Are we moving the needle? A simple technique to understand and analyze variation in performance and operational data.

1. **Variation happens** – All systems and processes exhibit variation in the data being reported on their performance or operations. It is critical to understand that some variation is predictable and shows random noise due to common causes. Some variation, however, shows special causes at work as it pushes the data into patterns that are outside random expectations.
2. Examples of variation
    - **a.** Writing exercise c. Crime rates e. Department variances from budget
    - **b.** Commuting d. Fire turnout time f. HR time to fill positions
3. **Why do numbers vary?** – All systems and processes are affected not by one factor but many factors or causes. Some may be strong, some weak. Some may be always present while others will pop up at different times or places. But having many potential causes at play has two consequences:
    - **a.** You can always find a "reason" to explain why the numbers are up/down.
    - **b.** You can't be sure if your selected reason is right.
4. **Seeing variation is hard with tables of data**. – While we may know numbers vary, typical presentation styles may make it hard to see. We need context.
    - **a.** Typical tables showing one, two or three data points can be misleading.
    - **b.** Typical traffic light dashboards may hide the patterns.
    - **c.** Simple line graphs can dramatically improve our awareness of the variation in place.
5. **We need to see two different types of variation if we want to raise our understanding**.
    - **a.** Common Cause – Also called predictable or routine. It is always present and accordingly can be used to predict the future within limits. There is no single assignable cause that we can separate out from all the causes. If we want to improve the problem we have to change the process itself.
    - **b.** Special Cause – Also called unpredictable or exceptional. This is not always present, can change over time and thus can't be predicted. A single assignable cause dominates the process though it may not be clear in all situations. If we want to improve, we have to fix and remove the assignable cause.
3. **Control charts (or Process Behavior Charts) are a simple but effective tool for seeing variation, analyzing it, and interpreting it to make useful changes for improvement**.
    - **a.** There are lots of different types of control charts
    - **b.** The I-MR or X-MR chart (Individual Moving Range) is the Swiss Army knife of control charts. It is particularly good for services and administrative processes. It also is reasonably effective and dependable even when other control charts might be the first choice so it should be the key chart you know.
    - c. See the latter sheets explaining how to calculate and interpret the I-MR control chart
4. Some common challenges when using control charts.
    - a. ***Recognize the value of special causes.*** While special causes suggest problems they may also be opportunities. Either indicate the process is not fully predictable. The special cause is valuable because it points you right to where something changed in the process. This might be a point in time where a mistake happened spiking the data or it might be where the process shifted. The control chart is valuable because it gives you strong clues to where to

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look for further detail. You may not always determine what the cause is, but you have a strong starting point as determined by the unusual variation. This should make it easier to identify some needed fixes to causes which actually drive the process.

b. ***"The calculated range is too wide"*** – Keep in mind the control chart is the voice of the process and is telling you what is, not what you may want to be. If the range is wider than desired, that calls for process improvement. If the range seems too wide for good predictability, realize that nevertheless that is your current process.

c. ***"The range is so wide no problems are evident"*** – This may be fine. But it could also be your data may be made up of sub-categories that need to be broken up or stratified. For example it may be that overall, there are no special problems but if we compare the northern units versus the southern units or the patients with one type of disability versus another, we may find differences that get hidden in the group averages. Digging deeper into the data to analyze sub-groups is a better first step than immediately moving to experiments to improve the process or detailed process investigation.

d. ***"Sometimes we get special causes on the good side"*** – This is a good finding. If you get points highlighted as special causes but on the favorable side of your measurement, look to see if you can determine what caused the good result and if it can be adopted or adapted into your process for overall improvement.

5. While control charts are the most common name, if you are just starting out, I recommend the alternate terminology suggested by Donald Wheeler in the table to the right.

Traditional Terms	Better Terminology
Control Chart	Process behavior chart
In-control process	Predictable process
Out-of-control process	Unpredictable process
Control limits	Natural process limit
Statistical process control	Continual improvement

6. Control charts have many benefits not easily achieved with other tools.
    a. Establish a baseline and predictable limits for performance
    b. Determine if a process is stable/predictable.
    c. Detect special variation which needs fixing
    d. Monitor a process over time for continuity or change.
    e. Determine whether efforts to improve made a difference.

Control charts (process behavior charts) are an excellent way for you to understand the variation in your systems and processes. They can help you avoid overreacting to each move in your data. They can help you avoid blaming employees when numbers move even though the processes haven't changed. The information can be to predict results if the process is stable. If unstable, you should focus first on correcting special causes where appropriate or recognizing when processes have shifted. Control charts provide the context for focused effort to improve processes in a way that distinguishes between common and special causes and lets you determine if future changes actually make a difference.

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Some resources:

Books • **Understanding Variation by Donald Wheeler** • Making Sense of Data by Donald Wheeler • Data Sanity by Davis Balestracci ***Websites*** • www.spcpress.com/djw_articles.php • www.davisdatasanity.com/newsletter-archives/	***Software*** • www.qimacros.com for Excel control chart add-in and training materials on Lean Six Sigma • http://www.mercerqualityconsulting.com/statistical-thinking.html for a less expensive add-in but it just does control charts. • Google other software by using search terms like "SPC software" or "Excel add-ins for control charts". • See Excel template and I created and shared which has limited features but can be used as a start.

Table for writing example.

1. Write the letter "a" using your dominant hand (e.g. right hand if you are right handed.) Do this as best and consistently as you can but do it quickly. Do it ten times, once for each row.
2. Repeat the exercise for the second column but this time use your non-dominant hand (the opposite hand you used in the first round).
3. Finally, start in the third column using your dominant hand and then randomly pick a number between 4 and 7 and change to your non-dominant hand at that row. Complete to the tenth row with that hand.

Order	**Dominant Hand**	**Non-dominant**	**Combo**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

- *Can you see both the consistency but also the variation within each of the first two columns even though the process stayed the samewithin each column?*
- *Can you see the differences between the "two processes" of the first two columns?*
- *Can you show the third column to someone sitting next to you and have them tell you when you randomly started the "new process"?*

This is a simple exercise to let us see variation within a process (common cause), between two processes, and when a process changes (special cause).

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Imagine some day tracking how long we wait in line for service.

Trip	Waiting in Line	Range
1	3.5	
2	2.4	1.1
3	4.1	1.7
4	2.8	1.3
5	3	0.2
6	4.7	1.7
7	1.2	3.5
8	0.9	0.3
9	2.5	1.6
10	3.1	0.6
11	3.6	0.5
12	4.1	0.5
13	3.8	0.3
14	2.5	1.3
15	2.8	0.3
16	4.3	1.5
17	4.1	0.2
18	3.6	0.5
19	2.4	1.2
20	4.8	2.4
21	3.5	1.3
22	2.5	1
23	1.3	1.2
24	4.5	3.2
Average	3.17	1.19

1. Calculate the range which is the absolute value of the difference between the current point and the previous point.
2. Find the average of the ranges.
3. Create an upper limit for the ranges by multiplying the average by 3.268 and add to the average.
4. Plot the range chart.
5. Find the average for the actual data.
6. Plot upper and lower control limits for the actual data with the formula Average ±2.66 *Average Range
7. Plot the data chart.

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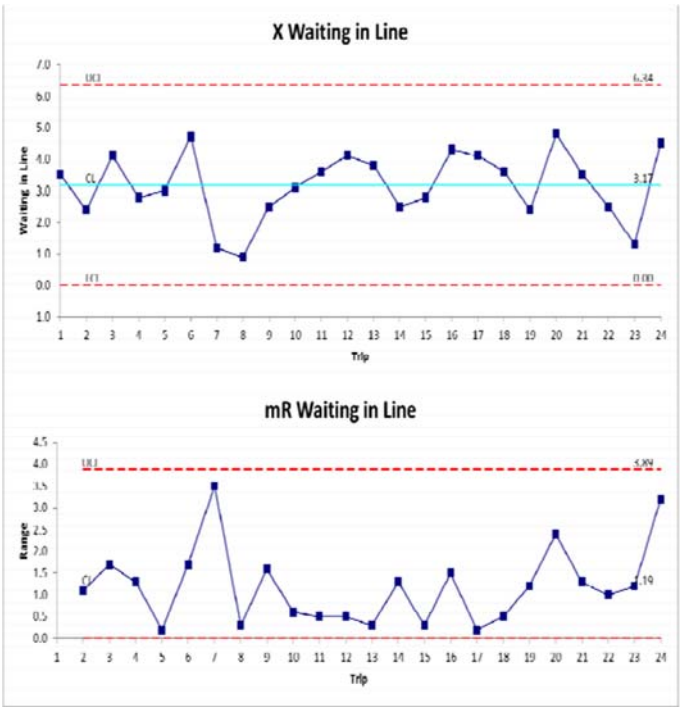
How to interpret the range chart.



1. The range chart tells us the average difference from period to period is 1.19 minutes and the maximum change in waiting time we should see assuming a predictable process is 3.89 minutes.

2. No points on the range chart are past the 3.89 control limit so there are no points of concern on that chart.

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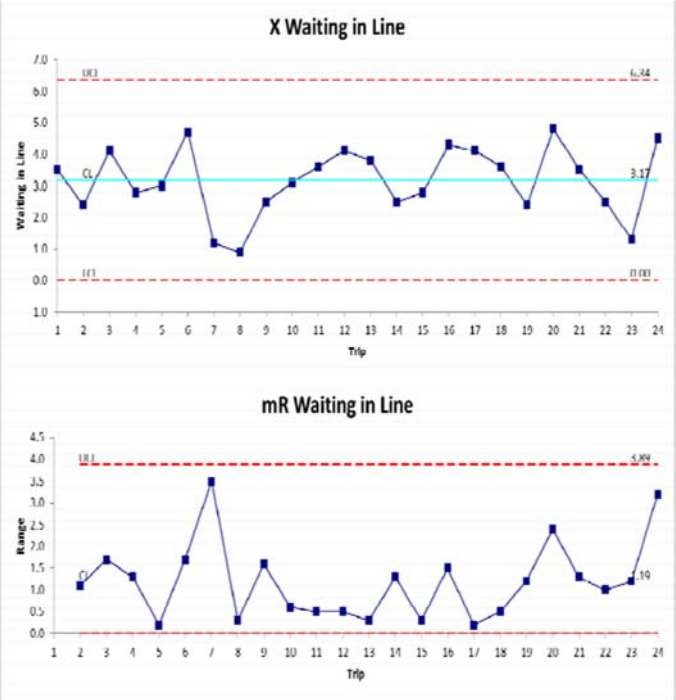
How to interpret the data chart.

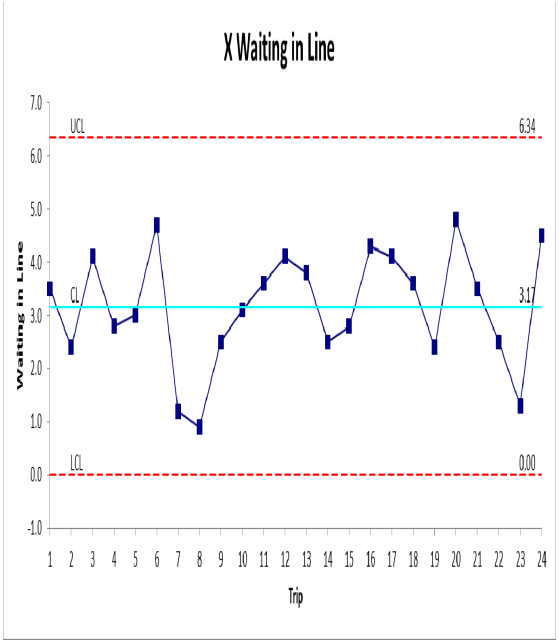


3. On the waiting time data chart, we see that the times, while varying, all lie within the control limits. We would conclude this is a stable and predictable process.

4. The average waiting time is 3.17 minutes and the maximum that would be expected is 6.34 minutes and we might see instances of zero waiting time.

5. Unless changes take place, we can use this for making predictions going forward and checking when we have problems.

A few things to note about the chart.



1. The numbers in the graph represent what actually happened, called the "Voice of the Process".
2. We may want something better (lower average times or a lower maximum time) but that is a separate question ("Voice of the Customer"). Don't confuse the two.
3. If we want to make changes we do it by focusing on the process overall and not on fixing specific points. Don't confuse common variation with special variation.