Why Attribute Control Charts Fail and How to Make Them Work for You

ASQ Austin Section 1414 Webinar

February 26, 2025

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This session will be recorded.

Send me an email if you would like for me to send you a **copy of these presentation slides (and recording)**, which contains links to the referenced metric reporting app, videos, articles, and books.

I will again provide my email at the end of this session

Have you seen out-of-control signals from a control chart and cannot find a reason?

You are not alone!

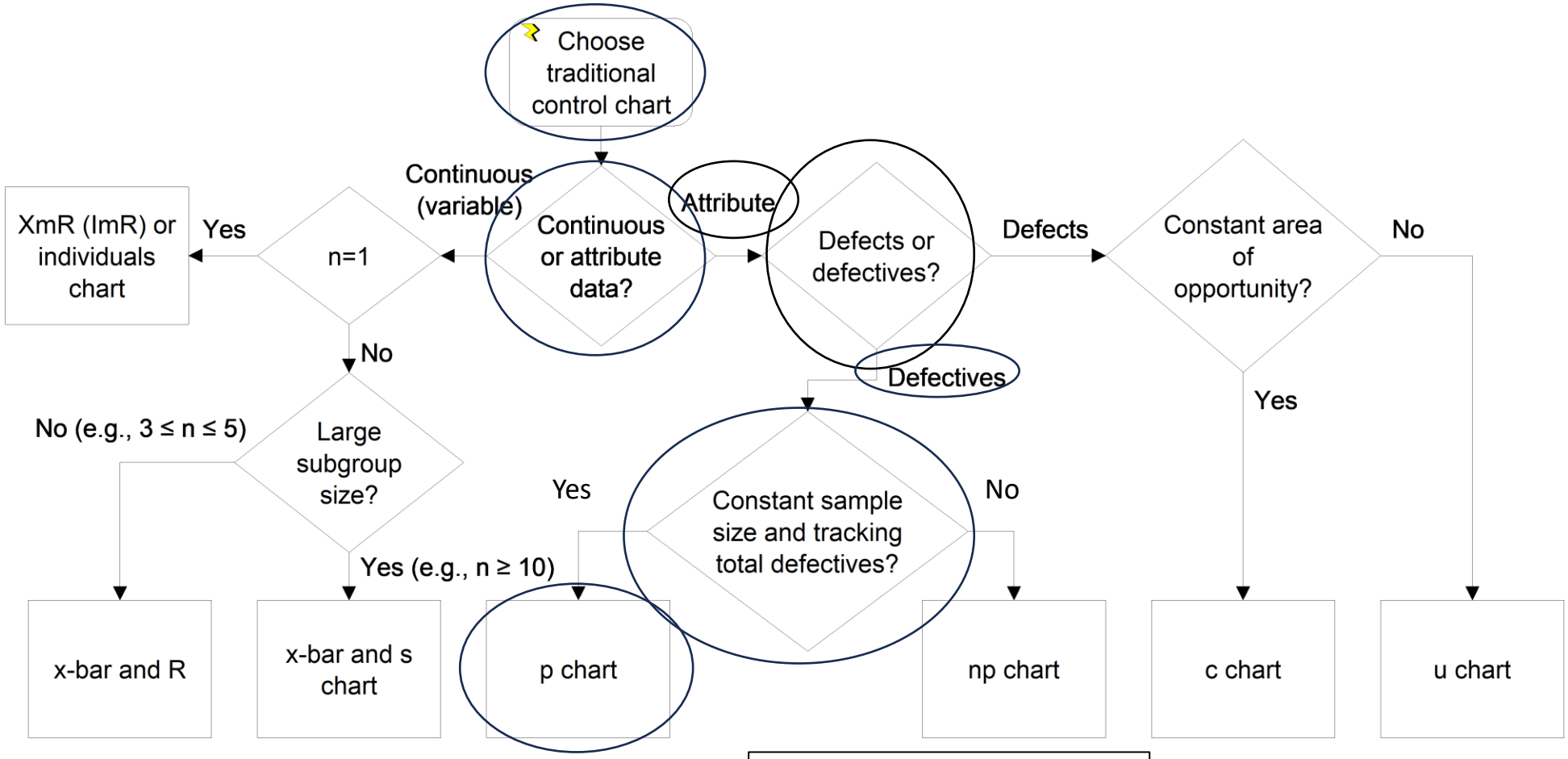
What is a P-chart?

Wikipedia states “In statistical quality control, the p-chart is a type of control chart used to monitor the proportion of nonconforming units in a sample,

where the sample proportion nonconforming is defined as the ratio of the number of nonconforming units to the sample size,

Let’s determine when a p-chart is appropriate.

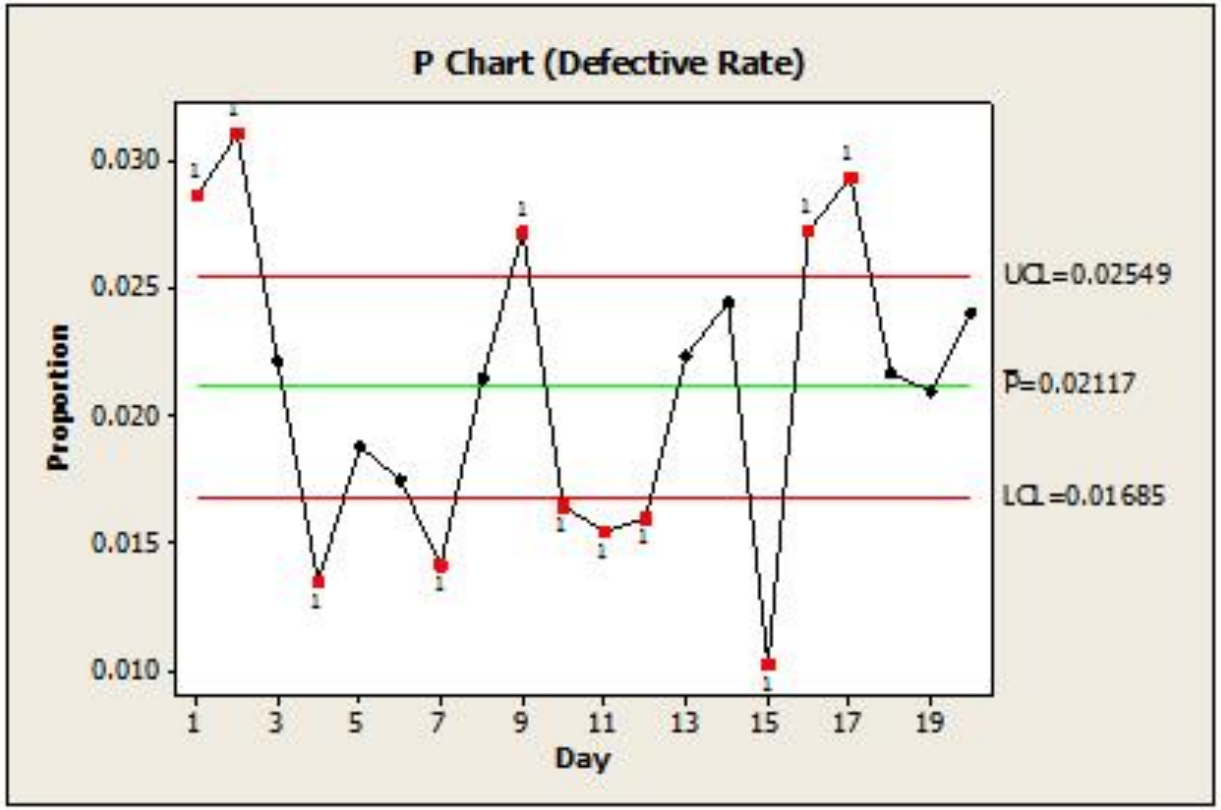
Traditional p-chart Selection



Let's examine a p-chart

P-Chart Illustration

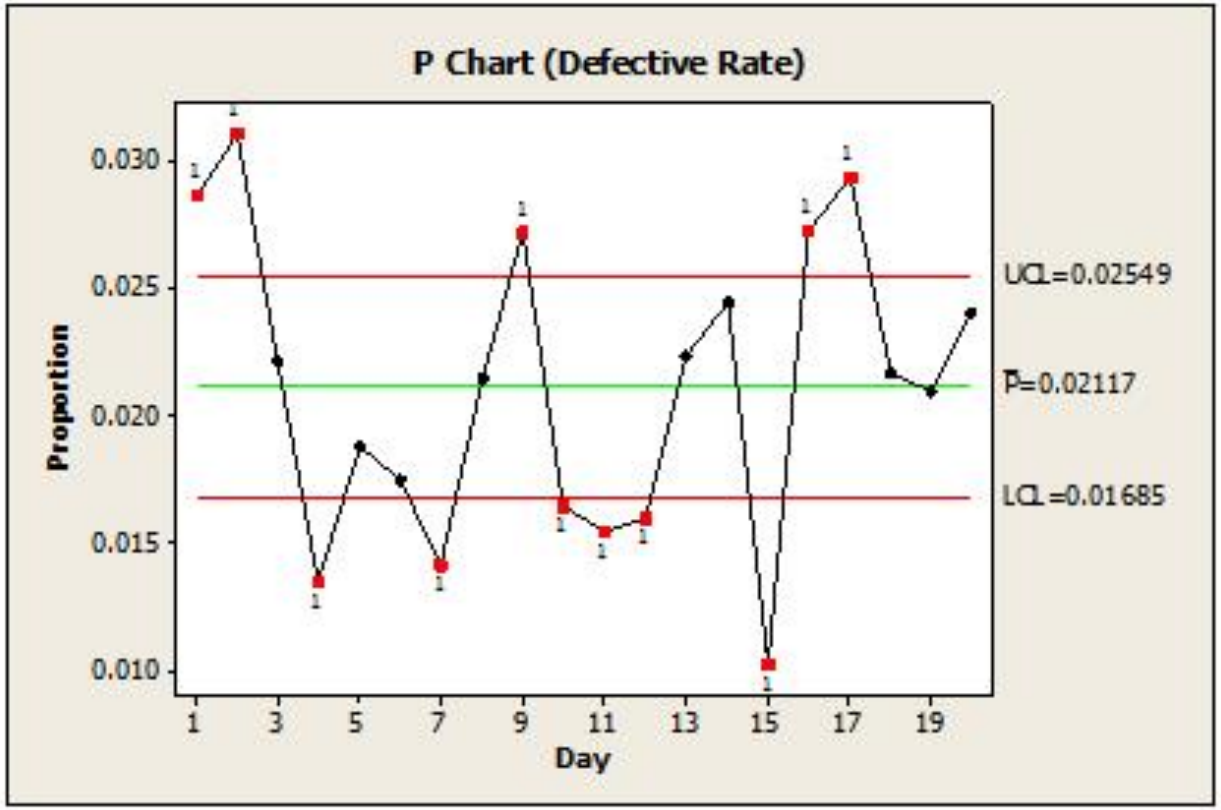
- What is your conclusion from this p-chart?
- Is there a customer problem?
- What action, if any, should be taken?
  - One would typically state that the special-cause events beyond the Upper and Lower (UCL and LCL) limits should be investigated and resolved



Modified from Table 12.1, *Integrated Enterprise Excellence Volume III - Improvement Project Execution: A Management and Black Belt Guide for Going Beyond Lean Six Sigma and the Balanced Scorecard*, Forrest W. Breyfogle III, Bridgeway Books/Citius Publishing, Austin, TX, 2008.

Conclusion

- Another data analysis indicates that this process is stable and has an approximate non-conformance rate of 2%.
  - If this non-conformance rate is unacceptable, there is a need for process improvement.
- How can this process stability statement be true?



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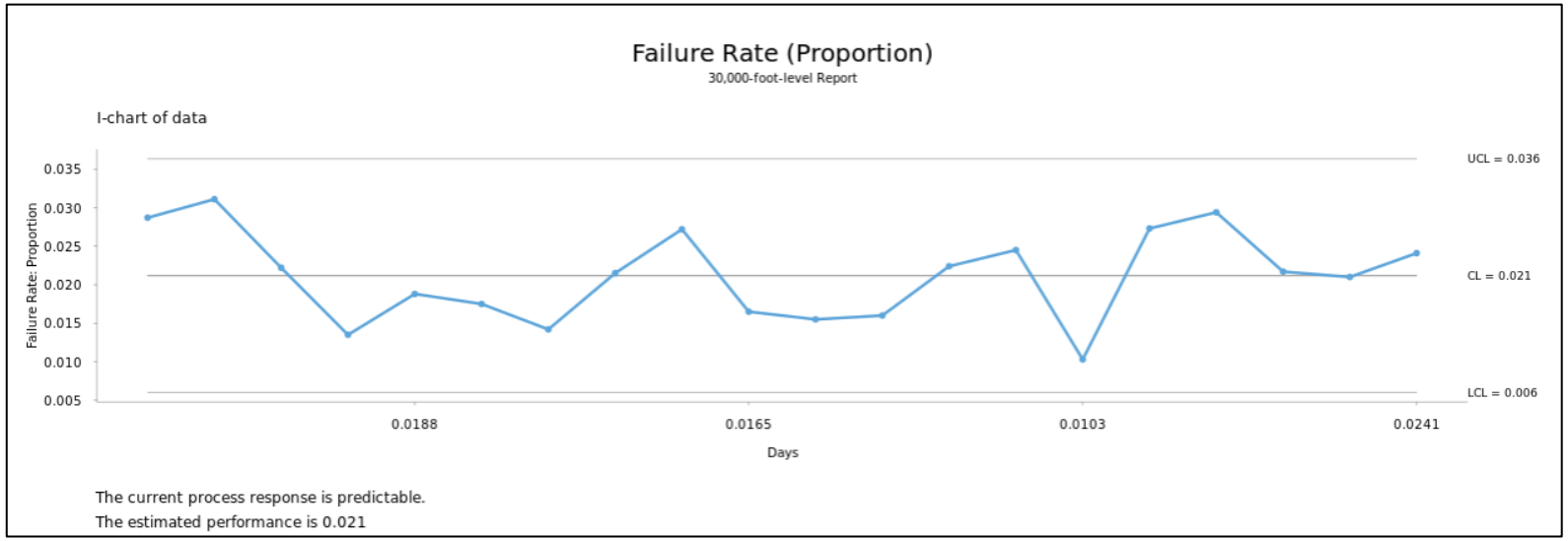
An Alternative to Monitoring an Attribute Process Output Response

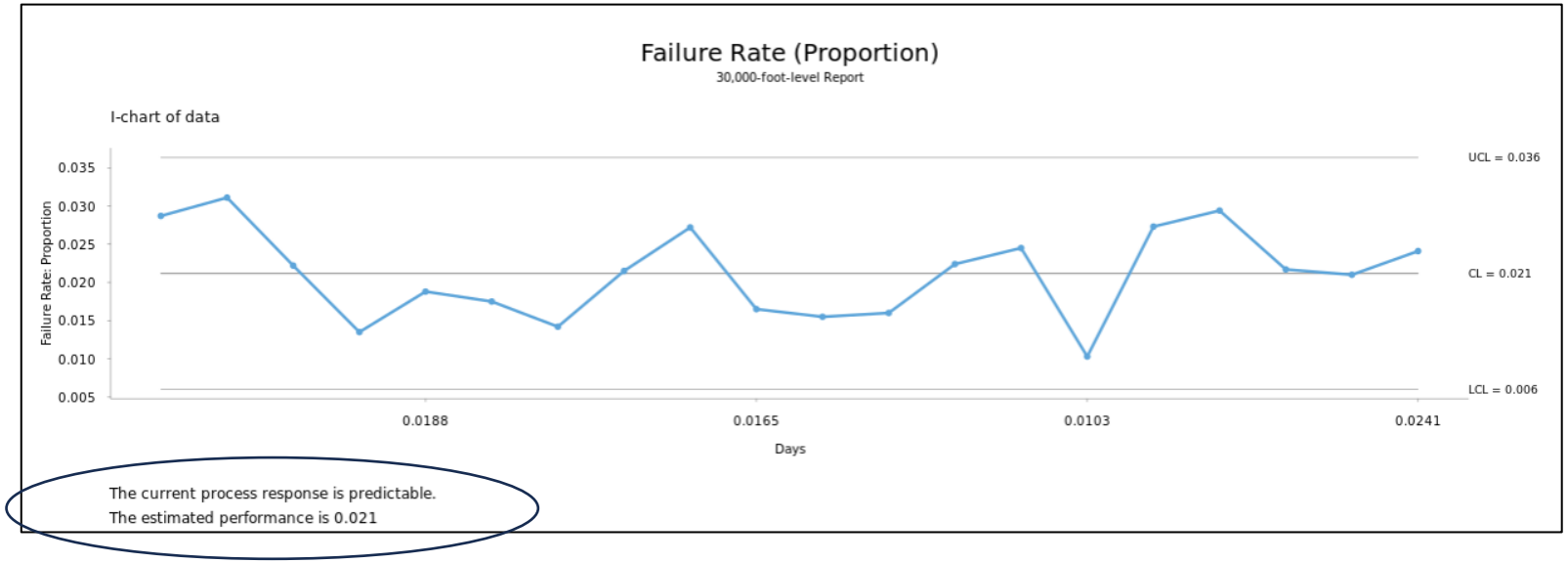
Meet 30,000-foot-level reporting

- Unlike a p-chart, this chart's upper and lower control (UCL and LCL) limits are calculated from between subgroup variability
  - i.e., 3 times the chart's sampling standard deviation
- This is a **big deal**, which I will discuss later

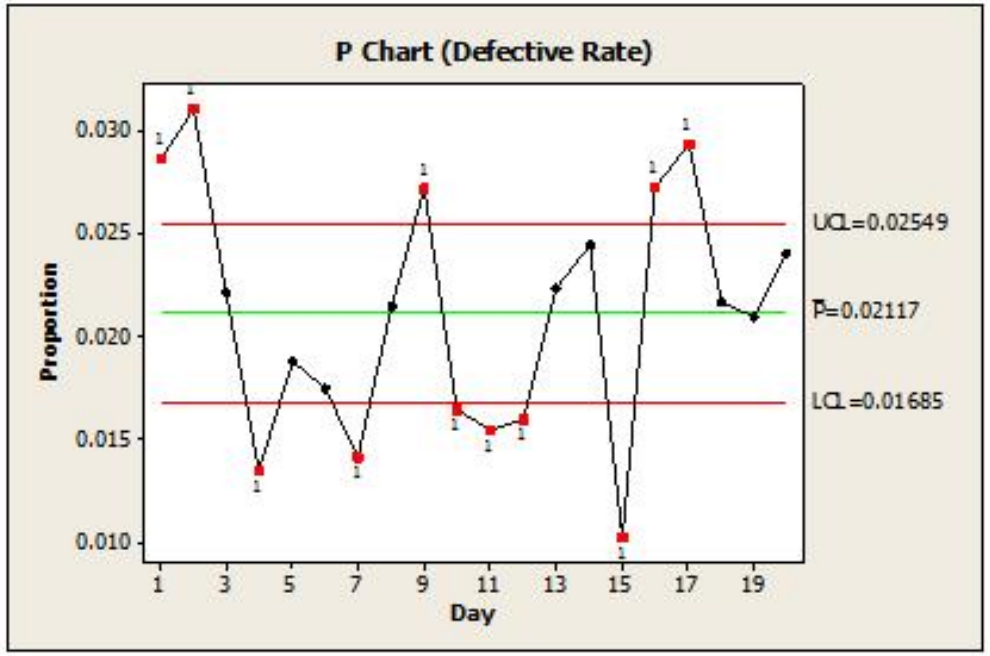


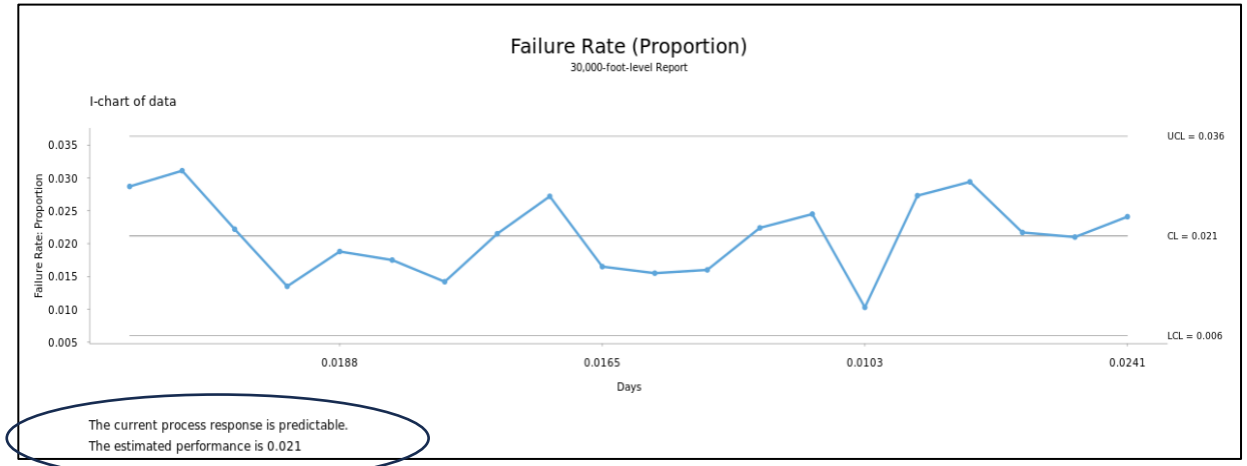
30,000-foot-level Reporting: Prediction Statement

- When a process is stable, there is a prediction statement at the bottom of the report
- If a prediction statement is unsatisfactory, there is a need for process improvement



30,000-foot-level Report Comparison to P-chart





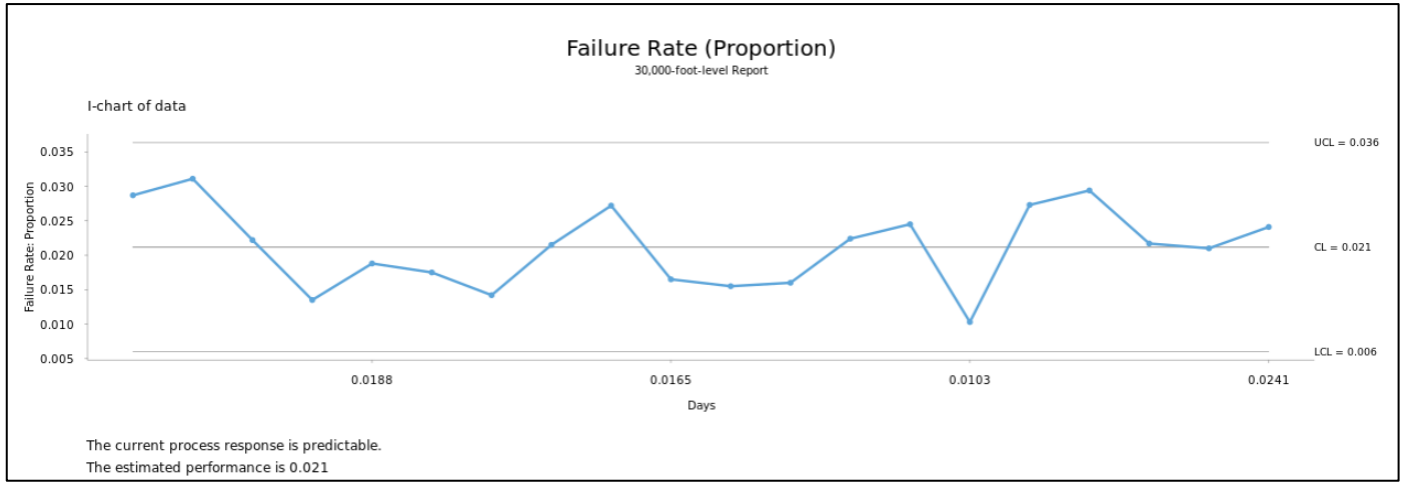
Traditional p-charts can lead to much firefighting high-level (i.e., 30,000-foot-level) common-cause variation as though it originated from special cause variability.

Benefits of 30,000-foot-level Reporting Over Traditional Control Charting

- Control charts are to identify “out-of-control” signals for timely actions via Upper and Lower Control (UCL and LCL) Limits
- Control chart UCL and LCL values are mathematically 3 times the **sampling** standard deviations from the mean
- Mathematically the **sampling** standard deviation for a p-chart is determined from **WITHIN SUBGROUP VARIATION (**calculated from the binomial distribution**)**
- **It is important to understand that for p-charts** between subgroup variation has **NO** impact on UCL and LCL values
- From a customer’s point of view, differences between work-shifts, days-of-the-week, machines, or other similar factors (that occur between subgroups) are potential sources of common-cause variation, which customers do not care about relative the quality of a product or service they receive
- **For a p-chart, if there is between subgroup variation caused by customer-viewpoint common-cause factors, many out-of-control signals can occur**
- Control charts do not assess how well a measurement meets the needs of customers, which 30,000-foot-level reporting does

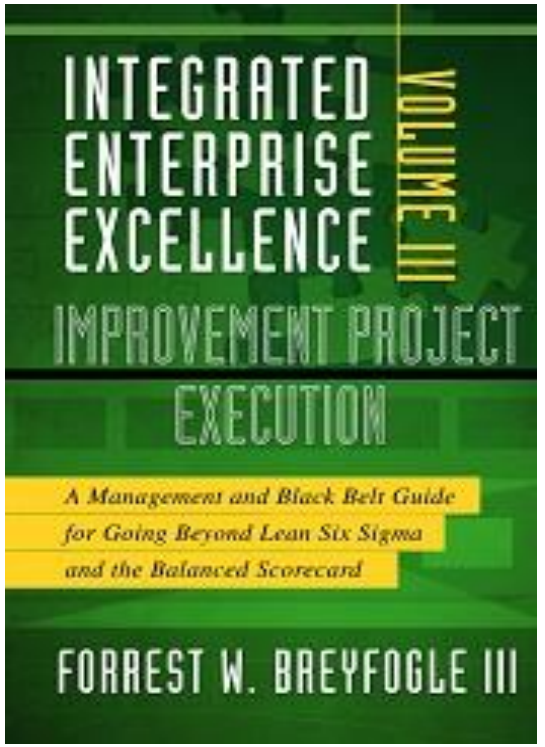
Free 30,000-foot-level Reporting App

- For your dataset, you can create a 30,000-foot-level report with a free 30,000-foot-level app that is available at https://smartersolutions.com/free-app
- I will later demonstrate how to use this app



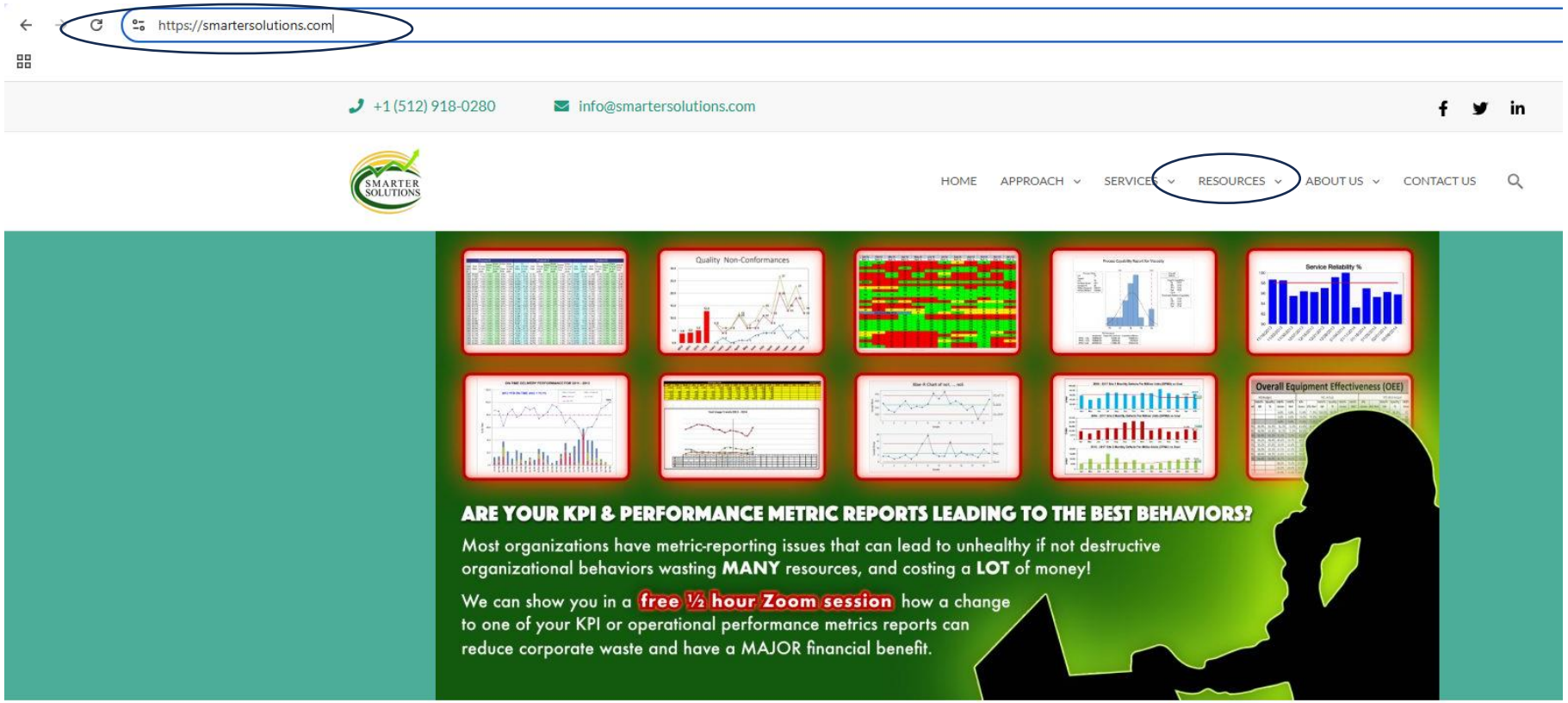
Book: Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting

- *Integrated Enterprise Excellence, Vol. III Improvement Project Execution: A Management and Black Belt Guide for Going Beyond Lean Six Sigma and the Balanced Scorecard*
- Chapters 12 & 13
- https://www.amazon.com/dp/1934454168/



Chapters 12 & 13

Article: Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting



What Our Integrated Enterprise Excellence (IEE) System Provides:

KPI and Performance Metrics Reporting 2.0

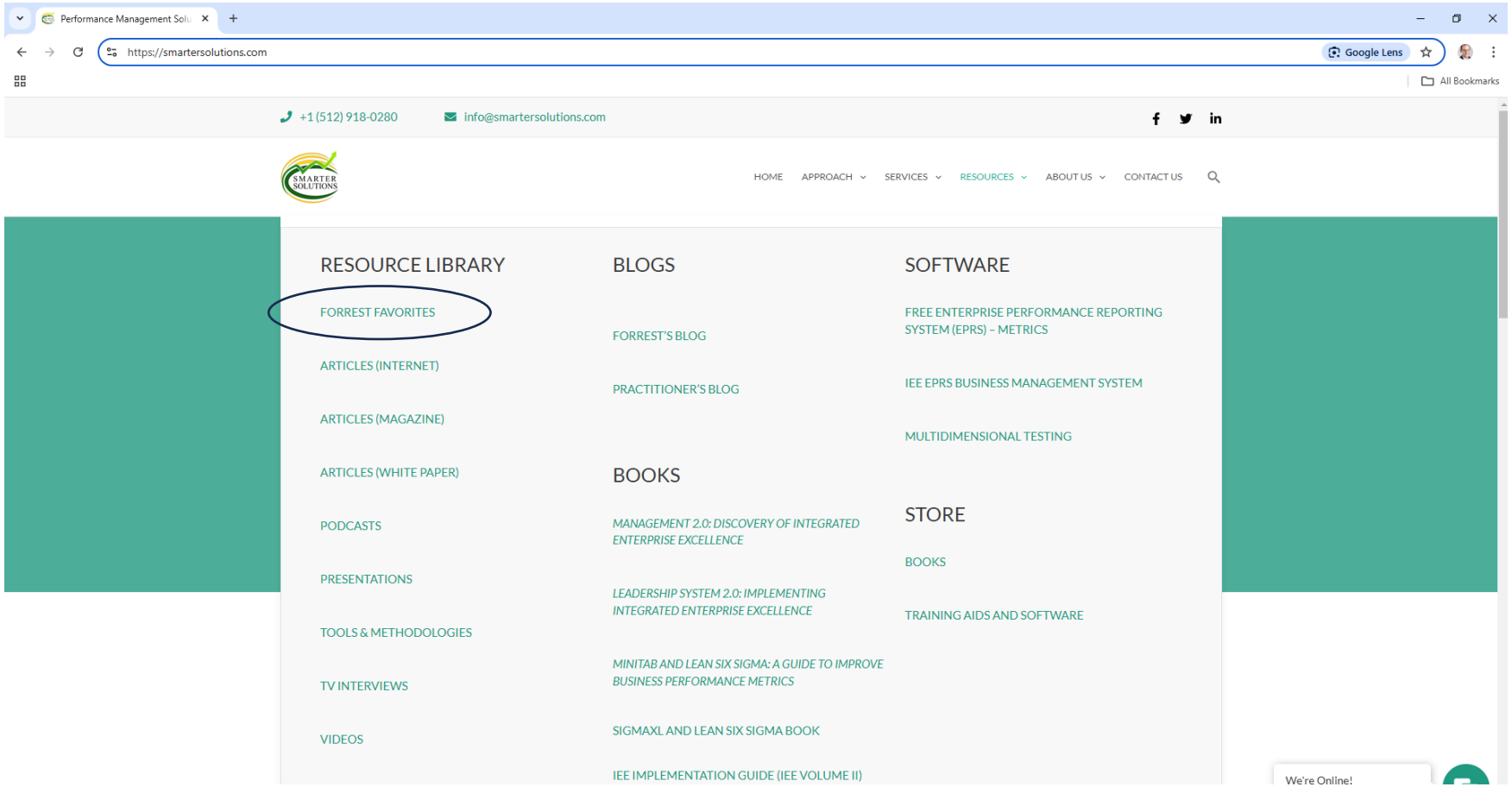
Business Management System 2.0

Business Process Management 2.0

Management Information System 2.0

Lean Six Sigma Implementation 2.0

Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article



Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

HOME APPROACH SERVICES

Business Management and Process Improvement: Forrest's Favorite Next Generation Topics

The following business management and process improvement links provide Forrest's favorite summary of next generation discussions on these topics.

Business Management and Process Improvement: Forrest's Favorite Topics

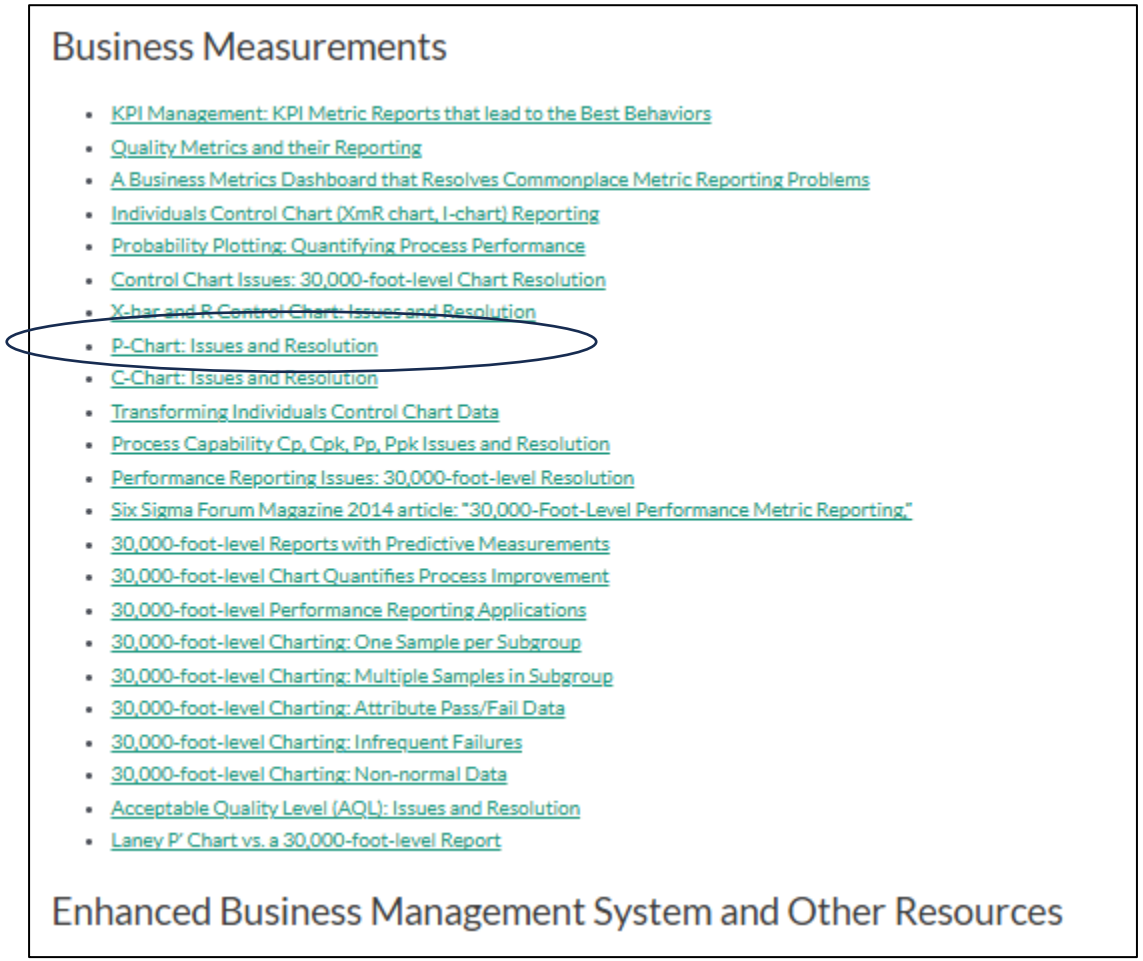
Forrest's favorite topics contain articles, videos, blogs, and webinars that describe the Integrated Enterprise Excellence (IEE) enhanced business management system and effective metric reporting which is predictive.
The following links provide convenient access to many enhanced business management and performance reporting techniques, which Forrest Breyfogle and the Smarter Solutions' team has found beneficial in many organizations.

Business Management Topics

- Positive Metrics Poor Business Performance: How Does This Happen? (Article)
- Positive Metrics Poor Business Performance: How Does This Happen? (Video)
- Business Management System Patent Press Release
- Patent: Systems for Reporting Enterprise Performance and Making Process Improvements
- Stoplight Scorecards: Issues and Resolution
- Performance Reporting (KPI Reports): Issues & Resolution
- Strategic Planning and Execution: Issues and Resolution
- Project Selection with Whole-enterprise Benefit
- Metric Selection, KPIs Report & Performance Measurements
- IEE Value Chain with Predictive Scorecards
- Lean Implementation with Business System Integration
- Business Management System: Issues and Resolution
- Enhanced Business Management System: Descriptive Videos
- Lean Six Sigma DMAIC Process Improvement Roadmap
- Big Data Integration with an Enhanced Management System

Business Measurements

- KPI Management: KPI Metric Reports that lead to the Best Behaviors
- Quality Metrics and their Reporting
- A Business Metrics Dashboard that Resolves Commonplace Metric Reporting Problems
- Individuals Control Chart (XmR chart, I-chart) Reporting
- Probability Plotting: Quantifying Process Performance
- Control Chart Issues: 30,000-foot-level Chart Resolution
- X-bar and R Control Chart: Issues and Resolution
- P-Chart: Issues and Resolution
- C-Chart: Issues and Resolution
- Transforming Individuals Control Chart Data



Business Measurements

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- C-Chart: Issues and Resolution
- Transforming Individuals Control Chart Data
- Process Capability Cp, Cpk, Pp, Ppk Issues and Resolution
- Performance Reporting Issues: 30,000-foot-level Resolution
- Six Sigma Forum Magazine 2014 article: "30,000-Foot-Level Performance Metric Reporting,"
- 30,000-foot-level Reports with Predictive Measurements
- 30,000-foot-level Chart Quantifies Process Improvement
- 30,000-foot-level Performance Reporting Applications
- 30,000-foot-level Charting: One Sample per Subgroup
- 30,000-foot-level Charting: Multiple Samples in Subgroup
- 30,000-foot-level Charting: Attribute Pass/Fail Data
- 30,000-foot-level Charting: Infrequent Failures
- 30,000-foot-level Charting: Non-normal Data
- Acceptable Quality Level (AQL): Issues and Resolution
- Laney P' Chart vs. a 30,000-foot-level Report

Enhanced Business Management System and Other Resources

Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

Issues and Resolution to p chart Control Limits Formula False Signals

Traditional p chart control limits formula calculations can lead to firefighting common cause variation as though it were special cause. This "false signal" issue can occur when common-cause process variation occurs between subgroups.

Described are p-chart issues and resolution to identified problems with the p chart control limits formula calculation, which can improve organizational action to attribute data events.

The techniques can also be applied to the implementation of an organizational Operational Excellence system that structurally integrates performance measures (and their improvement) with the processes that created them.

P Chart Control Limits Formula: Issues and Resolution

Content of this webpage is from Chapter 13 of *Integrated Enterprise Excellence Volume III – Improvement Project Execution: A Management and Black Belt Guide for Going Beyond Lean Six Sigma and the Balanced Scorecard*, Forrest W. Breyfogle III

P-charts are used in quality control to identify when special-cause or out-of-control conditions occur in time-series data so that timely corrective actions can be taken to resolve problems. Sometimes data from a p-chart are used also to provide a process capability statement or non-conformance statement.

However, there are issues in how p-charts are often created and applied because of the p chart control limits formula.

The application shortcoming of p-charts will be described in this article along with an alternative 30,000-foot-level charting methodology that not only addresses this issue but also enhances application of the techniques. The described methodology not only improves the accuracy of common-cause and special-cause statements but also provides a better and more easily- understandable process capability or a process performance statement that is predictive.

This article will build on the special-cause and common-cause variability concepts described in the article Control Charting Issues: 30,000-foot-level Chart Resolution as it relates to *time-series attribute data compiled in subgroups.*

Scroll down to see an illustration and mathematical explanation

Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

- For a p-chart, the equation indicates that sampling standard deviation originates from within subgroup
- For the 30,000-foot-level charts, the MR-bar (moving range) indicates sampling standard deviation originates from between subgroups

I will now demonstrate how to access a free app so you can easily create a 30,000-foot-level chart for your data.

For the *p* chart of these data, shown in Figure 1, many causal investigations could have been initiated because there are many out-of-control signals. Out-of-control processes are not predictable; hence, no process capability claim should be made.

For *p* charts, failure rate *p* is tracked over time with an LCL and UCL of:

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \qquad UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

From these equations, the LCL and UCL are determined using the average non-conformance rate ($\bar{p}$) and subgroup size (n). When the subgroup size is large, as it can be in many business situations, the distance between the LCL and UCL can become quite small. Variability from day-to-day material lot differences or day-to-day transaction differences can create the type of out-of-control signals shown in Figure 1.

What happens to the control limits when n is large?

30,000-foot-level Charting in lieu of the Traditional p Chart Control Limits Formula

An individuals (X) chart tracks an individual value over time where the chart's control chart limits consider between-subgroup variability. When adjacent subgroups are used to determine average moving range ($\overline{MR}$), the X chart has a LCL and UCL of:

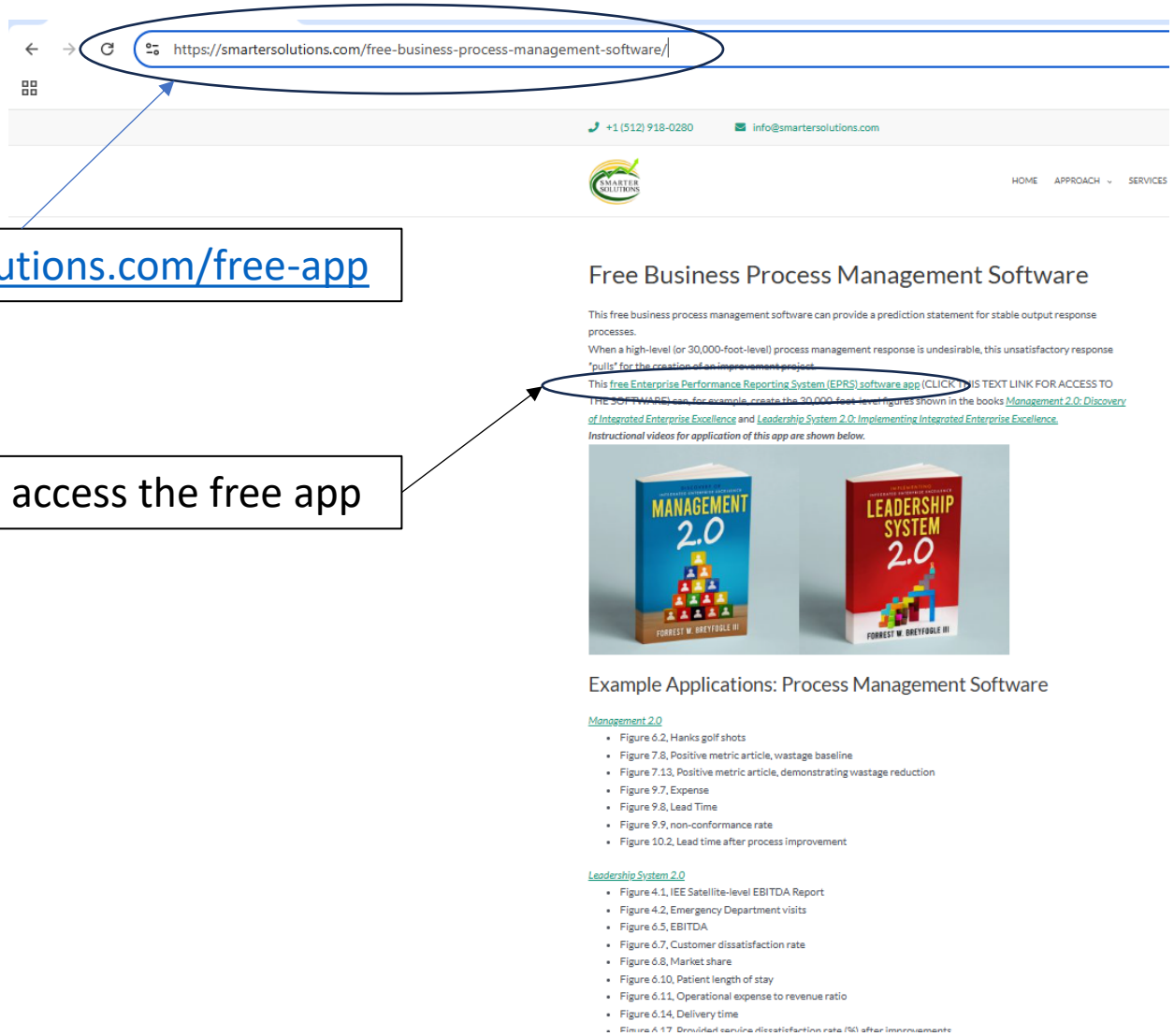
$$LCL = \bar{x} - 2.66(\overline{MR}) \qquad UCL = \bar{x} + 2.66(\overline{MR})$$

Unlike with a p-chart, the control limits for an individuals or X chart are a function of the average moving range between adjacent subgroups. The importance of capturing between-subgroup variability when calculating statistical process control-chart upper and lower control limits was discussed in Control Chart Issues: 30,000-foot-level Chart Resolution.

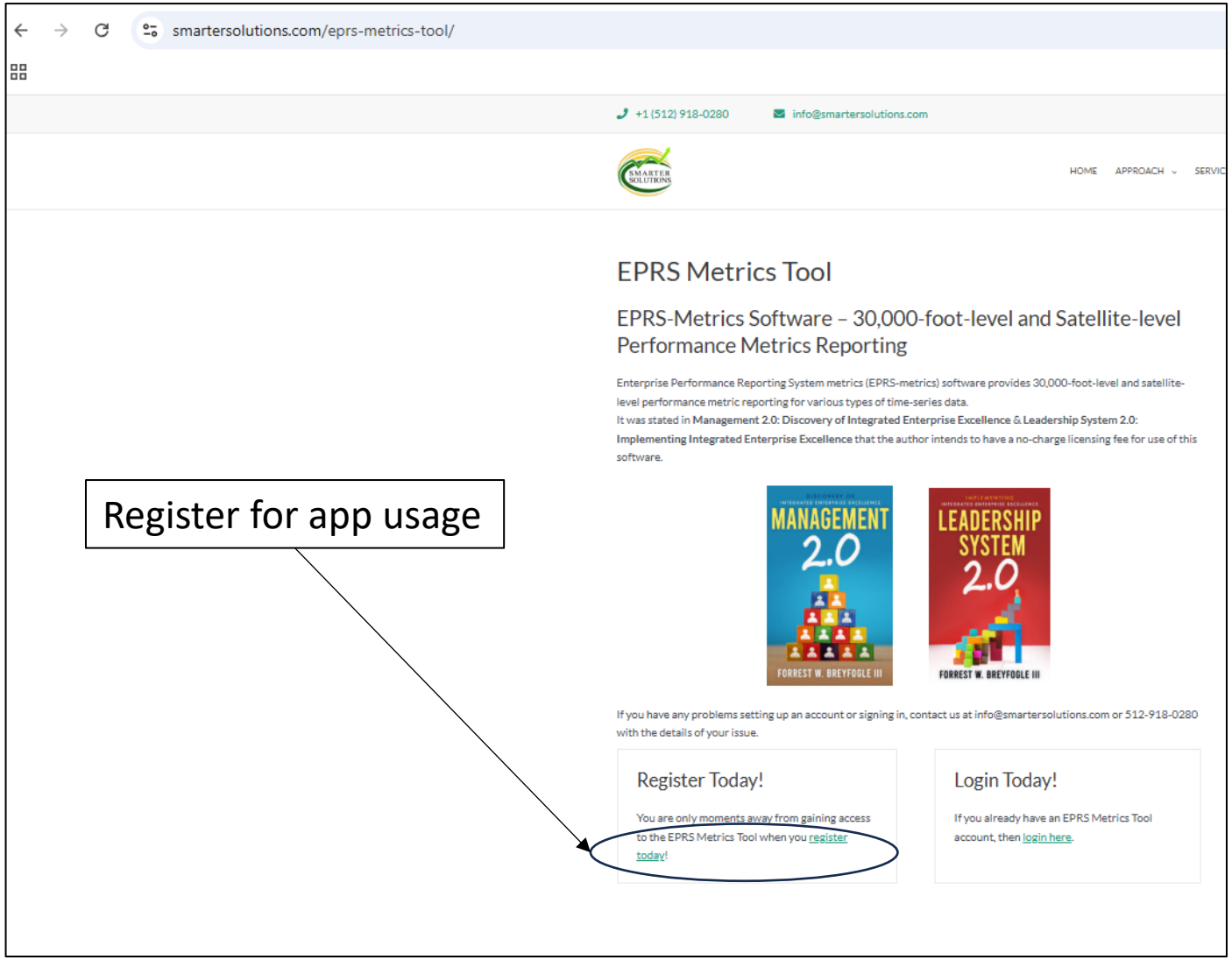
Accessing the Free 30,000-foot-level Reporting App

https://smartersolutions.com/free-app

Click on this link to access the free app



Accessing the Free 30,000-foot-level App



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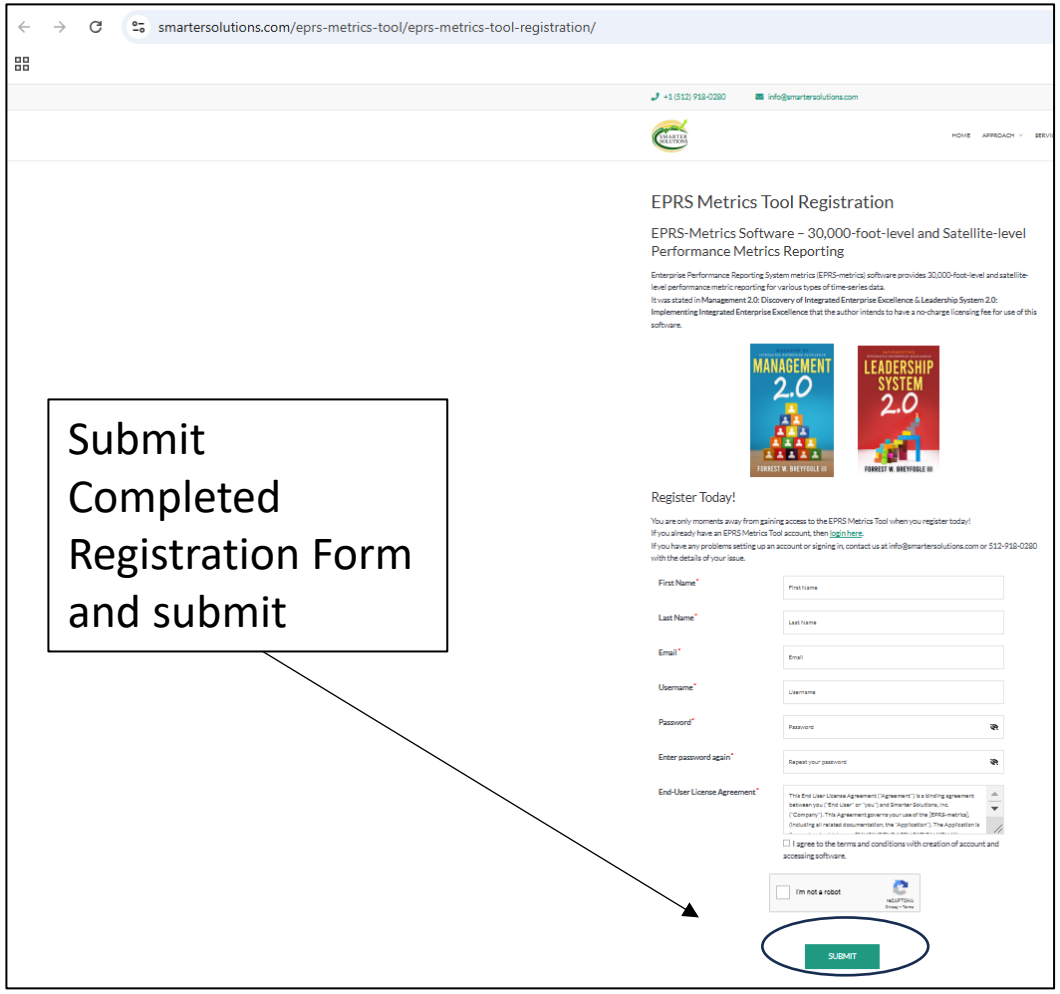
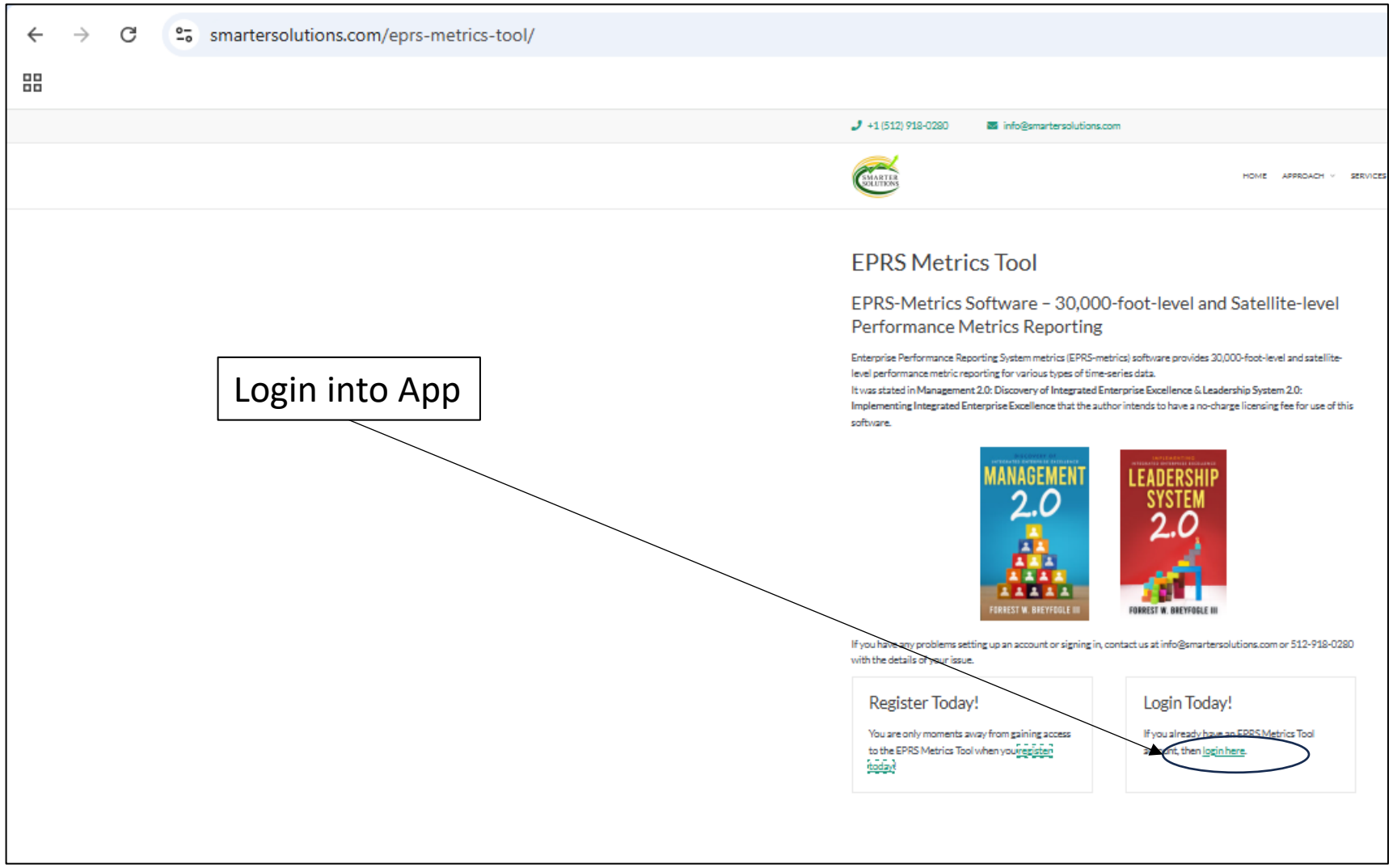


Accessing the Free 30,000-foot-level App



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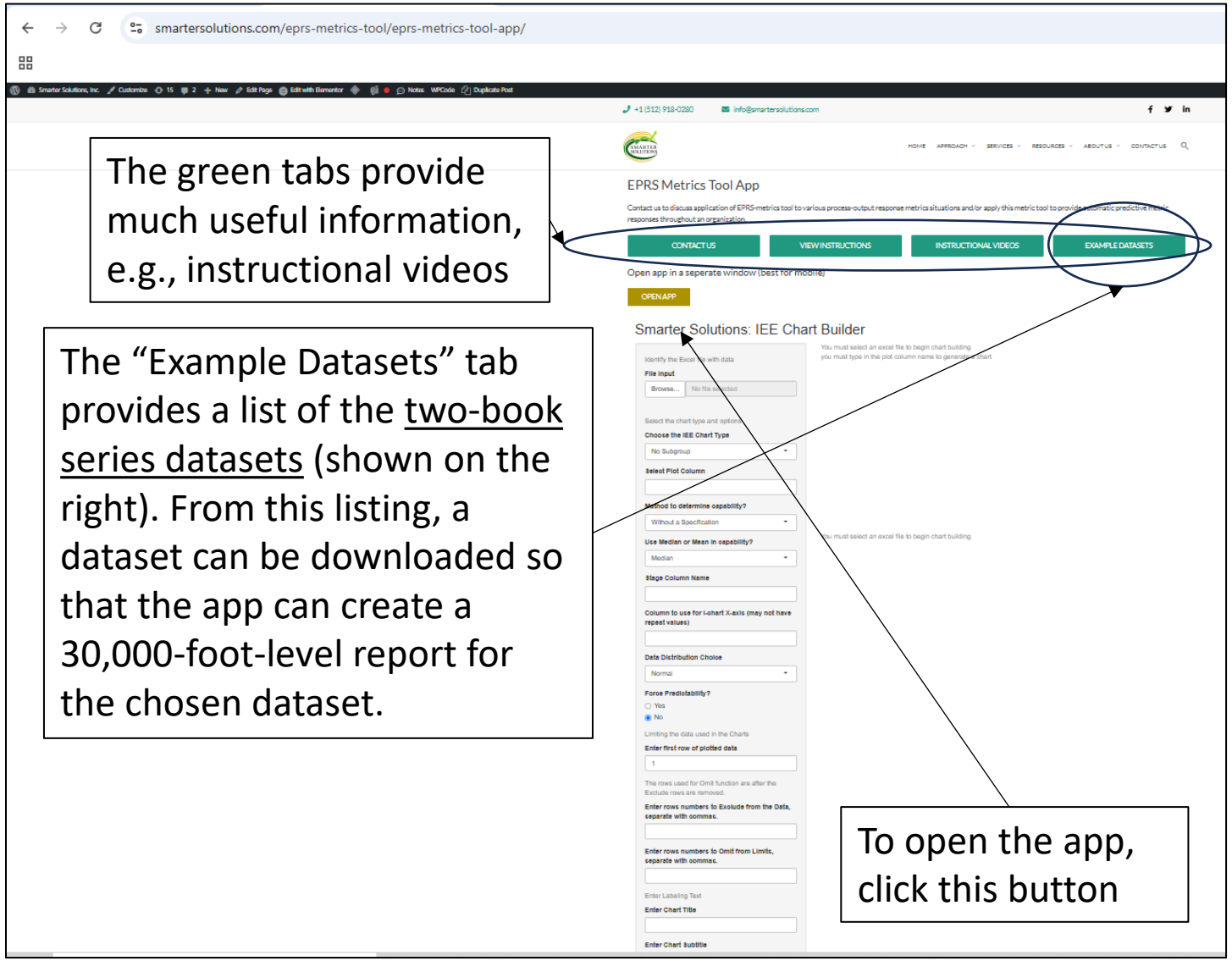
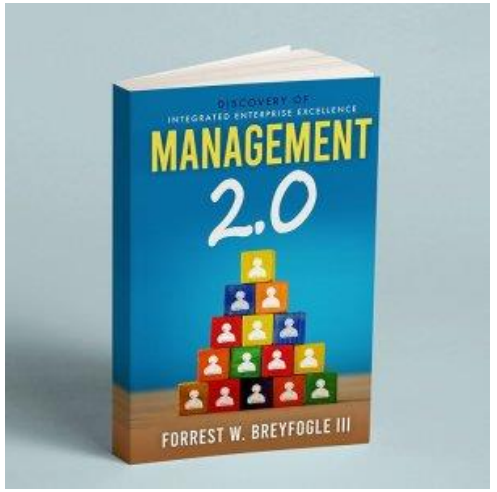


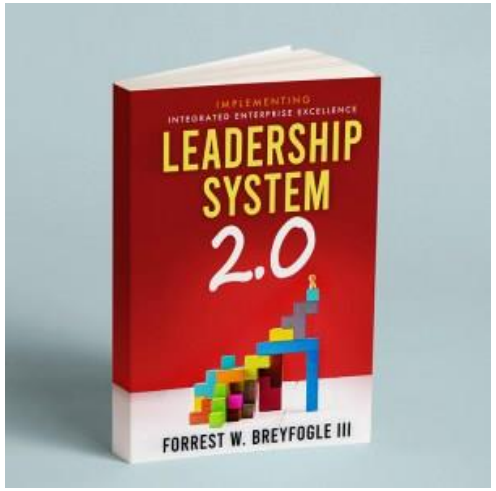
The green tabs provide much useful information, e.g., instructional videos

The "Example Datasets" tab provides a list of the <u>two-book series datasets</u> (shown on the right). From this listing, a dataset can be downloaded so that the app can create a 30,000-foot-level report for the chosen dataset.

To open the app, click this button

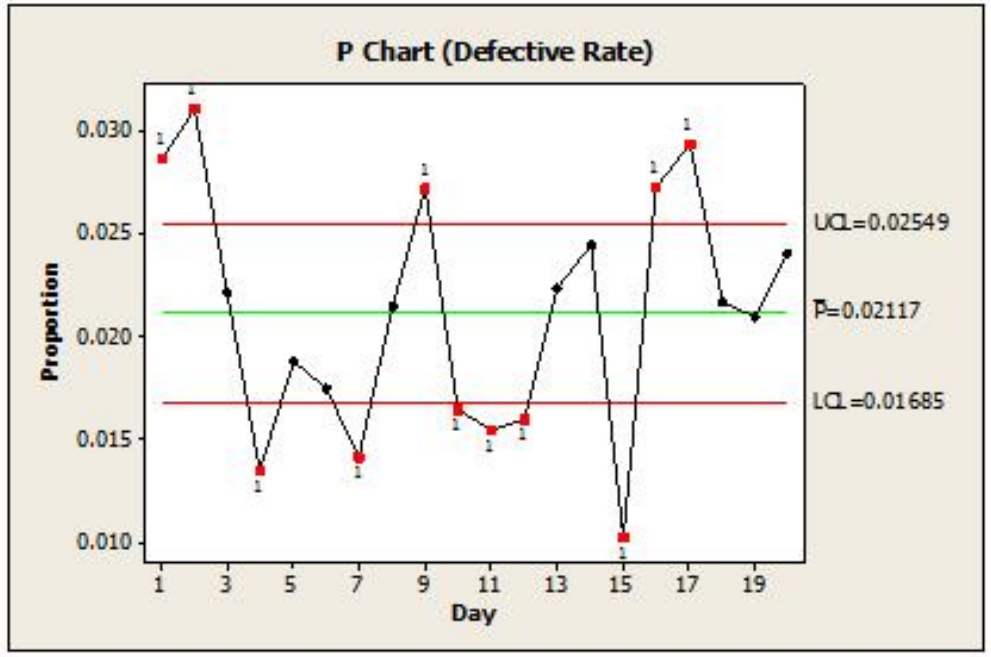
Two-book, Novel-written Series



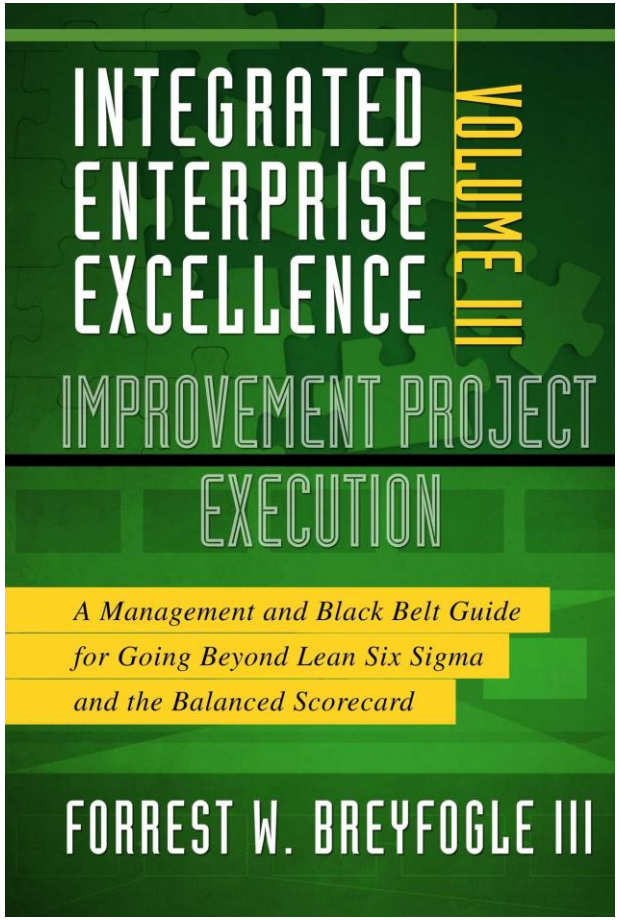


Accessing the Free 30,000-foot-level App

A 30,000-foot-level chart will now be created for the original p-chart dataset



Day	Failures	Subgroup	Failure Rate
1	287	10000	0.0287
2	311	10000	0.0311
3	222	10000	0.0222
4	135	10000	0.0135
5	188	10000	0.0188
6	175	10000	0.0175
7	142	10000	0.0142
8	215	10000	0.0215
9	272	10000	0.0272
10	165	10000	0.0165
11	155	10000	0.0155
12	160	10000	0.016
13	224	10000	0.0224
14	245	10000	0.0245
15	103	10000	0.0103
16	273	10000	0.0273
17	294	10000	0.0294
18	217	10000	0.0217
19	210	10000	0.021
20	241	10000	0.0241



V3 C13, Exam 13-01, IEE pass-fail predictability.xlsx

Using the Free 30,000-foot-level App

Smarter Solutions: IEE Chart Builder

Identify the Excel file with data

File input

Browse... V3 C13, Exam 13-01,IEE pass-fail predictability.xlsx

Upload complete

Select the chart type and options

Choose the IEE Chart Type

Attribute

Select Plot Column

Failure.Rate

Use Median or Mean in capability?

Mean

Stage Column Name

Column to use for I-chart X-axis (may not have repeat values)

Failure.Rate

Choose Type of Attribute

Rate

Box-Cox Lambda value

1

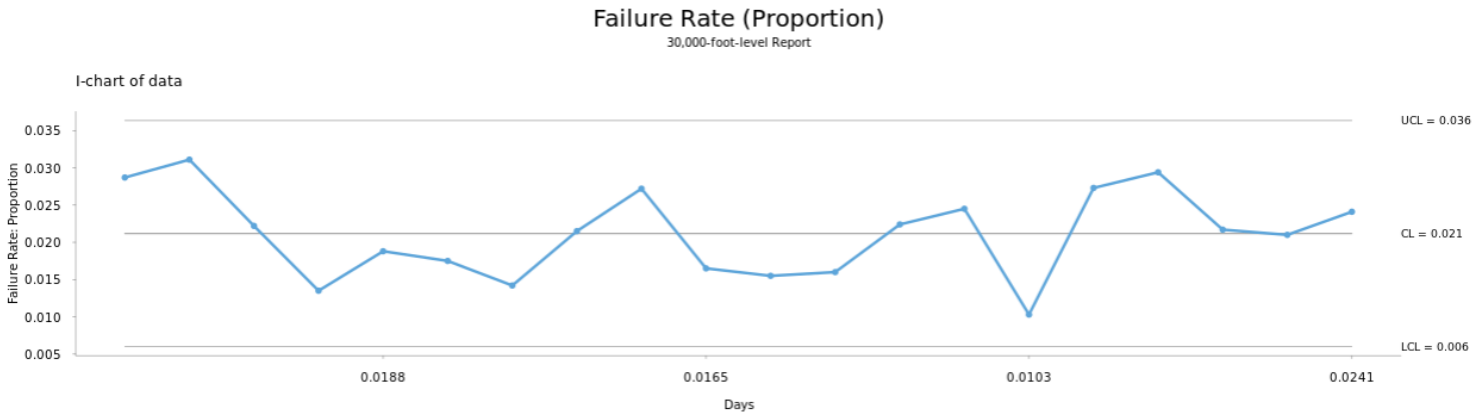
If any data values are <0, no tranform will be performed

Data Shift value

0

1

Click on Browse and select an appropriately formatted Excel .xlsx dataset accessible from your computer



The current process response is predictable.
The estimated performance is 0.021

Day	Failures	Subgroup.Size	Failure.Rate
1.00	287.00	10000.00	0.03
2.00	311.00	10000.00	0.03
3.00	222.00	10000.00	0.02
4.00	135.00	10000.00	0.01
5.00	188.00	10000.00	0.02
6.00	175.00	10000.00	0.02

2

This snippet shows information from the upper left corner of the spreadsheet

3

The plot in the top right of this screen will appear after selecting inputs for the 30,000-foot-level plot

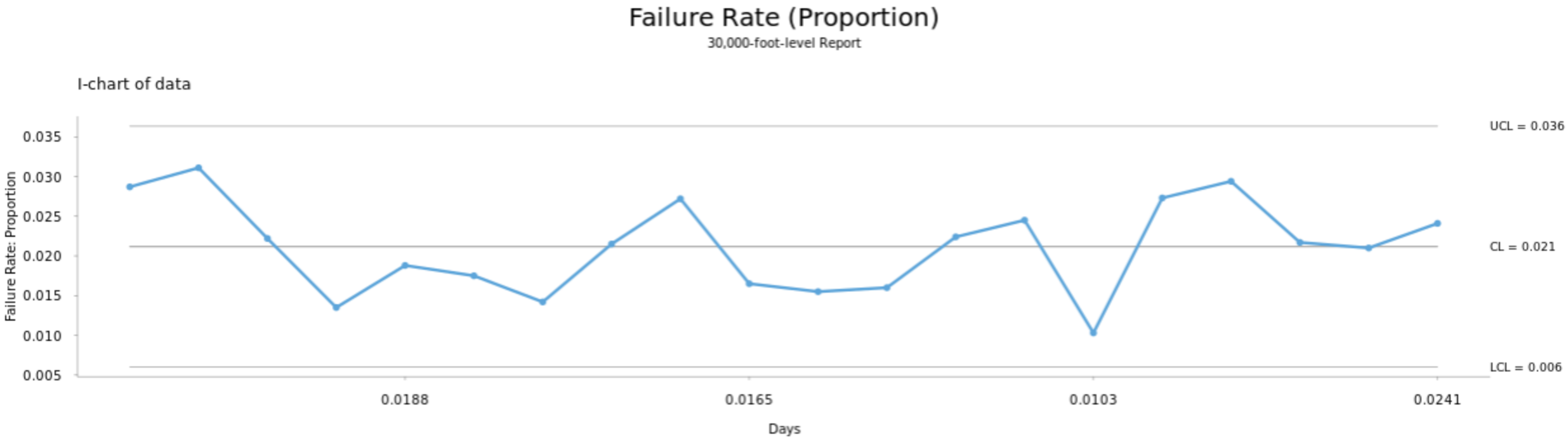
4

By right clicking on this slide's image, the image can be saved as a png file

5

https://smartersolutions.com/free-app/ provides more than 10 video instructions for using this app for various dataset situations

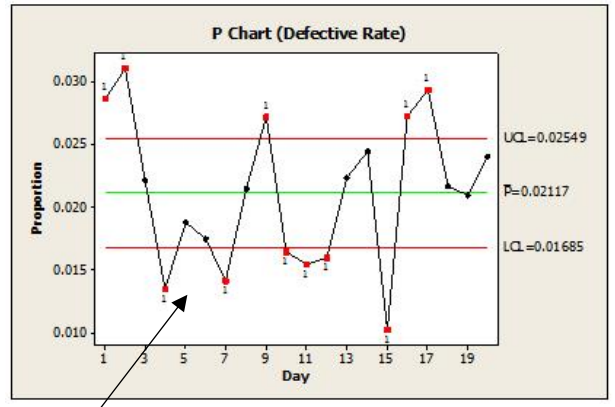
30,000-foot-level Report



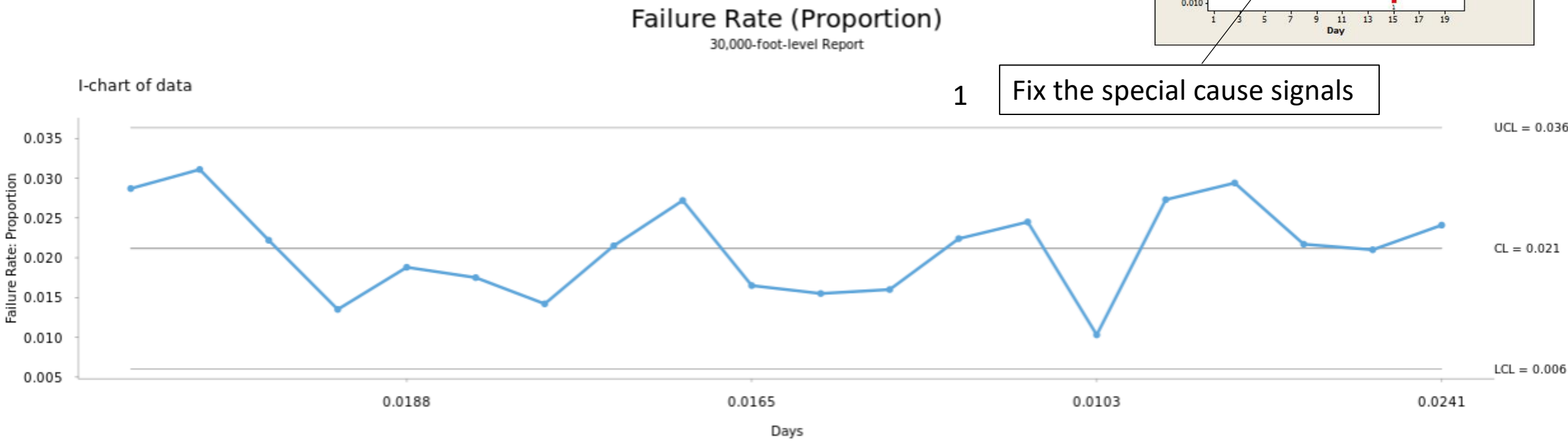
The current process response is predictable.
The estimated performance is 0.021

If this 2.1% non-conformance rate is unacceptable there is a need for process improvement

Comparing a 30,000-foot-level Report to a Traditional p-chart



1 Fix the special cause signals



The current process response is predictable.
The estimated performance is 0.021

2 If this 2.1% non-conformance rate is unacceptable there is a need for process improvement

3 These two charts created from the same dataset result in completely different actions

Using the Free 30,000-foot-level App

https://www.smartersolutions.com/free-app provides eleven videos on using this app

Free Business Process Management Software

This free business process management software can provide a prediction statement for stable output response processes.

When a high-level (or 30,000-foot-level) process management response is undesirable, this unsatisfactory response "pulls" for the creation of an improvement project.

This free Enterprise Performance Reporting System (EPRS) software app (CLICK THIS TEXT LINK FOR ACCESS TO THE SOFTWARE) can, for example, create the 30,000-foot-level figures shown in the books *Management 2.0: Discovery of Integrated Enterprise Excellence* and *Leadership System 2.0: Implementing Integrated Enterprise Excellence*.

Instructional videos for application of this app are shown below.

Example Applications: Process Management Software

Management 2.0

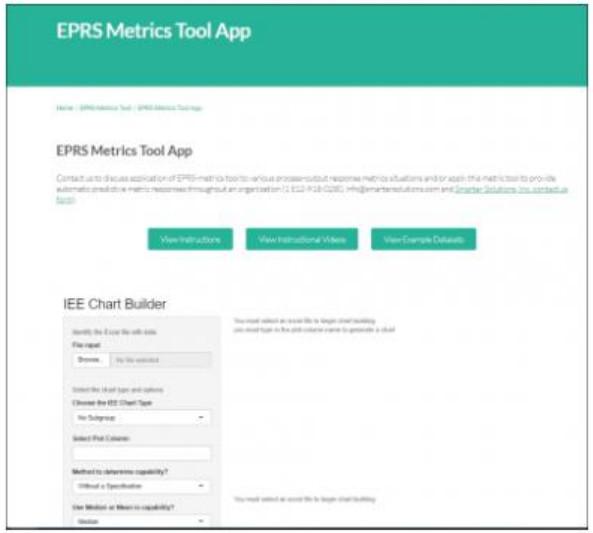
- Figure 6.2, Hanks golf shots
- Figure 7.8, Positive metric article, wastage baseline
- Figure 7.13, Positive metric article, demonstrating wastage reduction
- Figure 9.7, Expense
- Figure 9.8, Lead Time
- Figure 9.9, non-conformance rate
- Figure 10.2, Lead time after process improvement

Leadership System 2.0

- Figure 4.1, IEE Satellite-level EBITDA Report
- Figure 4.2, Emergency Department visits
- Figure 6.5, EBITDA
- Figure 6.7, Customer dissatisfaction rate
- Figure 6.8, Market share
- Figure 6.10, Patient length of stay
- Figure 6.11, Operational expense to revenue ratio
- Figure 6.14, Delivery time
- Figure 6.17, Provided service dissatisfaction rate (%) after improvements
- Figure 6.18, Delivery time after improvements
- Figure 6.19, Customer Dissatisfaction Rate after improvements
- Figure 6.20, Market share after improvements
- Figure 6.21, EBITDA after improvements

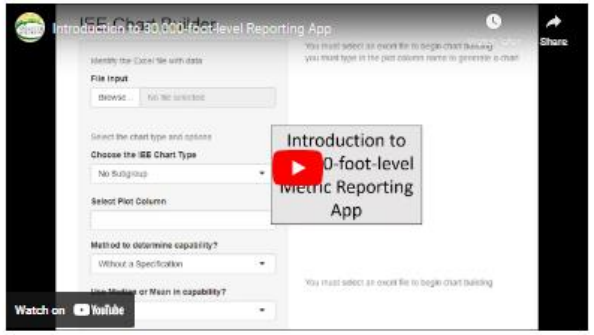
Application: Process Management Software

One can use this high-level process management software (EPRS Metrics Tool App) for their business process datasets. All that is needed is that the data be in an Excel spreadsheet format. This software can analyze both continuous and attribute data for a variety of situations.

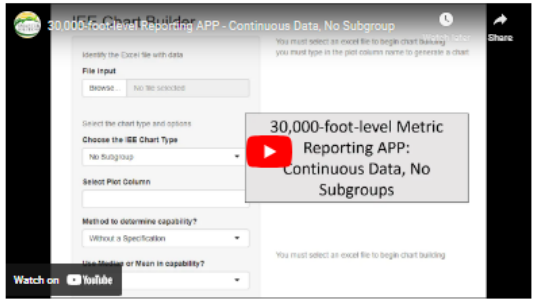


Instructional App Videos

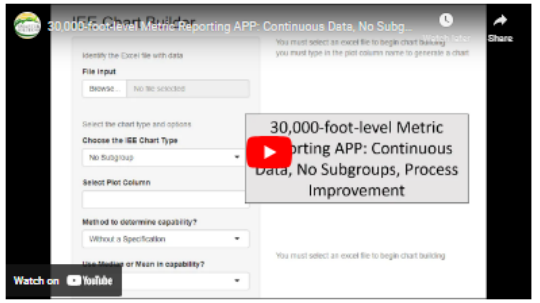
Introduction to 30,000-foot-level Reporting App



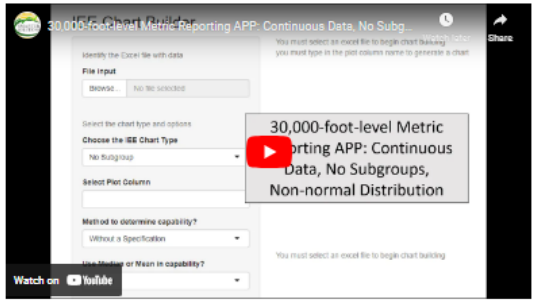
30,000-foot-level Reporting APP – Continuous Data, No Subgroup



30,000-foot-level Metric Reporting APP: Continuous Data, No Subgroups, Process Improvement



30,000-foot-level Metric Reporting APP: Continuous Data, No Subgroups, Non-normal Distribution



30,000-foot-level Metric Reporting APP: Continuous Data, with Subgroups

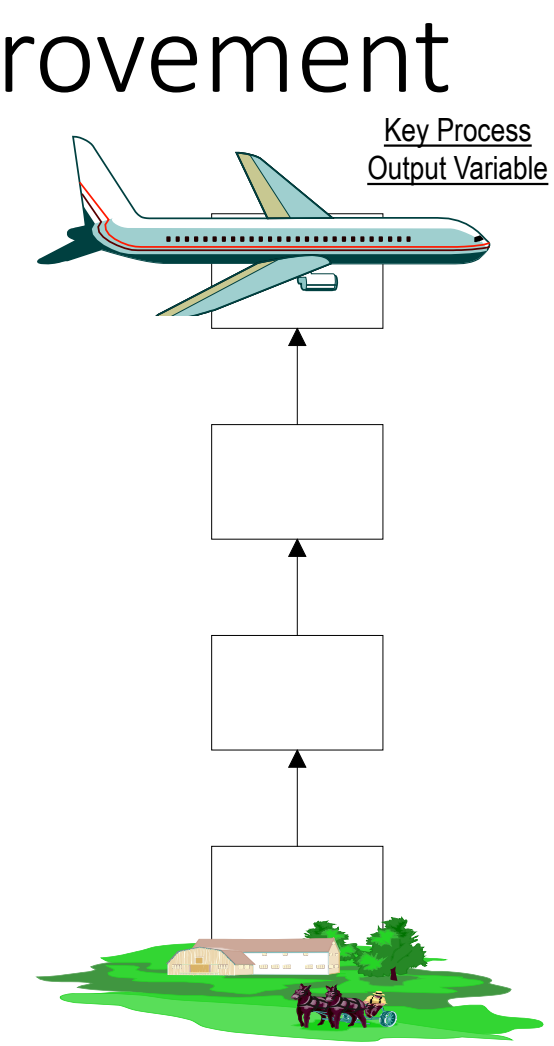
30,000-foot-level/Satellite-level reporting

30,000-foot-level/satellite-level reporting provides:

1. One for chart process stability and capability reporting
2. Easy to understand wording
3. Prediction statement that encourages process improvement when a futuristic statement is undesirable
4. Consistent reporting for continuous and attribute data, i.e., estimated proportion or percentage non-conformance rate for a stable process
5. 30,000-foot-level capability statements are easier to understand than process capability/performance indices, i.e., Cp, Cpk, Pp, and Ppk
6. Process change demonstration via a staging of the individuals 30,000-foot-level chart
7. Organizational consistency in reporting

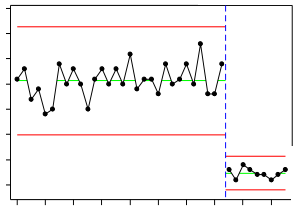
Process Improvement when a 30,000-foot-level Prediction Statement is Undesirable

30,000-foot-level reporting and Process Improvement



30,000 Foot-Level Metric

Frequency of non-conformance



Attribute Response

Bottom-line benefit is the translation of these differences into money

Measurement pulls for the creation of a project

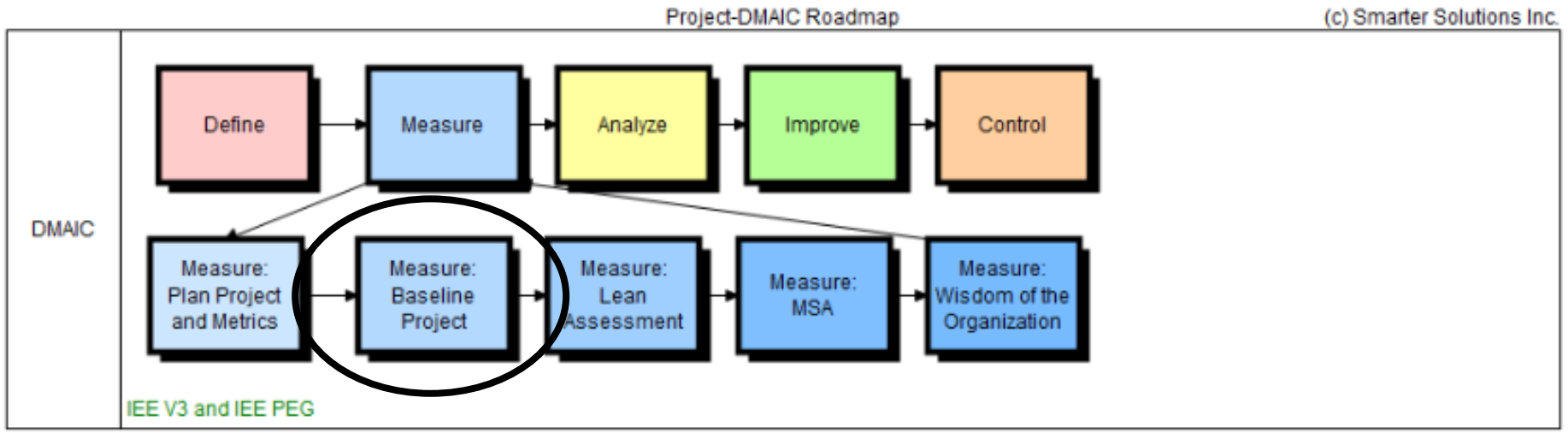
D	M	A	I	C
Define	Measure	Analyze	Improve	Control

Plan Project and Metrics	Baseline Project	Lean Assessment	MSA	Wisdom of the Organization

The roadmap

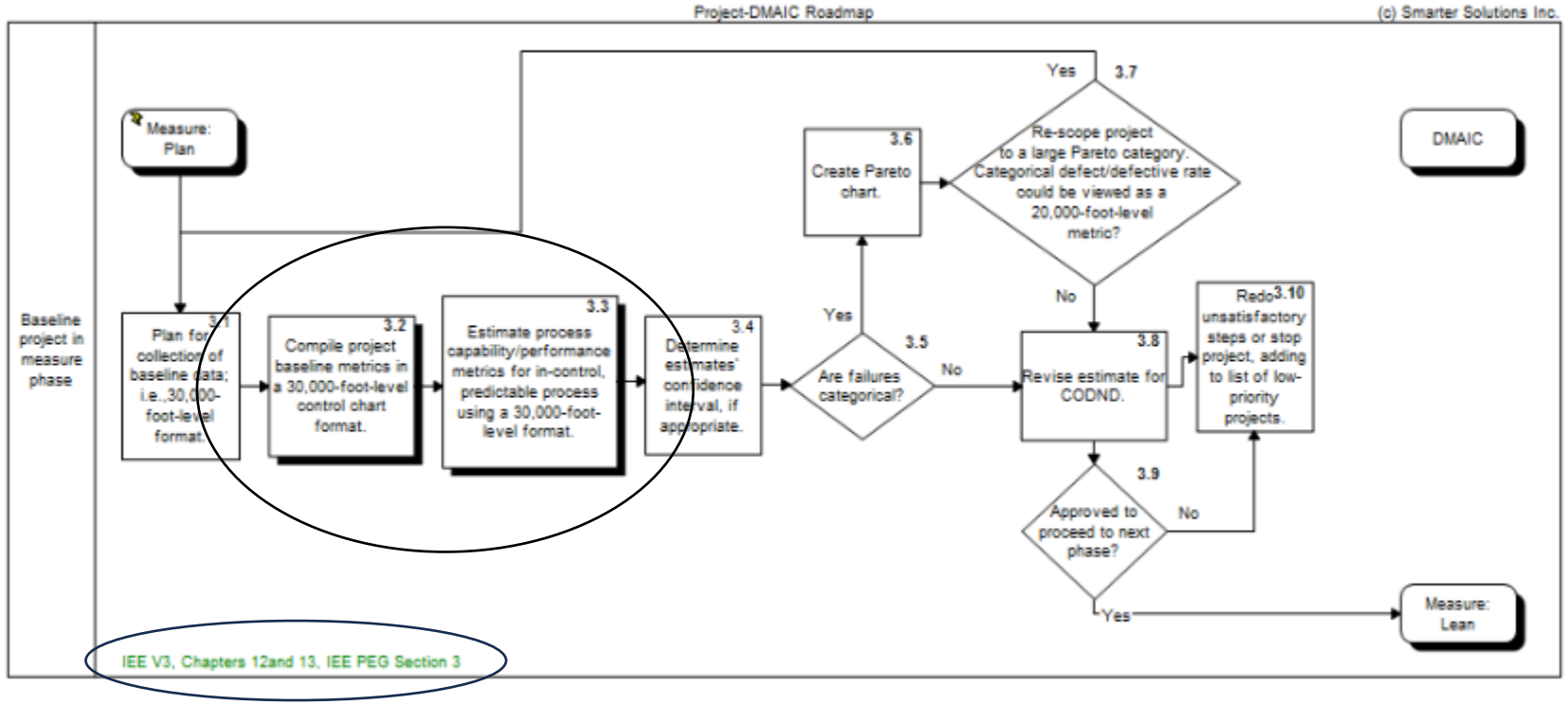
Clickable Lean Six Sigma DMAIC Roadmap

https://smartersolutions.com/roadmap



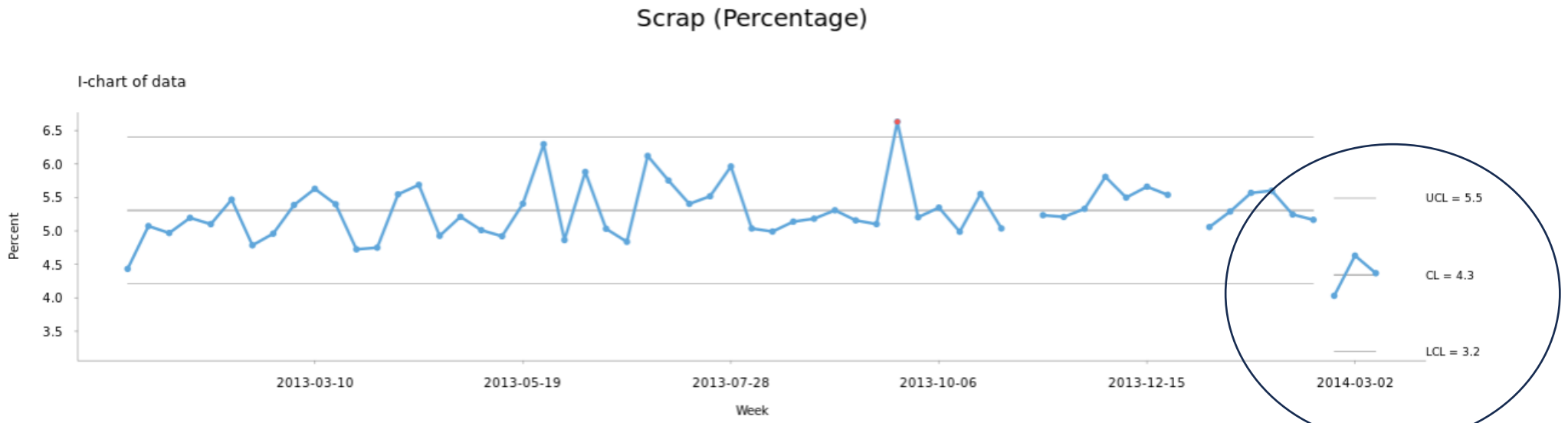
Clicking on “Measure: Baseline Project” provides the methodology for creating a 30,000-foot-level report

DMAIC Roadmap Drill Down



The described free 30,000-foot-level reporting app provides the vehicle for executing Steps 3.2 and 3.3, which can be the baseline metric for the process that is to be improved

Example 30,000-foot-level chart showing process improvement from a DMAIC Project



The current process response is predictable.
The estimated performance is 4.343 %

Week	Overall.Wastage	Methodology
2013-01-06	4.43	Old Method
2013-01-13	5.07	Old Method
2013-01-20	4.97	Old Method
2013-01-27	5.20	Old Method
2013-02-03	5.10	Old Method
2013-02-10	5.47	Old Method

The prediction statement reflects data from the most recent region of stability

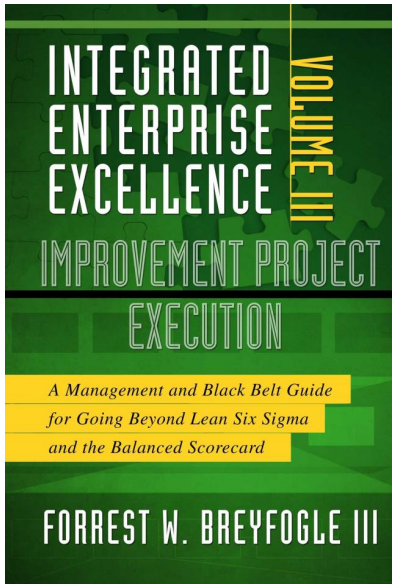
Infrequent Incidents (e.g., Safety – Injury at a company)

Infrequent Safety Incidents

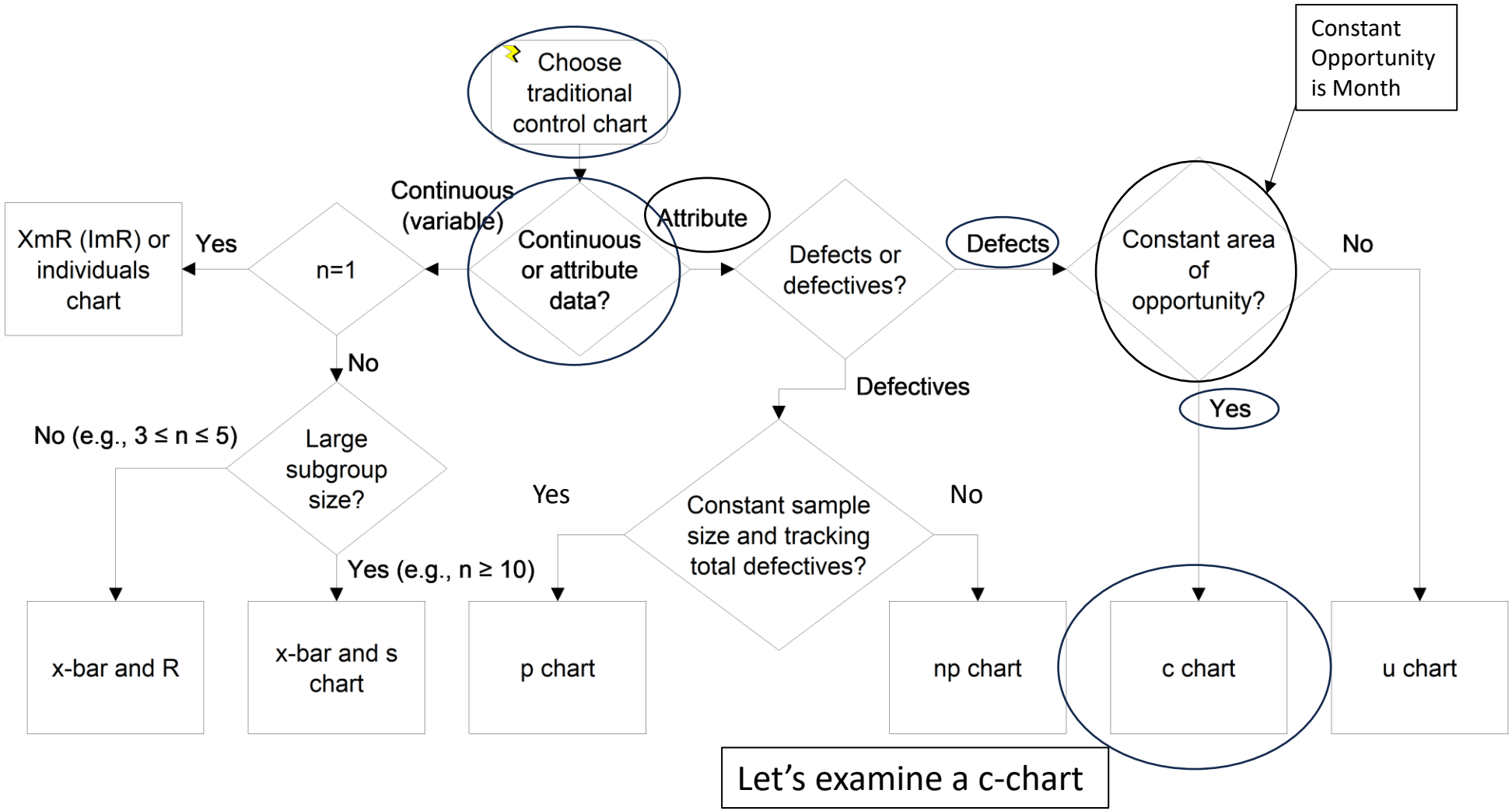
The number of safety incidents were tracked over time.

- Dataset: ***V3 C13, Exam 13-03, IEE Infrequent Events.xlsx***

Month	No.	Month	No.	Month	No.	Month	No.	Month	No.	Month	No.
1	0	11	0	21	0	31	0	41	1	51	0
2	0	12	1	22	1	32	0	42	1	52	0
3	1	13	0	23	0	33	1	43	0	53	1
4	1	14	0	24	0	34	0	44	1	54	0
5	0	15	0	25	1	35	1	45	0	55	0
6	0	16	1	26	0	36	0	46	1	56	1
7	0	17	0	27	1	37	0	47	0		
8	0	18	0	28	0	38	1	48	0		
9	1	19	0	29	0	39	0	49	0		
10	0	20	1	30	1	40	0	50	1		

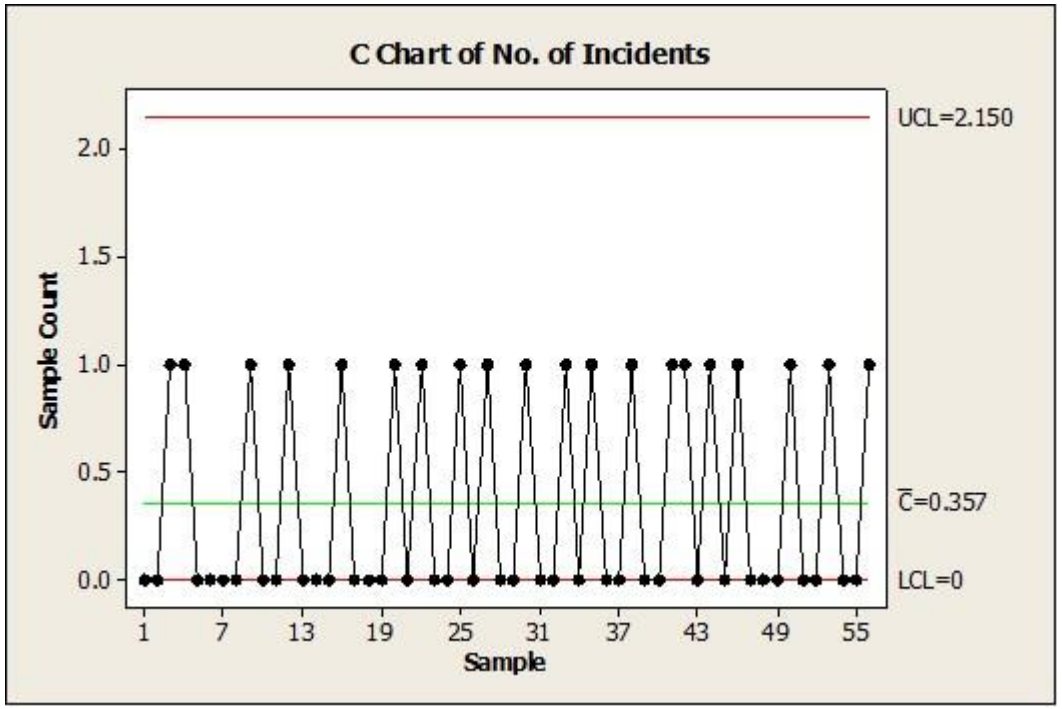


Traditional c-chart Selection



Infrequent Safety Failure Incidents

- A traditional control chart approach for this dataset is to create c-chart
- However, this c-chart is not informative, since there are so many months that had no safety incidents



Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

HOME APPROACH SERVICES

Business Management and Process Improvement: Forrest's Favorite Next Generation Topics

The following business management and process improvement links provide Forrest's favorite summary of next generation discussions on these topics.

Business Management and Process Improvement: Forrest's Favorite Topics

Forrest's favorite topics contain articles, videos, blogs, and webinars that describe the Integrated Enterprise Excellence (IEE) enhanced business management system and effective metric reporting which is predictive.
The following links provide convenient access to many enhanced business management and performance reporting techniques, which Forrest Breyfogle and the Smarter Solutions' team has found beneficial in many organizations.

Business Management Topics

- Positive Metrics Poor Business Performance: How Does This Happen? (Article)
- Positive Metrics Poor Business Performance: How Does This Happen? (Video)
- Business Management System Patent Press Release
- Patent: Systems for Reporting Enterprise Performance and Making Process Improvements
- Stoplight Scorecards: Issues and Resolution
- Performance Reporting (KPI Reports): Issues & Resolution
- Strategic Planning and Execution: Issues and Resolution
- Project Selection with Whole-enterprise Benefit
- Metric Selection, KPIs Report & Performance Measurements
- IEE Value Chain with Predictive Scorecards
- Lean Implementation with Business System Integration
- Business Management System: Issues and Resolution
- Enhanced Business Management System: Descriptive Videos
- Lean Six Sigma DMAIC Process Improvement Roadmap
- Big Data Integration with an Enhanced Management System

Business Measurements

- KPI Management: KPI Metric Reports that lead to the Best Behaviors
- Quality Metrics and their Reporting
- A Business Metrics Dashboard that Resolves Commonplace Metric Reporting Problems
- Individuals Control Chart (XmR chart, I-chart) Reporting
- Probability Plotting: Quantifying Process Performance
- Control Chart Issues: 30,000-foot-level Chart Resolution
- X-bar and R Control Chart: Issues and Resolution
- P-Chart: Issues and Resolution
- C-Chart: Issues and Resolution
- Transforming Individuals Control Chart Data

Business Measurements

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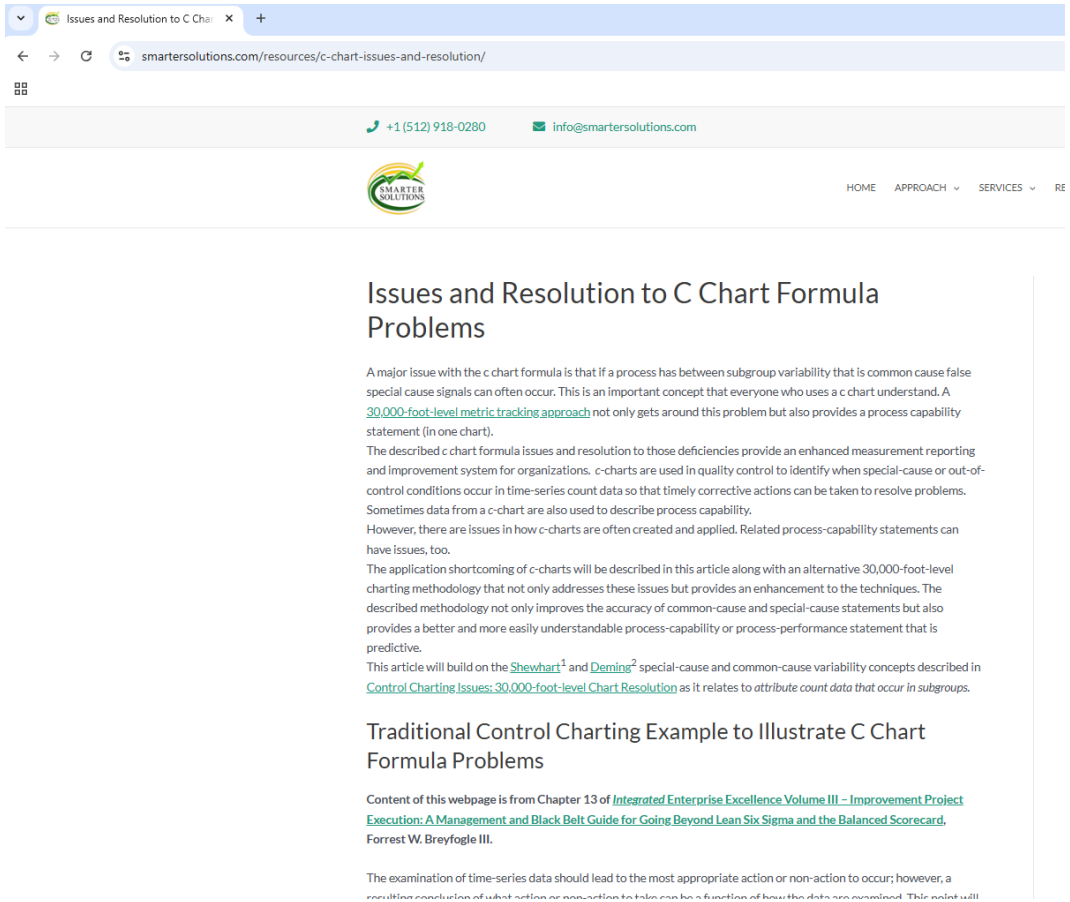
- Transforming Individuals Control Chart Data
- Process Capability Cp, Cpk, Pp, Ppk Issues and Resolution
- Performance Reporting Issues: 30,000-foot-level Resolution
- Six Sigma Forum Magazine 2014 article: "30,000-Foot-Level Performance Metric Reporting,"
- 30,000-foot-level Reports with Predictive Measurements
- 30,000-foot-level Chart Quantifies Process Improvement
- 30,000-foot-level Performance Reporting Applications
- 30,000-foot-level Charting: One Sample per Subgroup
- 30,000-foot-level Charting: Multiple Samples in Subgroup
- 30,000-foot-level Charting: Attribute Pass/Fail Data
- 30,000-foot-level Charting: Infrequent Failures
- 30,000-foot-level Charting: Non-normal Data
- Acceptable Quality Level (AQL): Issues and Resolution
- Laney P' Chart vs. a 30,000-foot-level Report

Enhanced Business Management System and Other Resources

Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

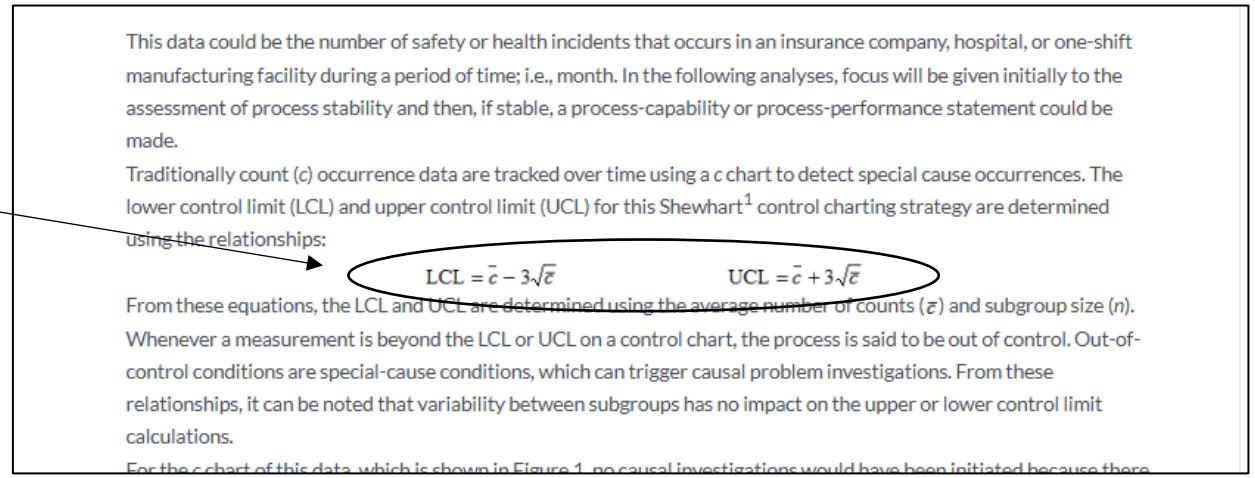


Scroll down to see an illustration and mathematical explanation

Mathematical Explanation of Benefits of 30,000-foot-level Reporting Over Traditional Control Charting: Article

- For a c-chart, the equation indicates that sampling standard deviation originates from within subgroup
- For the 30,000-foot-level charts, the MR-bar (moving range) indicates sampling standard deviation originates from between subgroups

I will now demonstrate the output of our free app to create this 30,000-foot-level report.



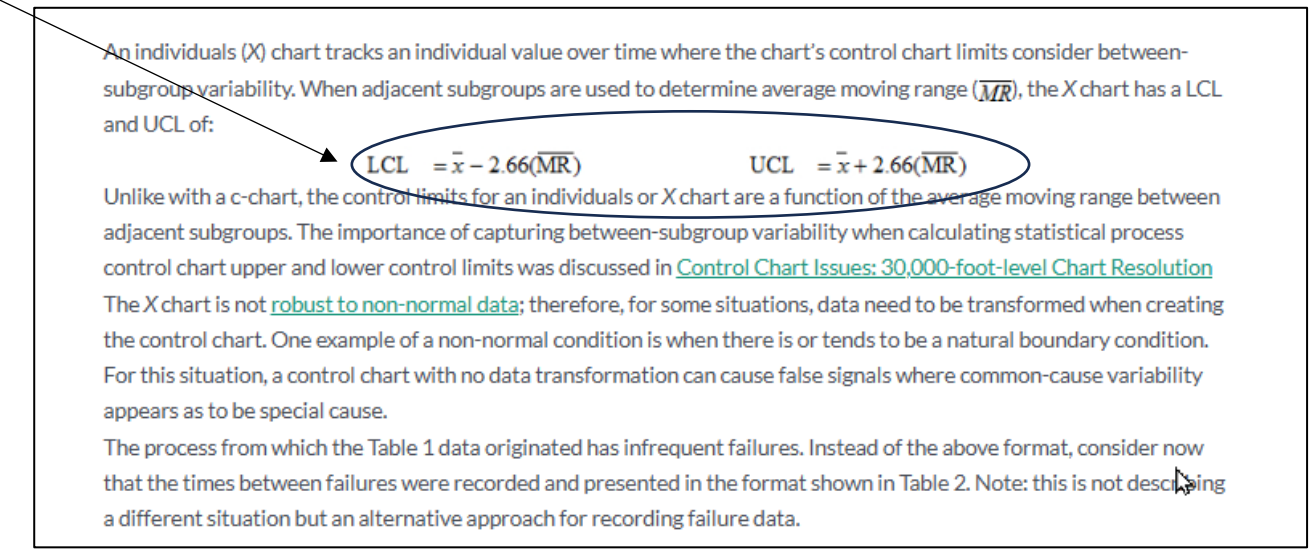
This data could be the number of safety or health incidents that occurs in an insurance company, hospital, or one-shift manufacturing facility during a period of time; i.e., month. In the following analyses, focus will be given initially to the assessment of process stability and then, if stable, a process-capability or process-performance statement could be made.

Traditionally count (*c*) occurrence data are tracked over time using a *c* chart to detect special cause occurrences. The lower control limit (LCL) and upper control limit (UCL) for this Shewhart[1] control charting strategy are determined using the relationships:

$$LCL = \bar{c} - 3\sqrt{\bar{c}} \qquad UCL = \bar{c} + 3\sqrt{\bar{c}}$$

From these equations, the LCL and UCL are determined using the average number of counts ($\bar{c}$) and subgroup size (n). Whenever a measurement is beyond the LCL or UCL on a control chart, the process is said to be out of control. Out-of-control conditions are special-cause conditions, which can trigger causal problem investigations. From these relationships, it can be noted that variability between subgroups has no impact on the upper or lower control limit calculations.

For the *c* chart of this data, which is shown in Figure 1, no causal investigations would have been initiated because there



An individuals (*X*) chart tracks an individual value over time where the chart's control chart limits consider between-subgroup variability. When adjacent subgroups are used to determine average moving range ($\overline{MR}$), the *X* chart has a LCL and UCL of:

$$LCL = \bar{x} - 2.66(\overline{MR}) \qquad UCL = \bar{x} + 2.66(\overline{MR})$$

Unlike with a c-chart, the control limits for an individuals or *X* chart are a function of the average moving range between adjacent subgroups. The importance of capturing between-subgroup variability when calculating statistical process control chart upper and lower control limits was discussed in Control Chart Issues: 30,000-foot-level Chart Resolution

The *X* chart is not robust to non-normal data; therefore, for some situations, data need to be transformed when creating the control chart. One example of a non-normal condition is when there is or tends to be a natural boundary condition. For this situation, a control chart with no data transformation can cause false signals where common-cause variability appears as to be special cause.

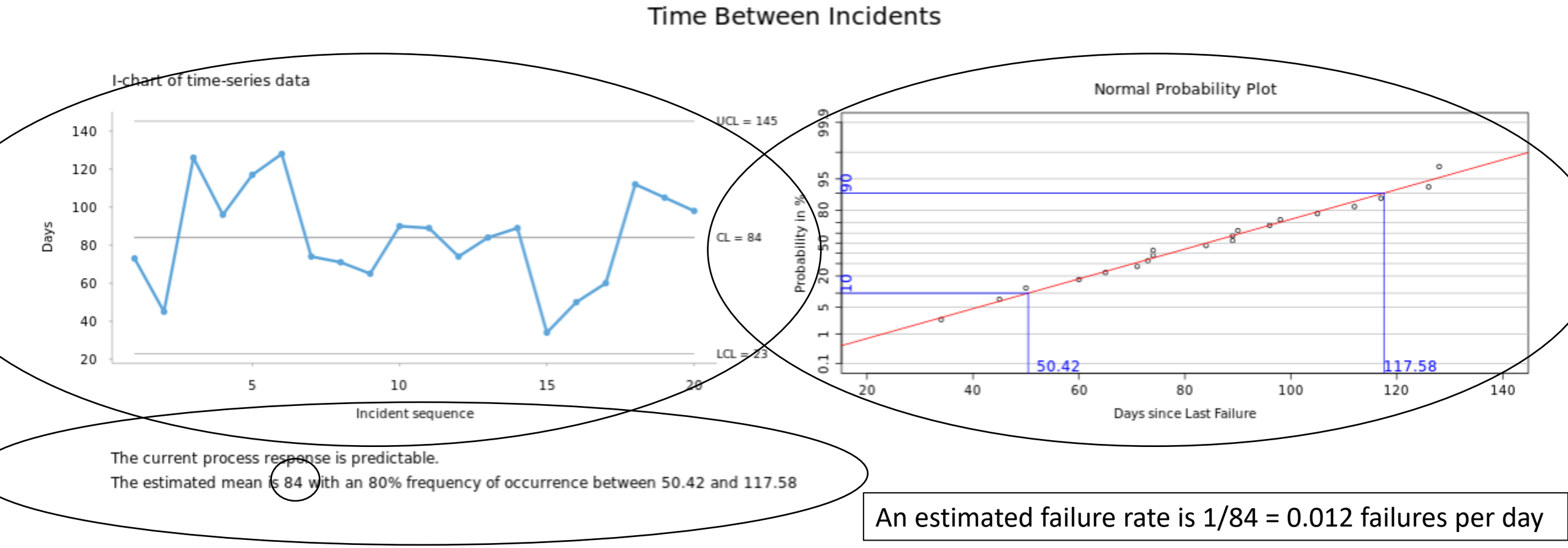
The process from which the Table 1 data originated has infrequent failures. Instead of the above format, consider now that the times between failures were recorded and presented in the format shown in Table 2. Note: this is not describing a different situation but an alternative approach for recording failure data.

30,000-foot-level Approach for Tracking Infrequent Safety Incidents

- Instead of reporting the number of failures per month, report the time between failures
- Track the “Days since last failure” as a continuous response
- A 30,000-foot-level report of this reformatted data is shown on the next slide

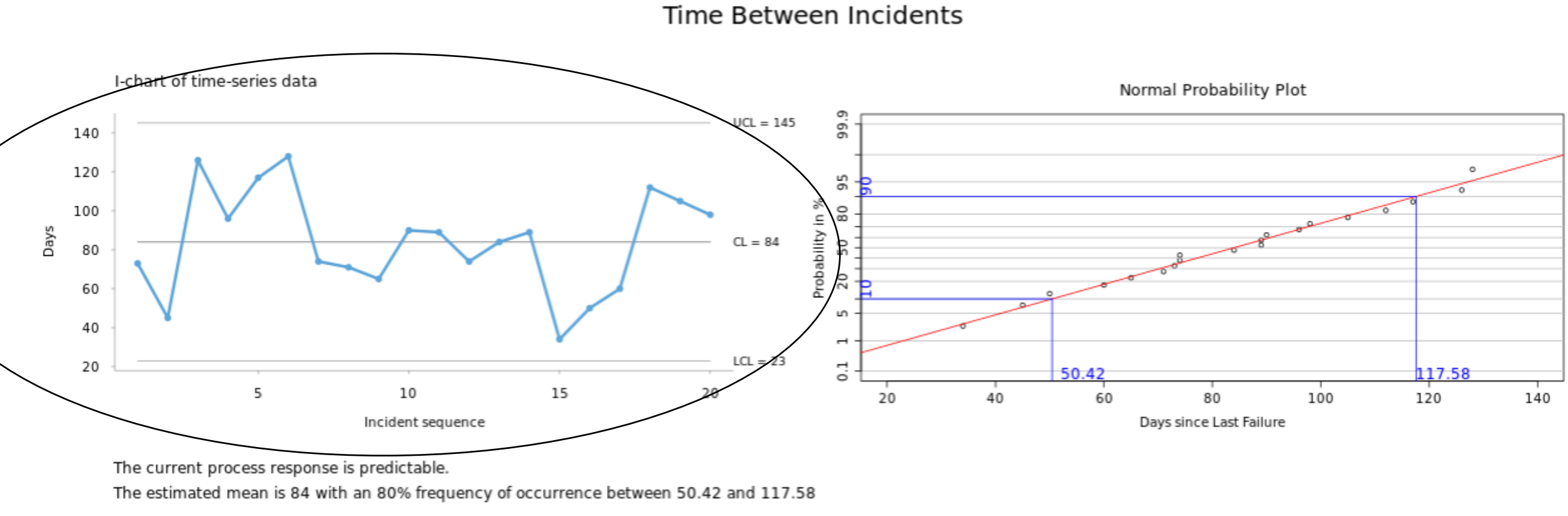
Failure Number	Days Since Last Failure
2	73
3	45
4	126
5	96
6	117
7	128
8	74
9	71
10	65
11	90
12	89
13	74
14	84
15	89
16	34
17	50
18	60
19	112
20	105
21	98

Example 13.3: 30-foot-level Report Infrequent Events



An estimated failure rate is 1/84 = 0.012 failures per day

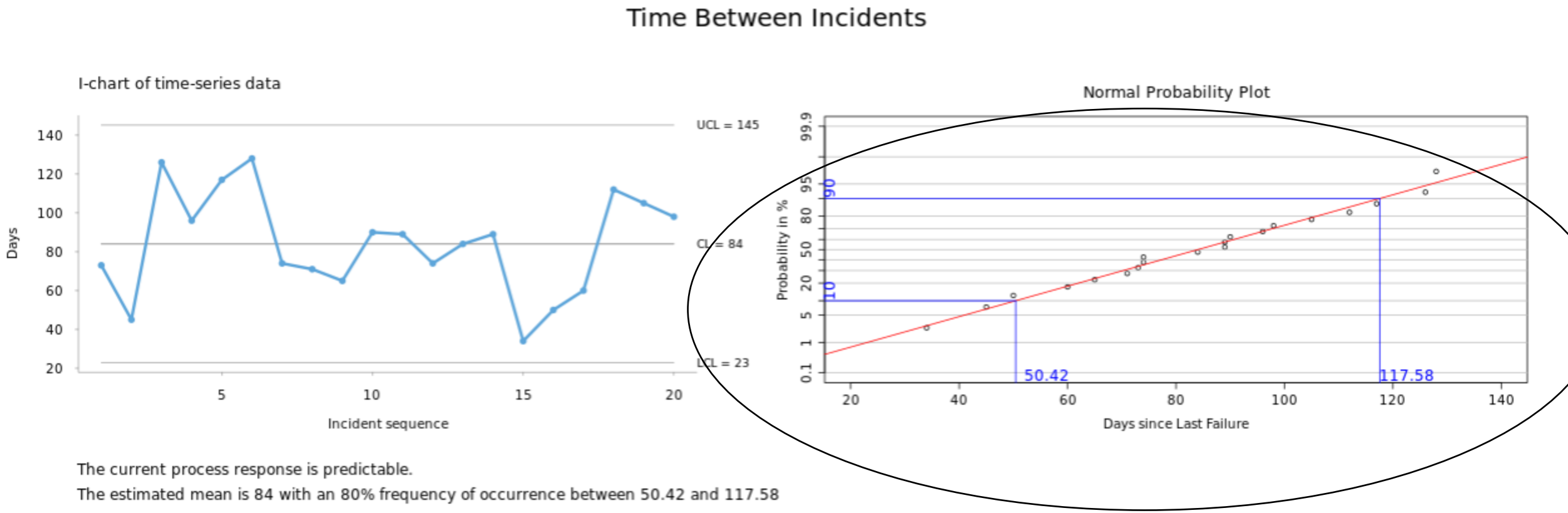
Example 13.3: 30,000-foot-level Report Infrequent Incidents



The current process response is predictable.

The estimated mean is 84 with an 80% frequency of occurrence between 50.42 and 117.58

Example 13.3: 30,000-foot-level Report Infrequent Incidents



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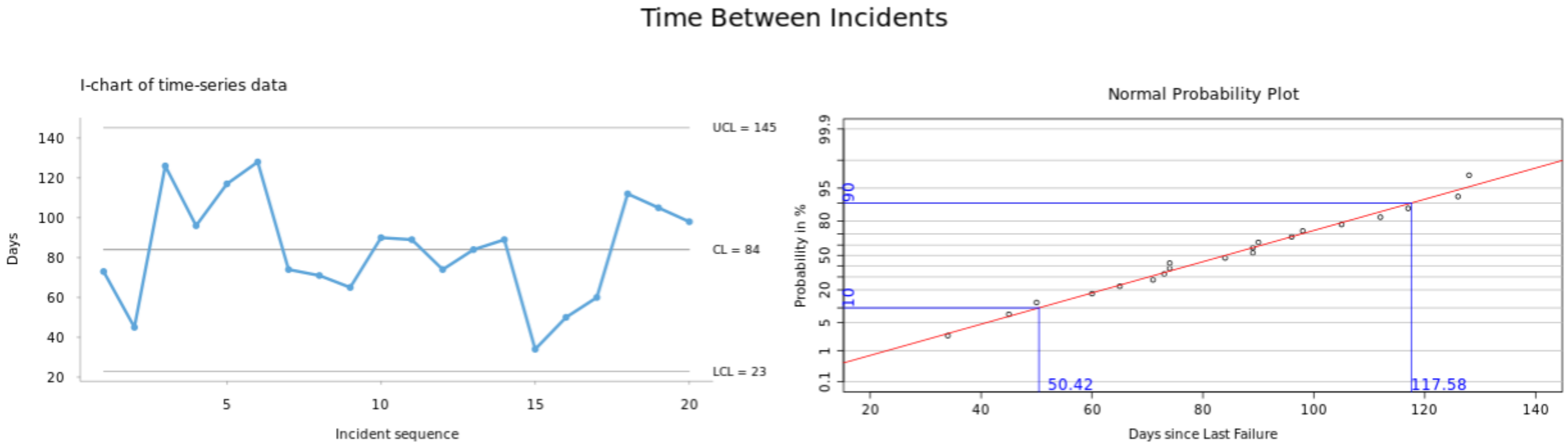
Example 13.3: 30,000-foot-level Report Infrequent Incidents



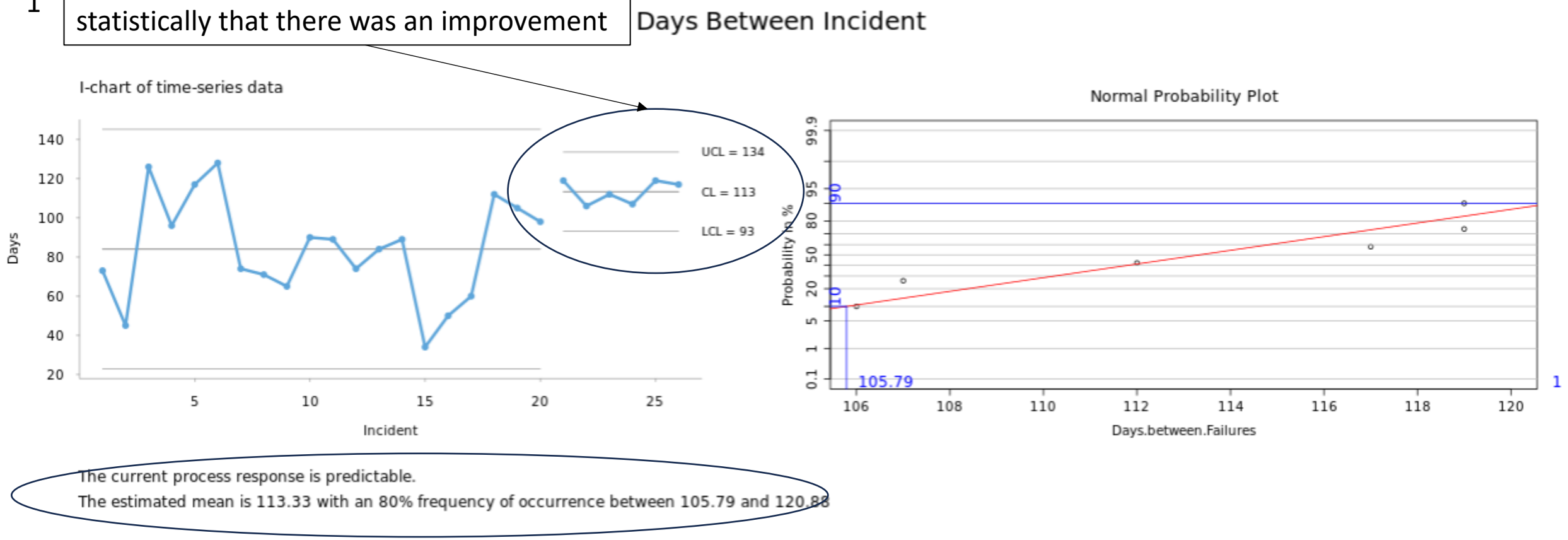
1 The current process response is predictable.
The estimated mean is 84 with an 80% frequency of occurrence between 50.42 and 117.58

2 An estimated failure rate is 1/84 = 0.012 failures per day

3 Process improvement efforts were taken to increase the time between safety incidents

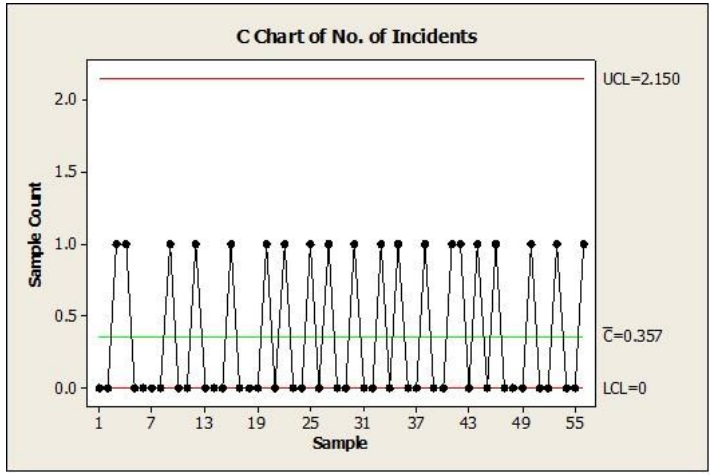
Example 13.3: 30,000-foot-level Report Infrequent Incidents (Process Improvement impact)

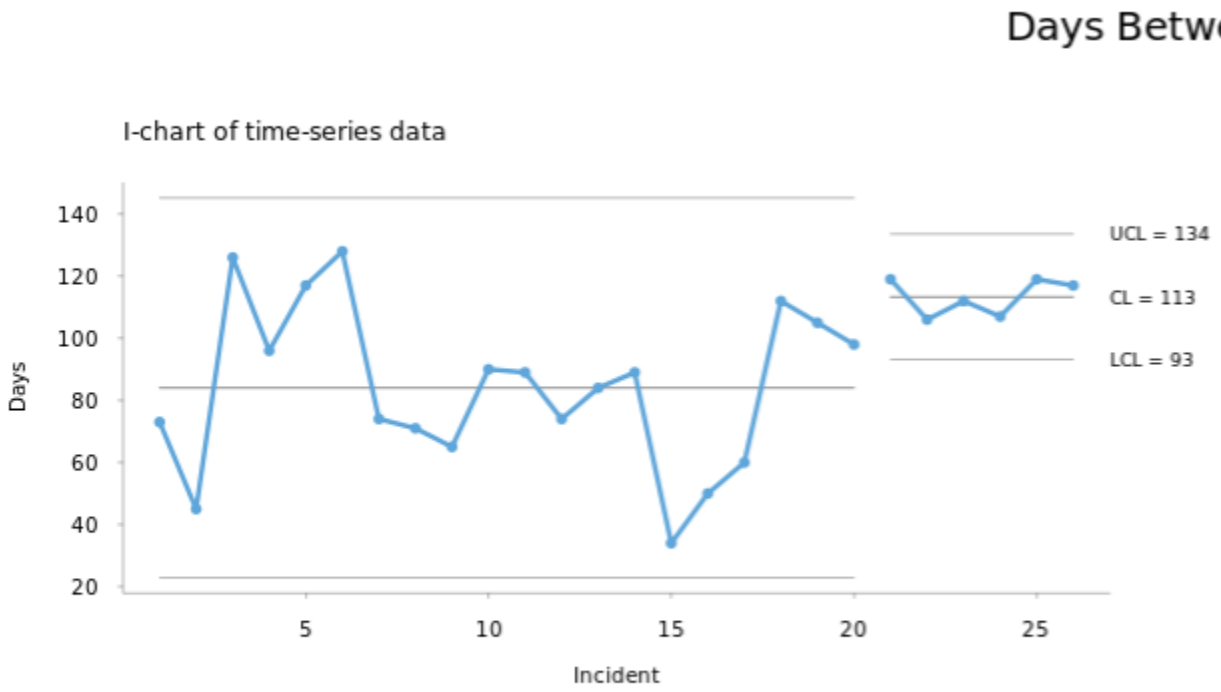
1 Staging of the individuals chart shows statistically that there was an improvement

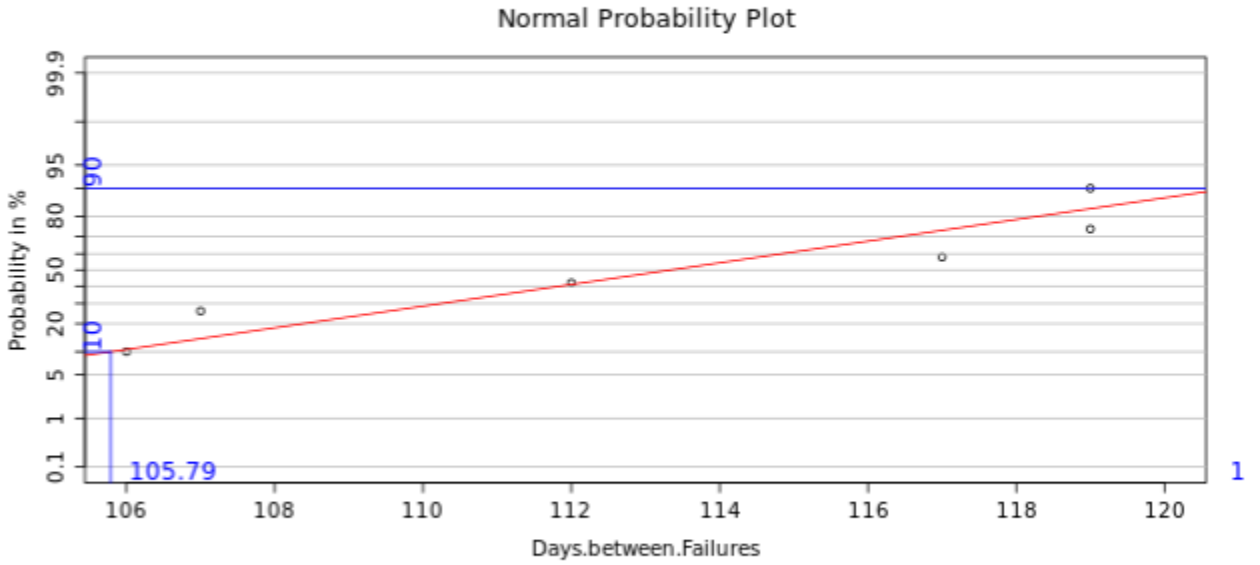


2 The bottom-of-the-report statement reports the estimated new level of performance

Example 13.3: 30,000-foot-level Report Infrequent Incidents (Comparison of reports)







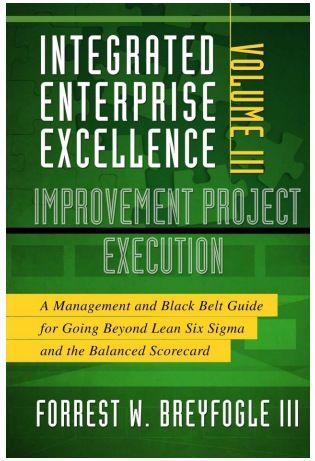
The current process response is predictable.
The estimated mean is 113.33 with an 80% frequency of occurrence between 105.79 and 120.88

Unlike 30,000-foot-level tracking, it would have been very difficult to see any process improvements with a c-chart tracking approach

Additional Information

Related Articles, Books, and Videos

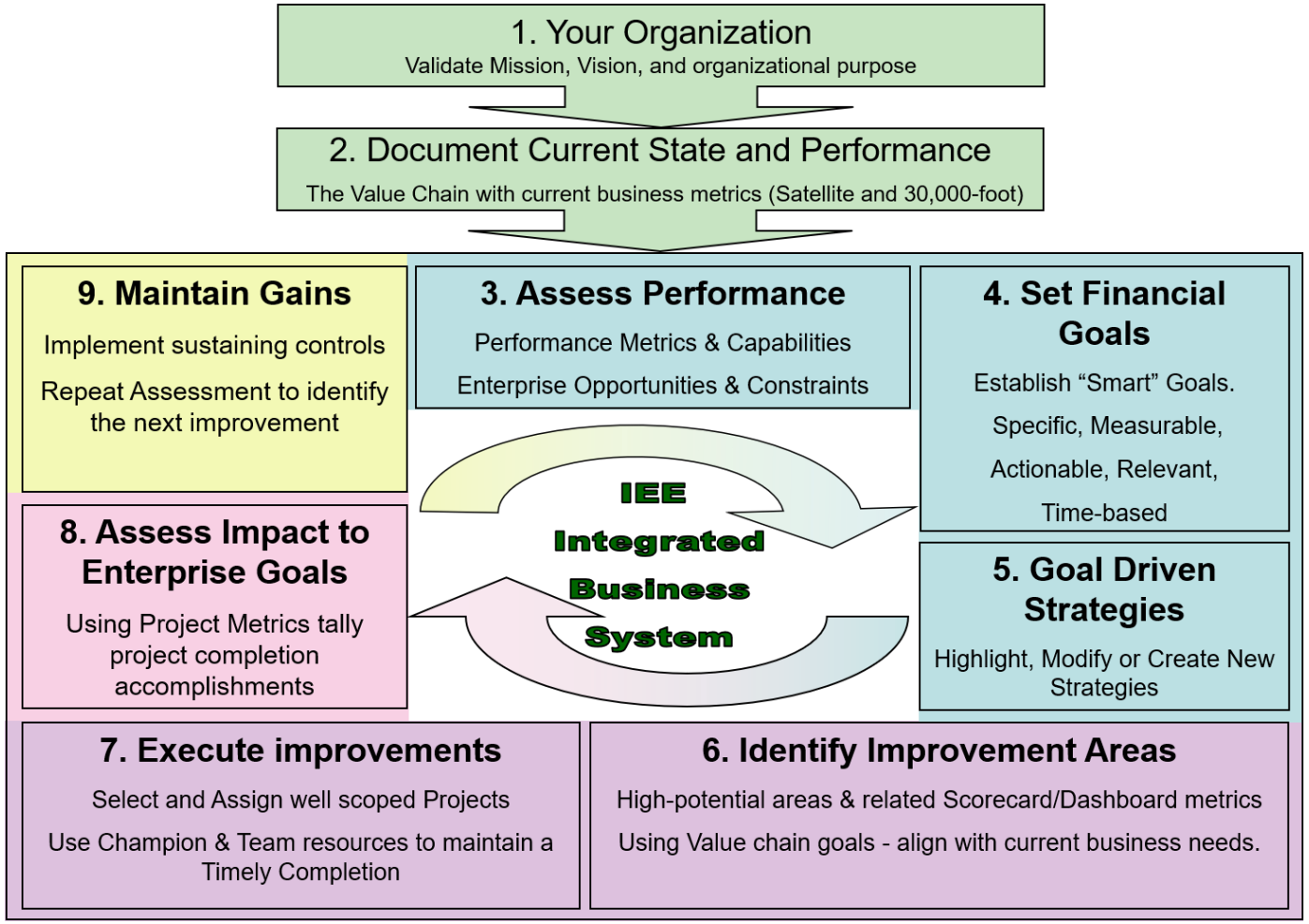
- “KPI Management: KPI Metric Reports that lead to the Best Behaviors” https://smartersolutions.com/kpi-management-kpi-metric-reports-that-lead-to-the-best-behaviors.html/
- “Control Charting Techniques Integration with Process Capability and Enhanced KPI Reports” https://smartersolutions.com/control-charting-techniques-integration-with-process-capability-and-enhanced-kpi-reports.html/



https://www.amazon.com/dp/1934454168/

https://www.amazon.com/Lean-Six-Sigma-Solutions-Improvement/dp/0982923171/

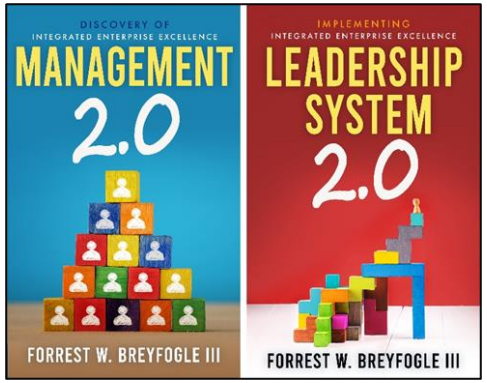
Integrated Enterprise Excellence (IEE) System



The IEE 9-step system provides a vehicle for organizational management that can have automatic updated 30,000-foot-level metrics throughout the business

Wrap Up

Q&A



These novel-books are available in paperback, e-book, and audio book formats from Amazon and other book retailers.

For questions about the IEE business management system and its application, contact
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forrest@smartersolutions.com
+1.512.695.4424 (m)

I have a **passion** for showing people how to apply and benefit from our free 30,000-foot-level app for THEIR dataset. Let me know some good times for you to have a ½ hour free Zoom application demonstration session.

There is a "schedule a video session" with me link near the bottom of https://smartersolutions.com/

For a copy of this PowerPoint presentation (and a recording of this webinar), send your request to forrest@smartersolutions.com

I respond to my e-mails. If I you did not see an e-mail response from me, check your spam filter. Also, call me to resolve any email problem.