of Statistical Engineering

- Identify Problem
- Provide Structure
- Understand Context
- Develop the Solution Strategy
- Develop and Execute Tactics
- Deploy Final Solution

Tactics of Statistical Engineering

- Data Acquisition
- Data Exploration
- Analysis
  - Traditional Statistical Methodologies
  - Modern Analytics (Big Data)

Tactics of Statistical Engineering

- Inference to the Process/Problem
- Deployment of Tentative Solution
  - Does It Work?
  - Is It Sustainable?

Overarching Methodologies

- Data Visualization
- Project Management
- Teamwork
- Organizational Culture

The Science for Solutions

- The Basic Tactical Tools Are Taught in Statistics/Industrial Engineering
- Data Acquisition:
  - Planning the Data Collection
  - Designing Experiments
  - Data Cleansing

The Science for Solutions

- Data Exploration:
  - Exploratory Data Analysis
  - Analytics!
  - Preliminary Models
  - Follow Up

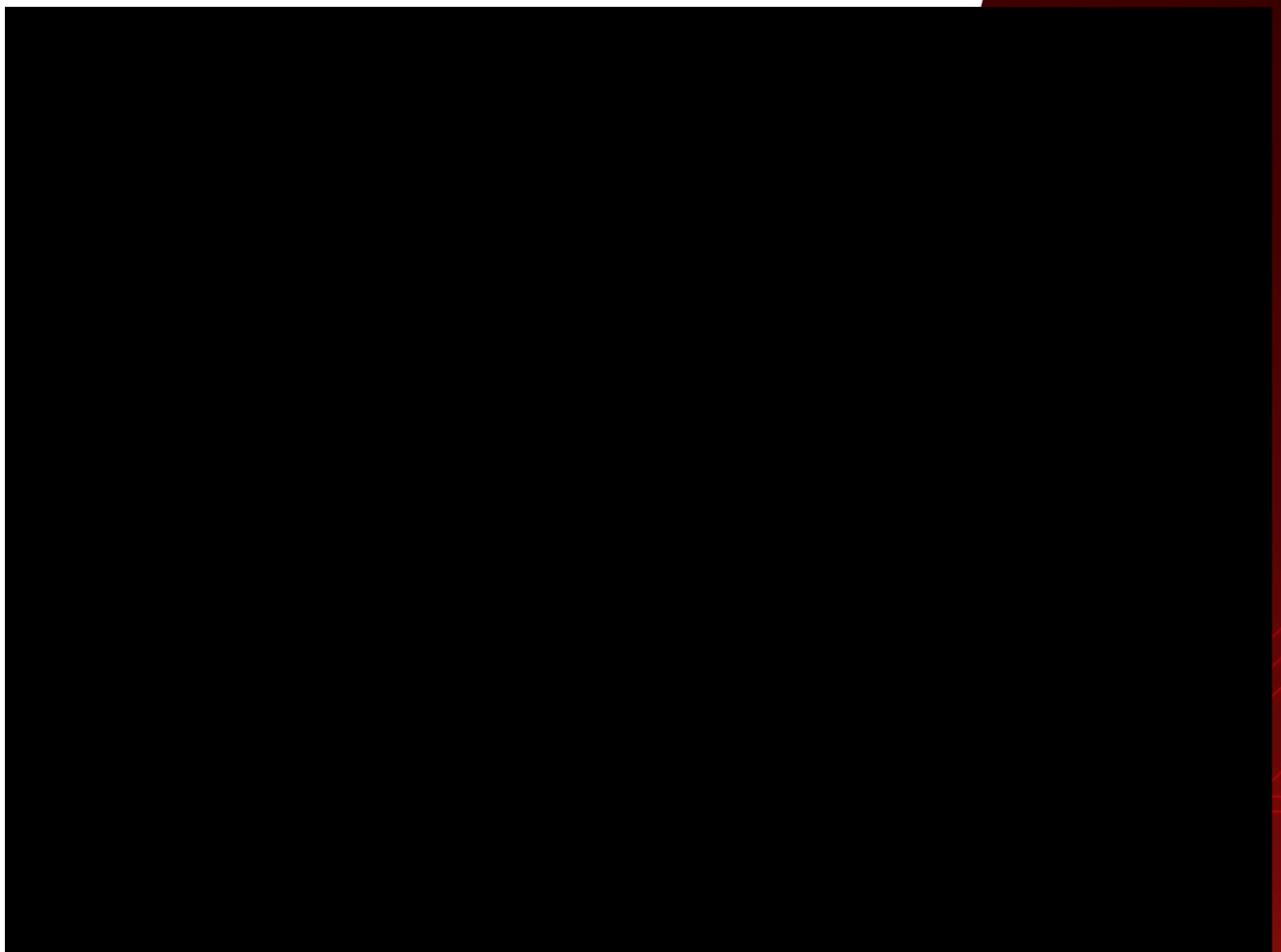
The Science for Solutions

- Analysis
  - Statistical Inference: Estimation and Testing
  - Formal Model Building
  - Predictive Analytics
  - Critical Point:
    - Right Tool
    - Properly Applied

The Science for Solutions

- Inference Back to the Problem – What Did We Discover?
- Propose, Evaluate, Deploy Solutions
- Statistical Engineering: The Science for Deploying the Tools!

NASA Statistical Engineering Example



The Future

- Success Requires Providing Value to Organizations
- Solving Large, Unstructured, Complex Problems Provides Great Value
- Current State: People Know Tools, Often Limited Number of Tools

The Future

- Future State: How Do We Use the Tools Most Effectively
  - Most Understand the Full Range of Tools Required
  - Most Understand Best Practices for Using the Tools
  - Must Understand Leadership in the Broad Sense
- The Future Is a Journey!