Improve Forecasts: Use Defect Signals

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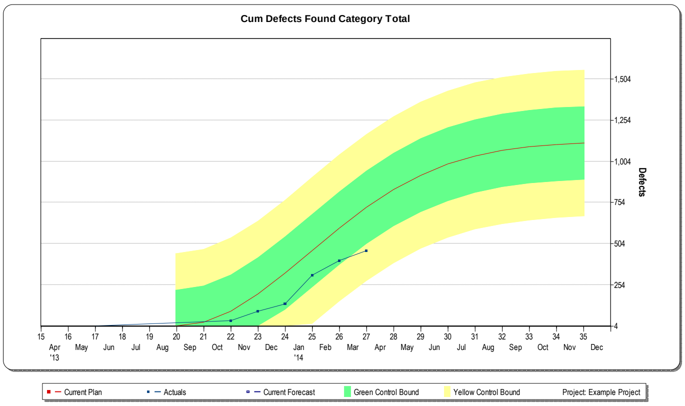
Introduction

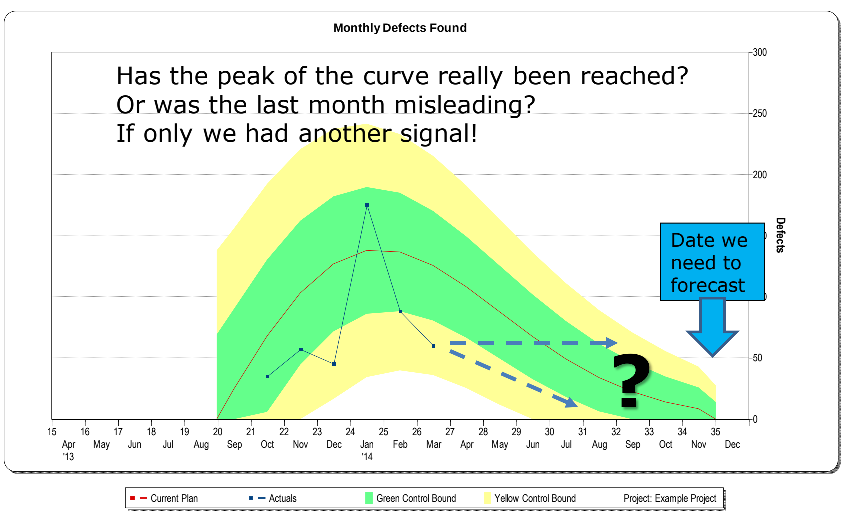
- Large development and integration project testing phases can extend over many months
- It is important to predict when the defect detection rate will drop to acceptable levels
- SLIM Control can be used to track and forecast defect detection rates
- The peak of the defect Rayleigh curve is an important point in the testing phase
- Control charts are another tool

Cumulative Defects Found by Month, Project XYZ



Project has found fewer defects than estimated. What will happen next?

Defects Found by Month, Project XYZ



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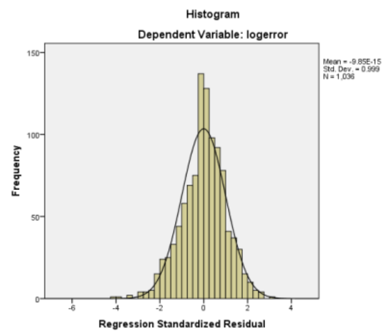
Comment on Defect Prediction

- It is possible to create very useful estimates of defects based on only a few key metrics. For example, I created a regression analysis to predict defects based on over 2000 recently completed software projects from the QSM database. This resulted in an adjusted R square of .537 using only the input variables the log of peak staff, the log of ESLOC, and the log of production rate (ESLOC per calendar month).
- Standardized residuals show a normal distribution with mean close to zero
- Large projects have multiple testing phases. Such models, with multiple control charts, can be used throughout. For example, with one Fortune 500 client, I found that merely using the number of prerelease defects was an excellent predictor of their go live release defects (R Square of over 0.7).



Control Charts

- Every process displays variation. Some processes display controlled variation and others display uncontrolled variation.
- In the 1920's, Control Charts were invented by Walter A. Shewhart. In most of the rest of the 20th century the concepts were popularized by people such as W. Edwards Deming.
- Control Charts are a major part of Statistical Process Control, and are integrated into Six Sigma and CMMI.

"The engineer desires to reduce the variability in quality to an economic minimum. In other words, he wants (a) a rational method of prediction that is subject to minimum error, and (b) a means of minimizing variability in the quality of a given produce at a given cost of production."
Walter A. Shewhart

Control Charts and Signals

- Purpose here is ***not*** to determine if the testing is in control or to improve product quality (both have been done, but are outside scope of this presentation, see sources at end)
- Purpose here ***is*** to determine if there has been a shift in quality of the underlying product
- I use Individuals and Moving Range charts (*XmR*), suitable for many situations including the periodic collection of items found in a given time
- It is important to calculate the control limits properly (see resources at end, or use a good stats tool)

Rules, Rules…

- There are a number of rules that are used to detect signals. The number of rules used and the definitions of the rules vary slightly from one source to another. However, the traditional use of control charts is best met by keeping the number of rules to a minimum, thereby reducing the chance of obtaining a false signal. But in our case, we don't want to miss a signal.
- In IBM *SPSS 22*, for example, there are 11 possible rules that can be turned on or off:
  - One point above +3 Sigma, or one point below -3 Sigma
  - 2 out of last 3 above +2 Sigma, or 2 of 3 below -2 Sigma
  - 4 out of last 5 above +1 Sigma, or 4 out of 5 below -1 Sigma
  - 8 points above center line, or 8 below center line
  - 6 in a row trending up, or 6 trending down
  - 14 in a row alternating up and down

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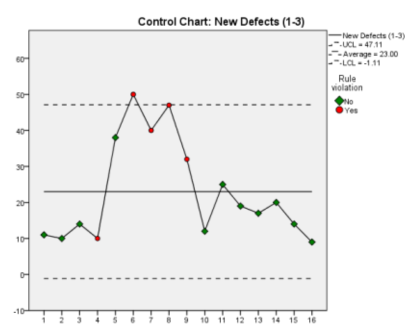
Why the Rules?

- All uses of control charts walk this decision line. Shewhart originally used 3 sigma limits because he wanted to minimize false signals, which would incur the unnecessary cost of researching a problem that didn't exist. In other words, when he saw a signal he wanted to be almost completely certain it was real.

	Possible States	
Possible Decision	**Problem**	**Not a Problem**
Investigate	Correctly Accepted	Type II error
Ignore	Type I error	Correctly Rejected

Another Example

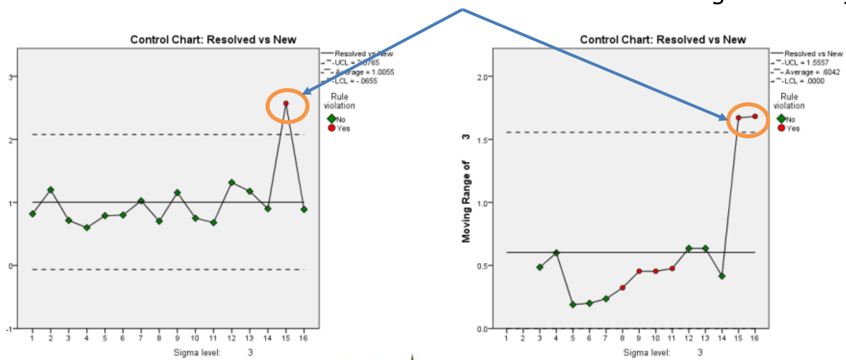
- In this example, the balance between testing and fixing has not remained constant.
- For defects detected, five of the points show up as red, meaning they violated one of the rules
- These violations are not unusual. As mentioned previously, defect metrics commonly follow a Rayleigh distribution
- What about backlog burndown?



Point #	Violations for Points
4	4 points out of the last 5 below -1 sigma
6	Greater than +3 sigma
6	2 points out of the last 3 above +2 sigma
7	2 points out of the last 3 above +2 sigma
8	4 points out of the last 5 above +1 sigma
9	4 points out of the last 5 above +1 sigma

XmR for Defects Resolved / Defects Discovered

Balance between fixed and found has shifted. Something has changed.



Summary

- Control charts can be used to determine whether apparent changes in defect rates are significant. Especially, has the peak of the defect detection Rayleigh curve been reached?
- One use for this knowledge is to create and improve forecasts of Program completion, or software quality at key Program milestones.

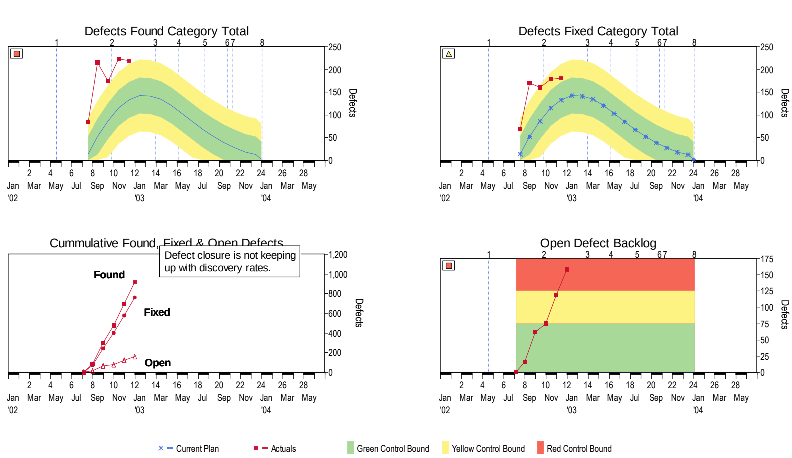
> "…since we can make operationally verifiable predictions only in terms of future observations, it follows that with the acquisition of new data, not only may the magnitudes involved in any prediction change, but also our grounds for belief in it."
> Walter A. Shewhart

Example from SLIM Training

SLIM Control Example: But wait, there's more!

From the SW-Wed Gateway example packaged with SLIM Control 8.1

Defect Closure & Backlog - Web Gateway



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Let's Look at a Defect Forecast

SW-Wed Gateway example packaged with SLIM Control 8.1

Arbitrary: Weighted every metric evenly that had Excellent Goodness of Fit

Curve Fit Analysis - Web Gateway

Curve Fit Analysis Report

Forecast Assumptions
Projection Date: 12/31/2002
Implied PI: 15.3

Curve Fit Weighted Results
Projected Phase 3 Time: 19.2 Months
Phase 3 End Date: 11/27/2003
Life Cycle End Date: 3/1/2004

Tradeoff Results
Phase 3 Peak/Shape: na
Tradeoff Results: na

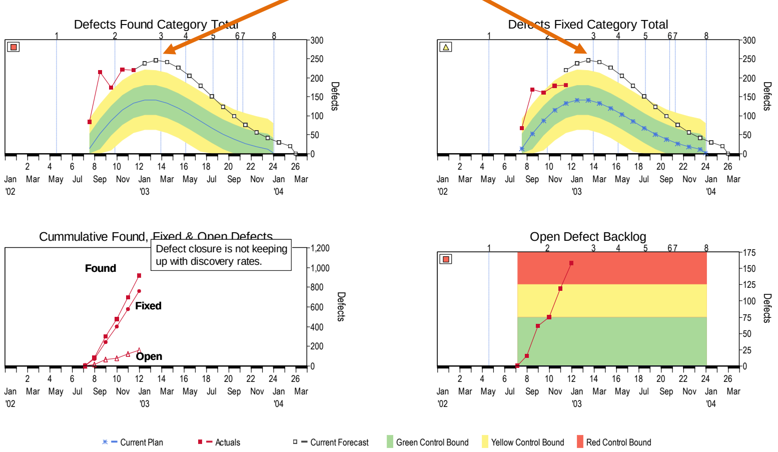
Metric	Number of Data Points Used	Relative Weight (User)	Goodness of Fit	Predicted Phase 3 Time (Months)
Phase 3 Milestones	1	25	Excellent	21.4
Cum Eff SLOC	7	25	Excellent	21.5
Defects Found (Moderate)	5	25	Excellent	17.6
Defects Found (Serious)	5	25	Excellent	17.5
Defects Found (Critical)	5	25	Excellent	16.0
Earned Tasks	12	25	Excellent	21.0
Use Cases		0	Metric Complete	
Design Components		0	Metric Complete	
Integration Builds	4	0	Poor	23.4

Current Plan: Baseline Plan
Lifecycle includes R&D, C&T, P_Mnt
Current Forecast: Forecast as of 12/31/2002

SLIM Control Example

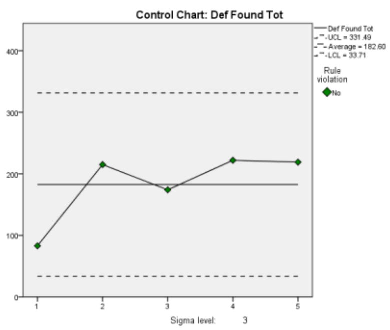
Forecast predicts we are still a couple of months away from peak of defect discovery Rayleigh curve.

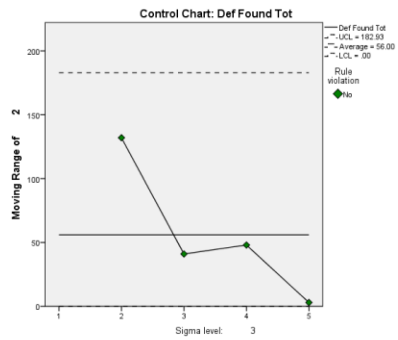
Defect Closure & Backlog - Web Gateway



SLIM Control Example
XmR for Defects Discovered

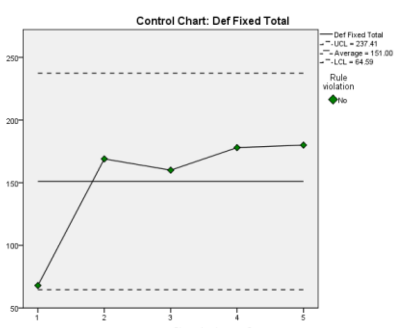
No rule “violations”. Therefore, no significant change (month to month variation in defects discovered can be explained by random variation).

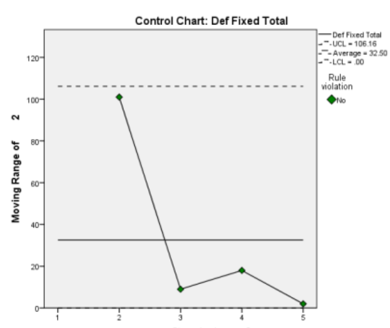




SLIM Control Example
XmR for Defects Fixed

No significant change. Note though that the moving range chart picked up on month 2 as almost 3 sigma, when they ramped up fixing.

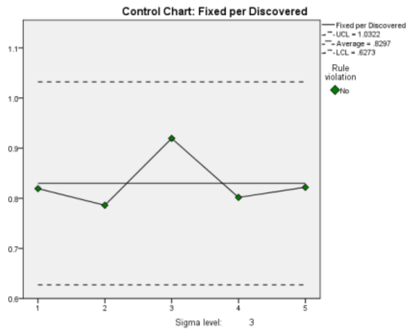


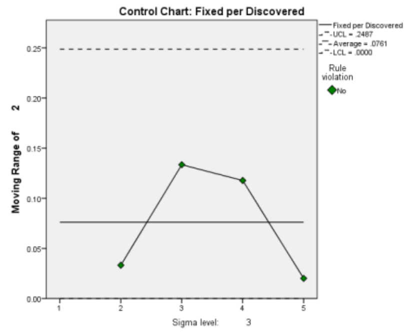


SLIM Control Example

XmR for Defects Fixed / Defects Discovered

No significant change. Control charts agree with SLIM Control Forecast, in that we have no evidence that curve peak has been reached.





Resources

Statistical Method from the Viewpoint of Quality Control, Walter A. Shewhart. Dover, 1986 edition, p.9 and p. 104.

Why CMMI Maturity Level 5?, Michael Comps. Crosstalk, Jan-Feb, 2012, pp 15-18.

Do Not Get Out of Control: Achieving Real-time Quality and Performance, Craig Hale and Mike Rowe. Crosstalk, Jan-Feb 2012, pp. 4-8.

Understanding Statistical Process *Control*, Donald J. Wheeler. SPC Press, 2010.

Implementing Six Sigma: Smarter Solutions Using Statistical Methods, Second Edition, Forrest W. Breyfogle III. John Wiley & Sons, 2003.

The IFPUG Guide to IT and Software Measurement: A Comprehensive International Guide, IFPUG, ed. CRC Press, 2012. Chapter 17, Paul Below, pp. 319-333.

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Extra Material

XmR Control Limits

- Individuals Chart (*X*)
  - Center line is the mean of *X*, m*X*, the average of all the individual values
  - Upper Control Limit is m*X* + (2.66 * mR)
  - Lower Control Limit is m*X* – (2.66 * mR)
- Moving Range Chart (mR)
  - Center line is the mean of ranges, mR
  - Upper Control Limit is 3.268 * mR

Mean Range, mR, is the average of a moving range of 2. For each data point, except the first, the moving range of 2 is the difference between that data point and the preceding one. Those ranges are averaged to get the mR. For in depth explanation, see Chapter 3 of Wheeler (on resources slide).