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Statistical Process Control (SPC)

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FLUOR®

SPC Trending Primer/ Two Day Training

http://www.efcog.org/wg/esh_es/Statistical_Process_Control/index.htm

What is SPC?

- A way of:
  - presenting data on a chart
  - determining if you have a trend
  - determining if you are stable
  - determining the capability of your process

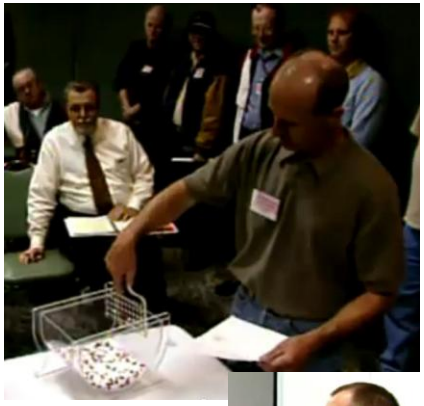
- It is also a way of thinking and leading

Trending

- **Many procedures and policies call for "trending" to be performed, for "trends" to be identified.**
- **Webster's Dictionary:**
  - to extend in a general direction,
  - a general movement,
  - to veer in a new direction,
  - to show a tendency,
  - to become deflected
- **For our purposes: a changing condition**

Lessons of the Red Bead Experiment

- In the Red Bead Experiment, we reacted to the random noise from result to result.
- Rewards, punishments, ranking of the workers, feedback to the workers had no effect on the results of the process.



Photos from
http://www.youtube.com/view_play_list?p=8E522DD542C4CA69

Fluor Hanford YouTube Channel

The process was stable and needed to be changed!

Importance of Trending

- **Actions taken to improve a process are different, depending on whether or not the process is "stable".**

- **Attempting to explain or correct for individual datum point changes in a stable process will not improve performance.**

  This is a "Type I" error.

  You will make a mountain out of a molehill

- **Missing initial indication of a change (and missing the opportunity to determine the cause of the change).**

  This is a "Type II" error.

  You will allow the molehill to grow into a mountain.

Photos from National Park Service

Importance of Good Trending

- Minimize “knee jerk” reactions to random noise
  - Avoid “two points make a trend”
  - Want to ensure that we don’t declare victory (or failure) on an individual “lucky” result
  - Want to be sure that an improvement has taken hold and is stable and predictable
- Minimize failures to detect a trend
  - Dr. Winokur, DNFSB: “Changes in Culture often Precede Major Accidents”
- Similar function as a smoke alarm

Why use SPC for Trending?

- **Provides a formal method to detect trends**
- **Provides credibility and rigor at minimum cost**
- **Balances false alarms and failures to detect**

  (Type I and II Errors)
- **Accepted industry standard with long history**
- **Results are visual on a chart rather than buried in a table of numbers**

SPC methodology is analogous to the circuitry in your home's smoke alarm.

Management Theory: The Theory of Variation

- SPECIAL CAUSE VARIATION

If a statistically significant trend occurs, find the special cause of this trend. Use this information to correct or reinforce these special causes.

- COMMON CAUSE VARIATION

If no trends exist, you must look at the long run performance of the process and fundamentally change the process in order to improve the process.

SPC detects the difference

Implications of the Theory of Variation

- No amount of explanation of, corrective action to, or causal analysis of an event will fix a broken stable process
  - **What if we did a root cause analysis of why Red Bead #298 fell in hole #19 of the paddle?**
  - **What about "Find it Fix it"?**

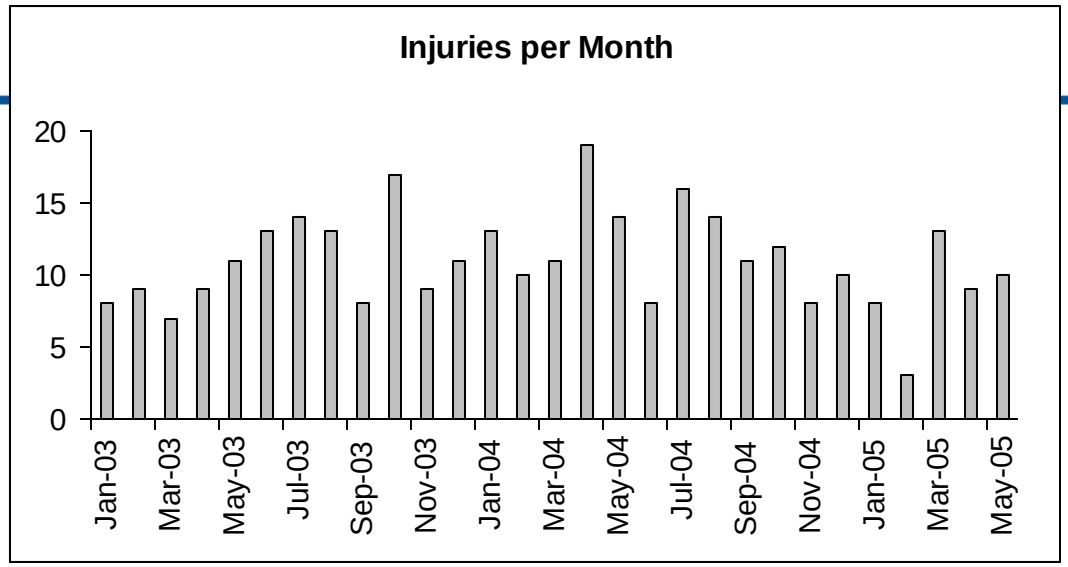
Implications (2)

- What if we miss an emerging trend?
  - **Bad parts sent to customers**
  - **Increase in injuries**
  - **Increase in costs**
  - **Missed schedule**
  - **Impact on Employee morale**

The Losses

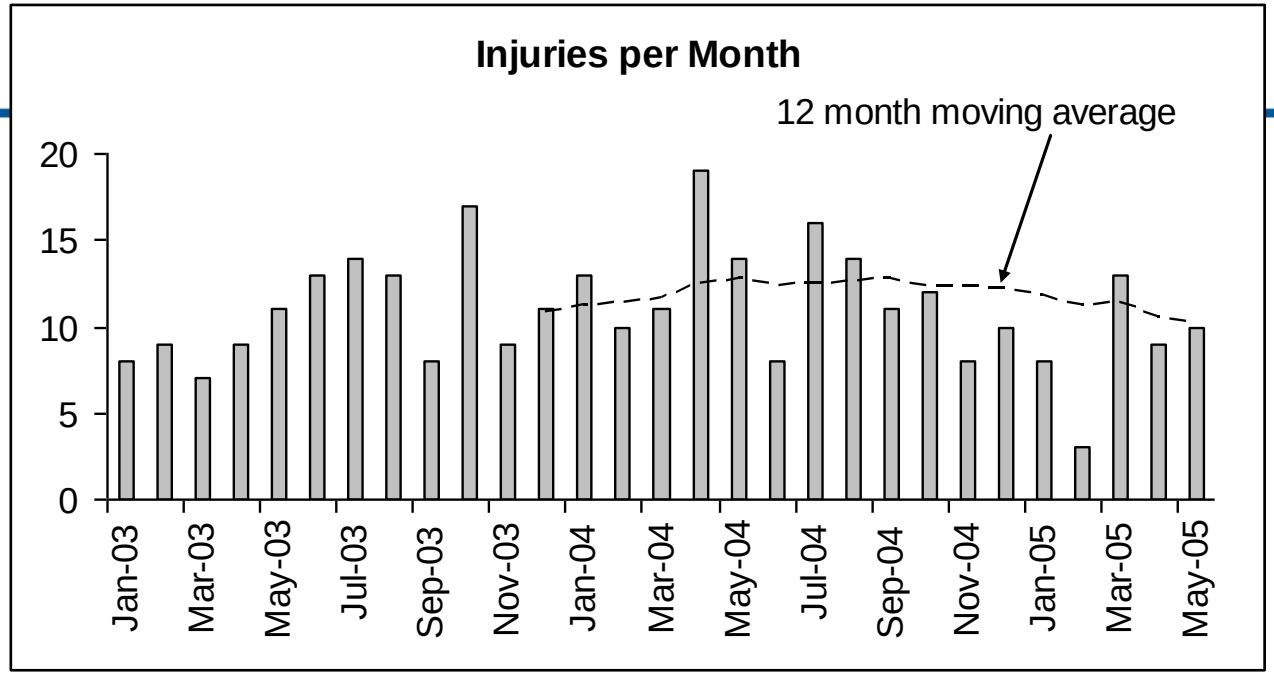
- Misinterpretation of Performance Results can lead to:
  - **Missed Opportunities**
  - **Incorrect Actions**
  - **Frustration and Bewilderment**

Let's take an example:



Great improvement from July 2004 – February 2005 !!!

Alas, something obviously has gone wrong in March. We jumped from 3 injuries to 13. The injury rate increased more than 400%! April and May have recovered somewhat, but not by much.

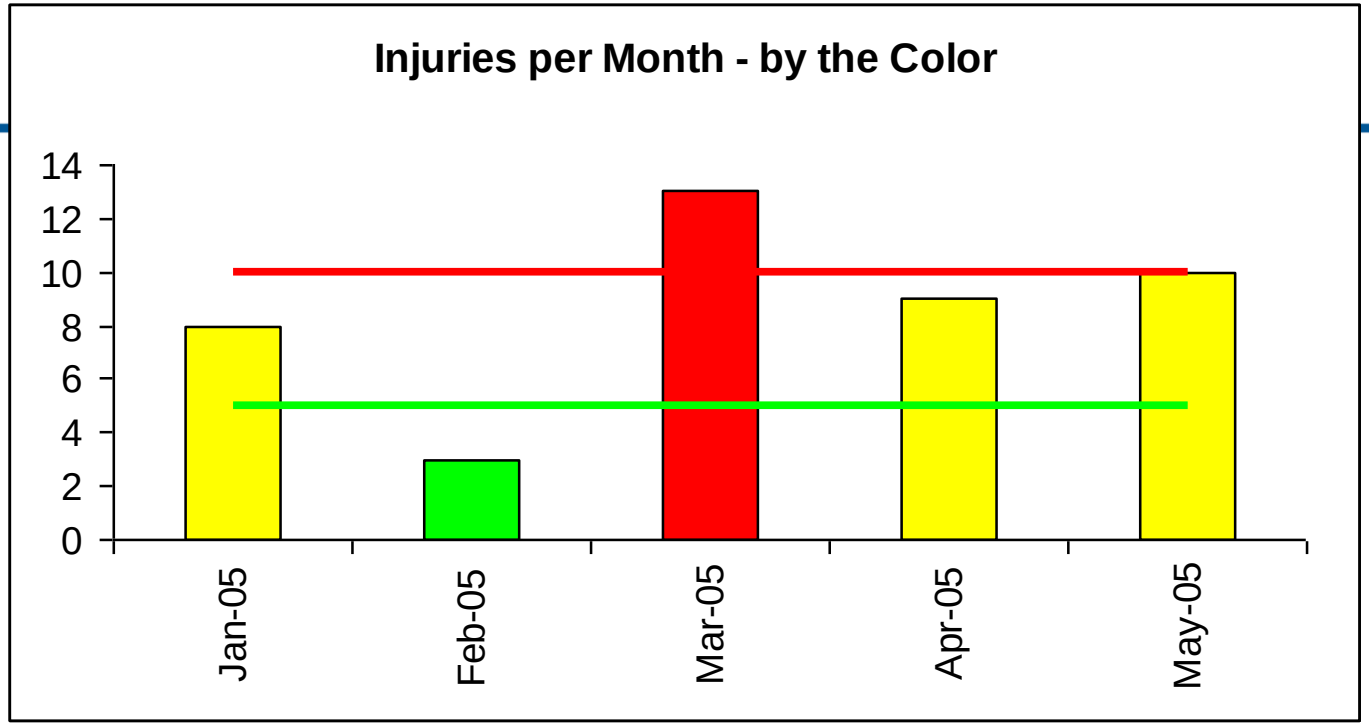


Addition of a 12 month moving average shows us we are actually improving!

Or are we?

The Hazards of Moving Averages

- **A moving average simply compares the new datum point to the oldest. If the new point is higher, the moving average moves up; if lower, the moving average moves down.**
- **There is no criteria for when to declare a trend, when to sound the alarm**
- **Year-to-date averaging has even more hazards**
  - Over-reaction to the first month's results
  - Under-reaction to the last month's results

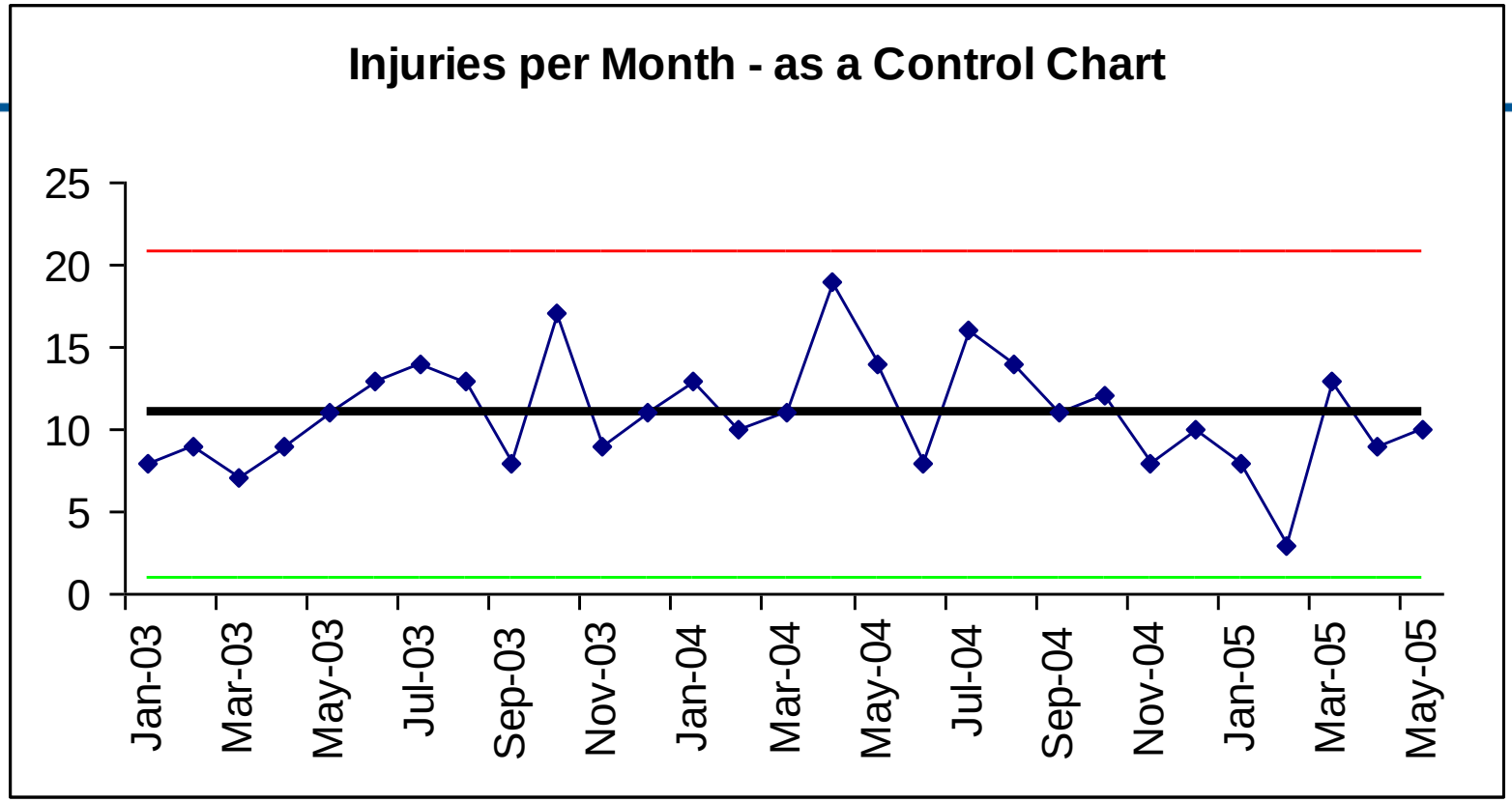


Adding color and cutting back to the current year certainly eliminates confusion . . .

Oh, really?

The Hazards of Rainbow Charts

- The traditional color coded charts against numerical targets add to the reaction to random noise
- Although we now have an alarm threshold, there is a high rate of false alarms against arbitrary thresholds
- Will miss developing adverse trends that begin within a color band
- Detection of trend delayed until the level is affected (even worse if used in combination with moving average)



The SPC “control chart” allows us to see that this is a stable, but random process

Yes, Really – it was random numbers

Construction of the Control Chart

- Plot the actual data by month (or whatever time interval you are using)
- Plot at least 25 points (when available)
- Calculate a baseline average rate
- Add 3 standard deviation control limits
- Incorporate a set of trend rules
- Adjust the baseline only when there is a significant trend

SPC – A Lens to the World

Control Charting provides knowledge of variation. This knowledge is a lens, and provides a different way of viewing the world.

The Control Chart will give you a significantly different view of what is happening than will other methods.

Why Three Standard Deviations?

- Many courses incorrectly teach that the control limits cover 99.7% of the normal distribution
- Not all data are normal, “real data” can cause the rate to be as low as 95% (Dr. Wheeler)
- The Tchebychev Inequality states up to 11% can be outside three standard deviations
- We use a suite of trend detection rules, and we want to avoid too many false alarms

Why Three Standard Deviations? (2)

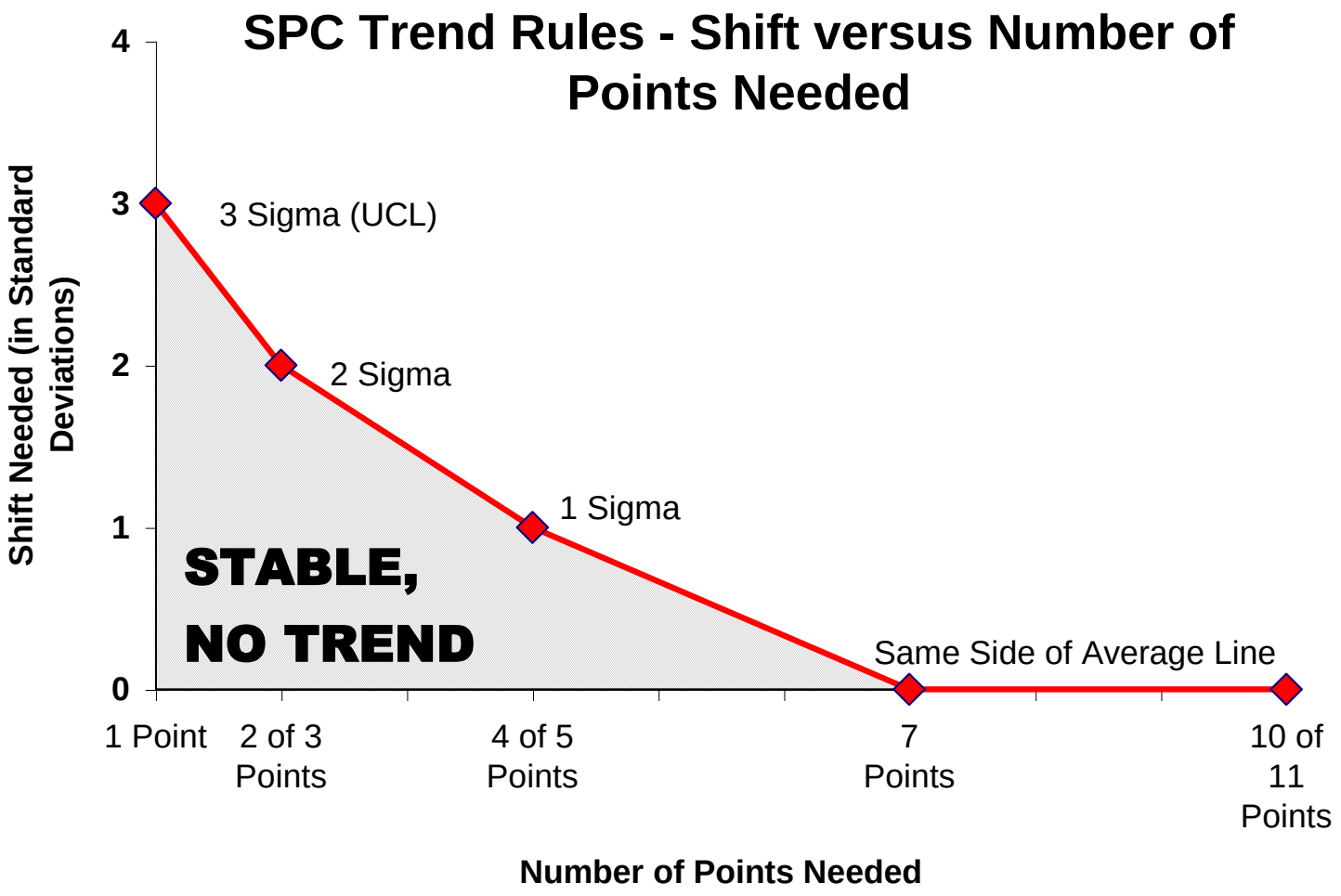
- Dr. Shewhart established 3 standard deviations as an economic balance between failure to detect and false alarms in 1930.
- If you don't believe this, go home and make your smoke detector more sensitive. Is your house now more safe?

Definition of a Trend, using SPC

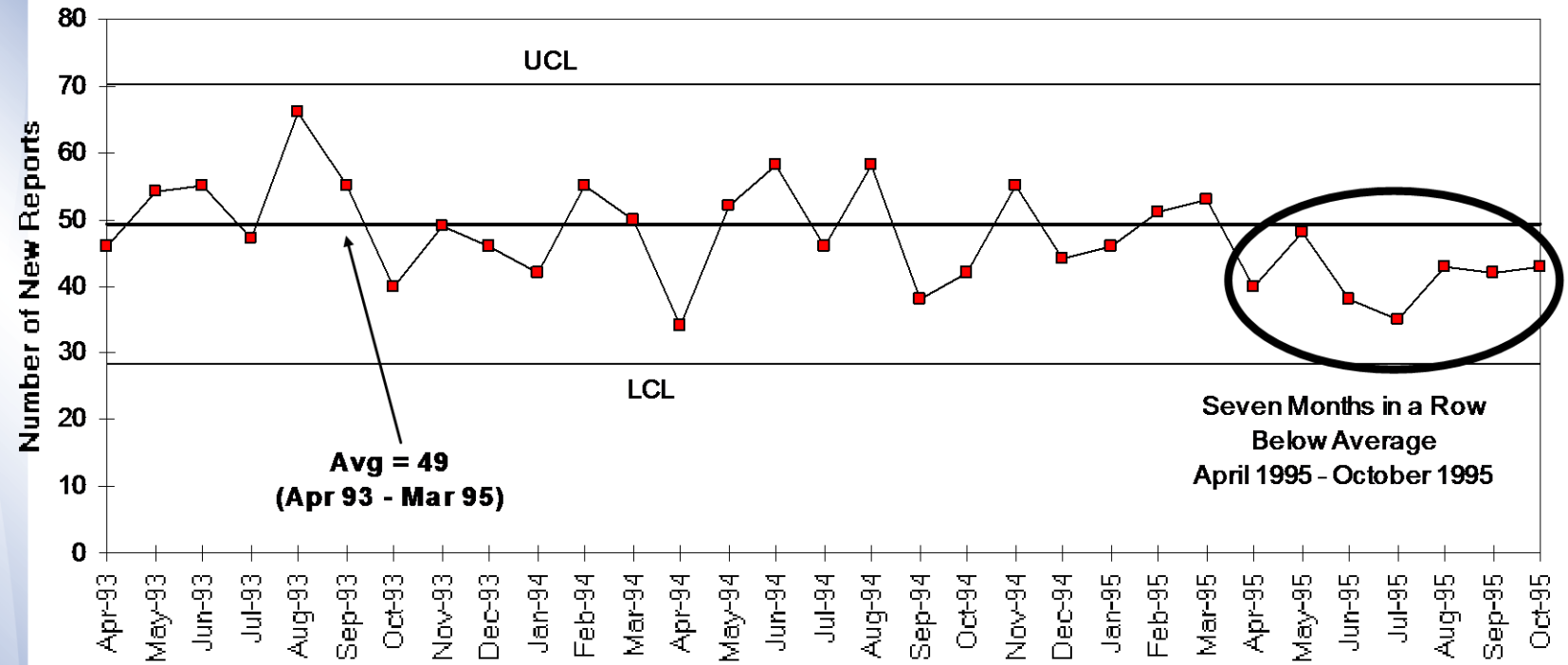
- One point outside the control limits
- Two out of Three points two standard deviations above/below average
- Four out of Five points one standard deviation above/below average
- Seven points in a row all above/below average
- Ten out of Eleven points in a row all above/below average
- Seven points in a row all increasing/decreasing

Note: There are variations on this list, depending upon author. Each list has its relative advantages and disadvantages. This list is a combination from Acheson Duncan's Quality Control and Industrial Statistics, and DOE-STD-1048-92 (cancelled)

Visualization of the SPC Rules

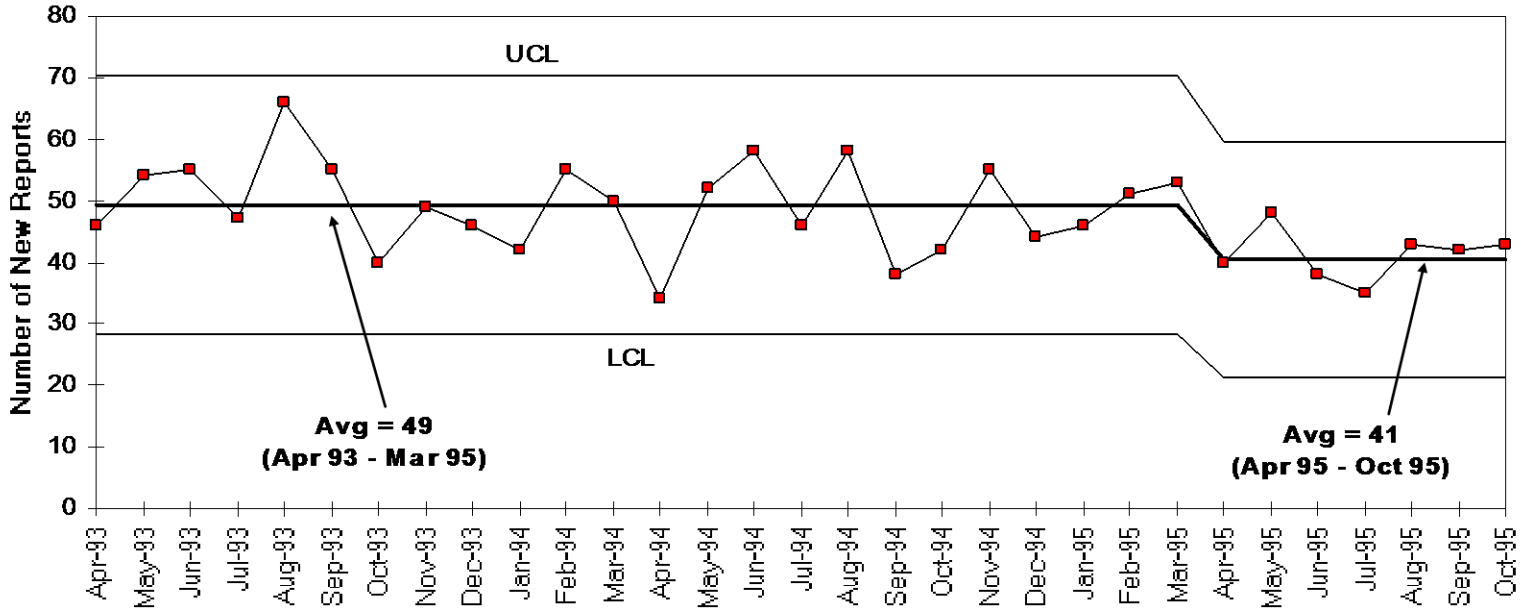


Example of a Trend



We should also determine the cause for the trend. In this case, it was a change in reporting requirements.

Generating a new Baseline following a Trend



After the data stabilize, consider adding a new baseline average

More about this will be included in “Life Cycle of a Trend” tomorrow

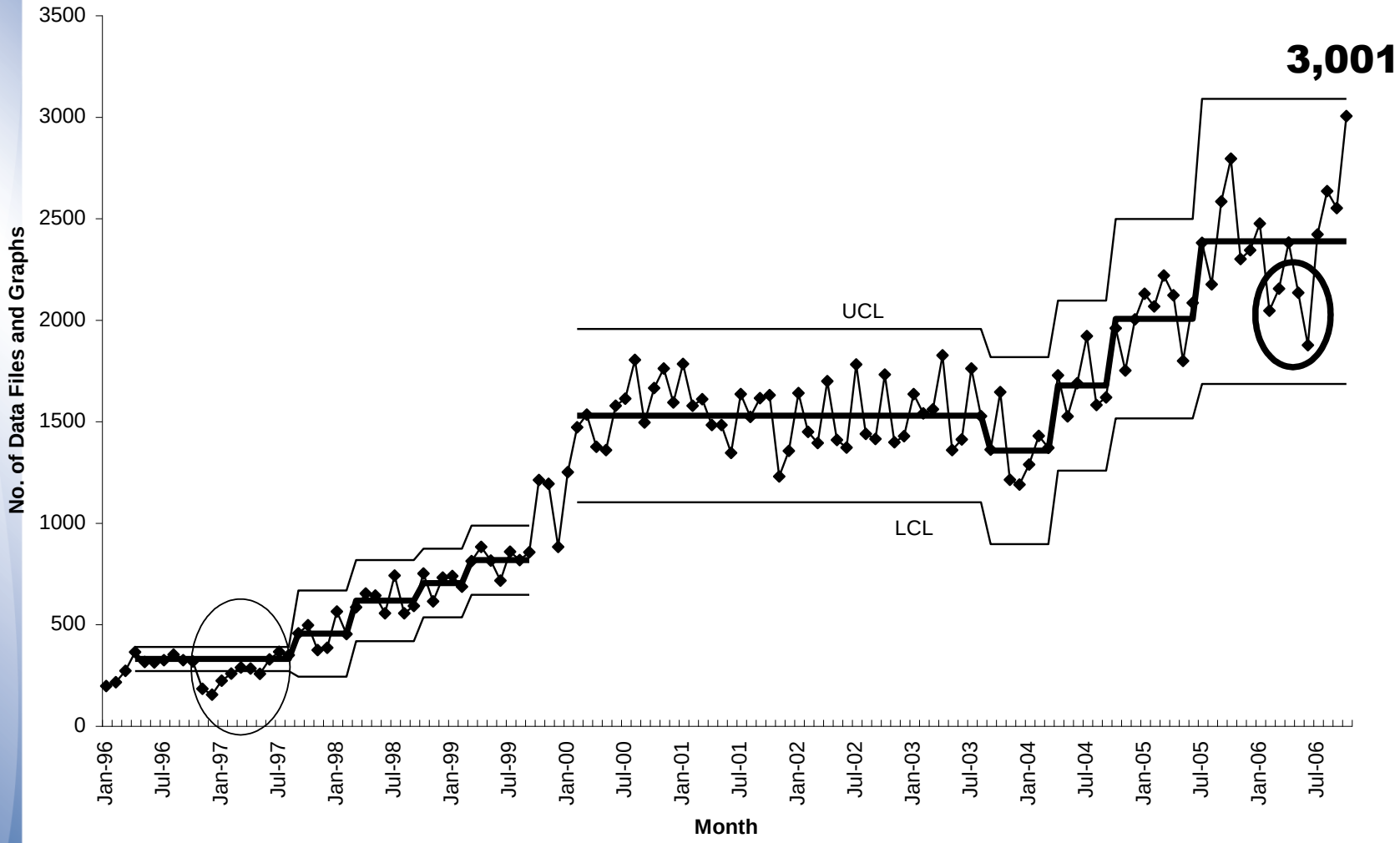
Annotating a Trend

- A set of data that is EITHER circled or has a shifted average line is still a Significant Trend.
- The only purpose to establishing a new average is to detect further significant trends after this trend plays itself out, and the data stabilizes.
- The existing average and control limits should NOT be changed unless a significant trend is detected.
- In rare cases, when fewer than 25 points were used in the average and control limits, the addition of new data into the existing average and control limits will “eliminate” the trend.

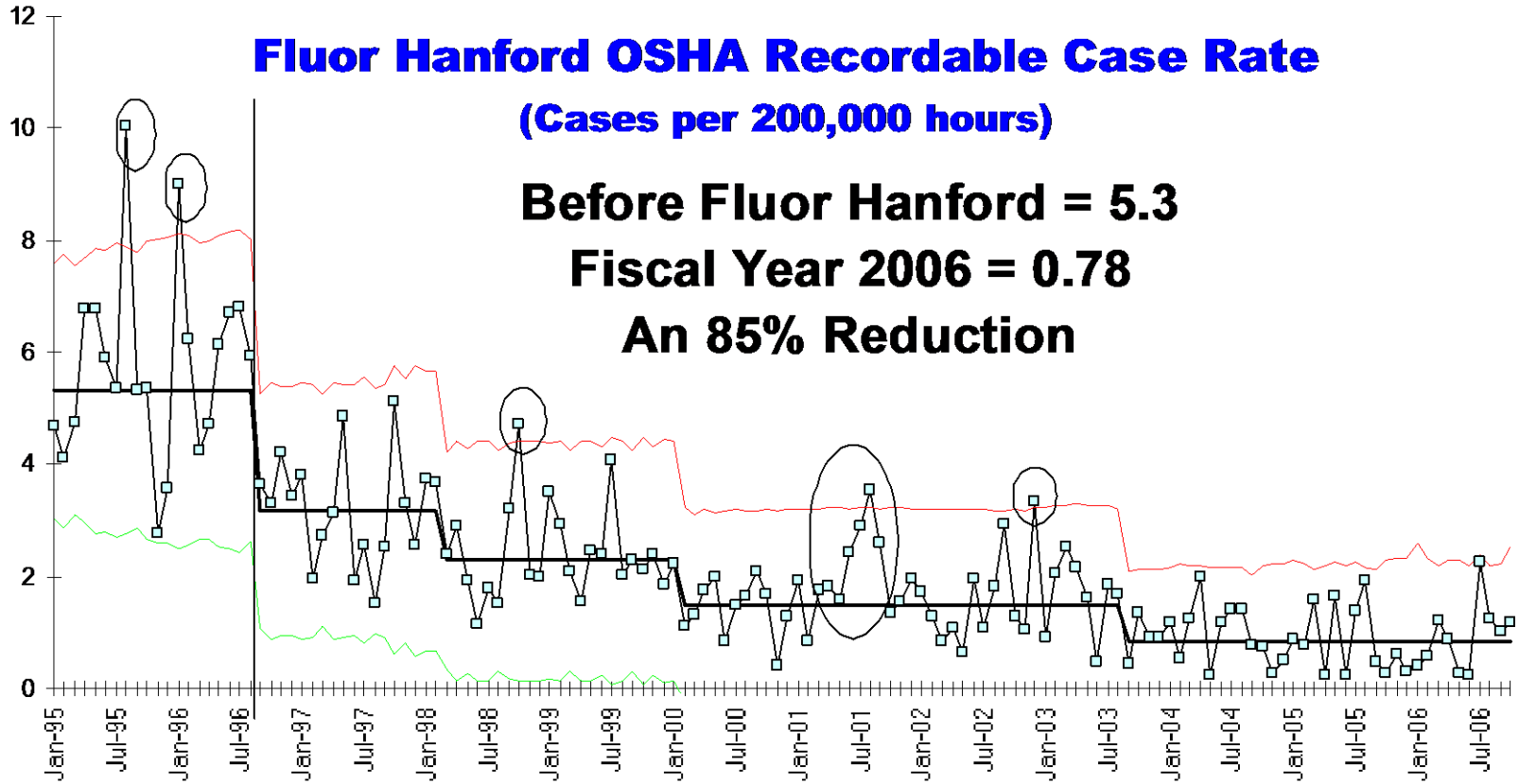
Benefits of SPC in the Department of Energy

- Minimized knee-jerk reactions to the latest events
- Detected changing conditions
- Allowed focus upon the system, the underlying processes
- Saved time and money, both in the act of chart making, and in management actions

Growth in use of SPC at Hanford over 10 Years



Reduction in Injuries at Hanford over 10 Years



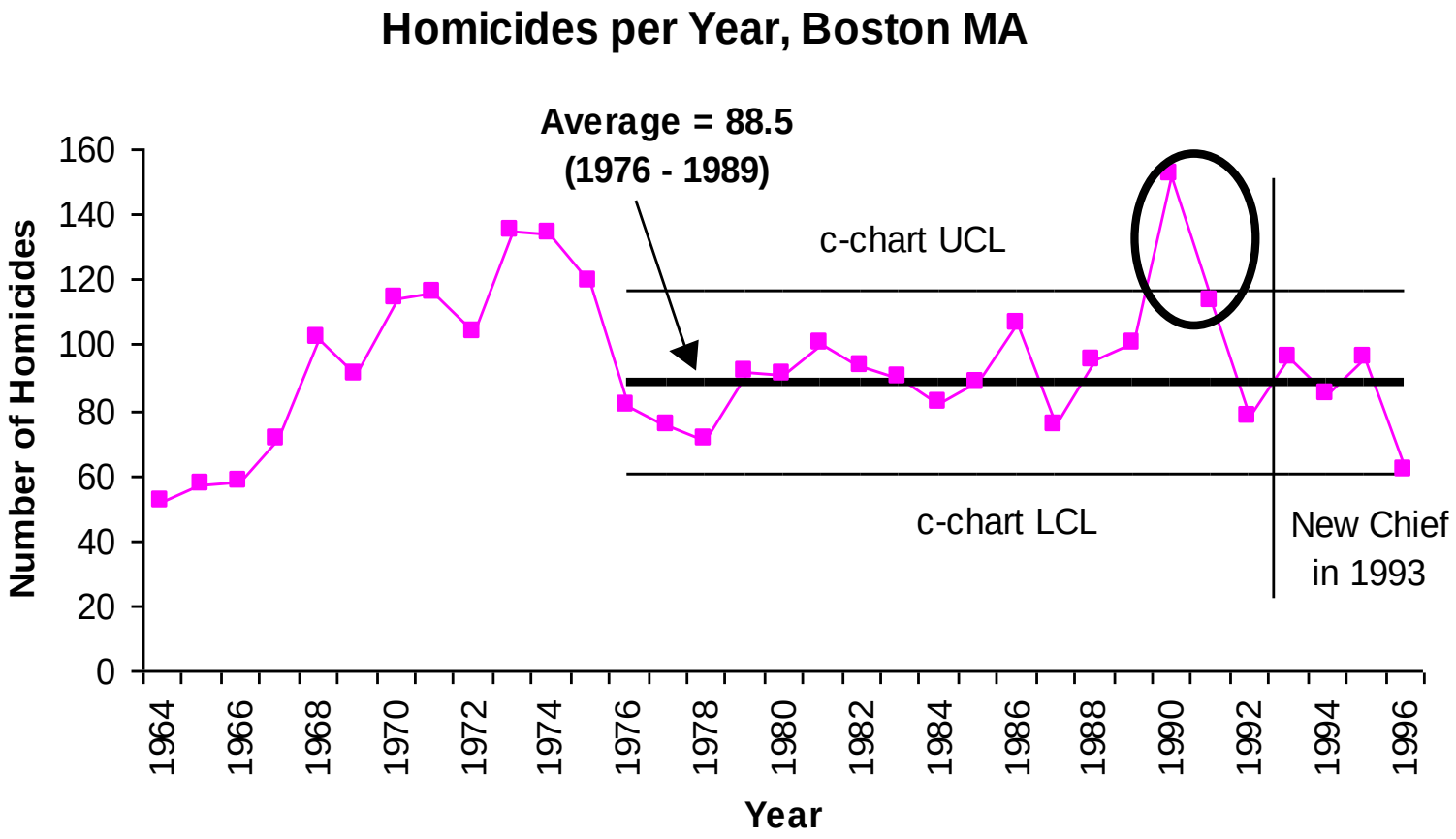
More Fun with Numbers

Boston Herald (Dec 23, 1996):

"Murders Sink To 30-Year Low "

"....major crime such as homicide is down. Over the last two years there has been a 52% reduction in shootings..... that's a dramatic difference....Police Commissioner Paul Evans has succeeded where others have fell [sic] short...."

More Fun with Numbers (2)



“Murder rate rises in Boston”

BOSTON (AP) — The number of murders in Boston rose in 2000 after years of steady decline, partially due to an alarmingly violent first six months.

The final tally was 37 — up from 31 last year.

[Police Commissioner] Evans noted that there were no homicides in October or November

For 2001, AP reported a 67% increase

Data Sanity

We can either react to numbers, with explanations of every percent change, with the inherent frustrations, fear, and failure

Or

We can understand our data, put it to good use, and apply valid management principles

The choice is ours.

Note: The phrase “Data Sanity” was coined by Davis Ballestracci

What's Next?

Dr. Deming's System of Profound Knowledge

Four elements, you have been exposed to one so far

Hands-on training making charts, including the Red Bead results from today

"Life Cycle of a Trend" to fit this in with an improvement methodology

Resources

- **EFCOG Trending Primer**
  http://www.efcog.org/wg/esh_es/Statistical_Process_Control/index.htm
- **SRS Procedure Q1-1 105**
  http://shrine01.srs.gov/eshqa/dps/admin/q1-1/105.pdf
- **Institute of Nuclear Power Operations (INPO) 07-007**
- **Hands on training tomorrow**
- **American Society for Quality**
  http://www.asq.org
- **The Elsmar Cove Discussion Board**
  http://elsmar.com/Forums/index.php

Conclusion

- Statistical Process Control is not just a charting technique
- SPC is a way of doing business
- SPC approach saves money
- SPC was proven very successful at Hanford, allowing management and the workforce to make significant improvements