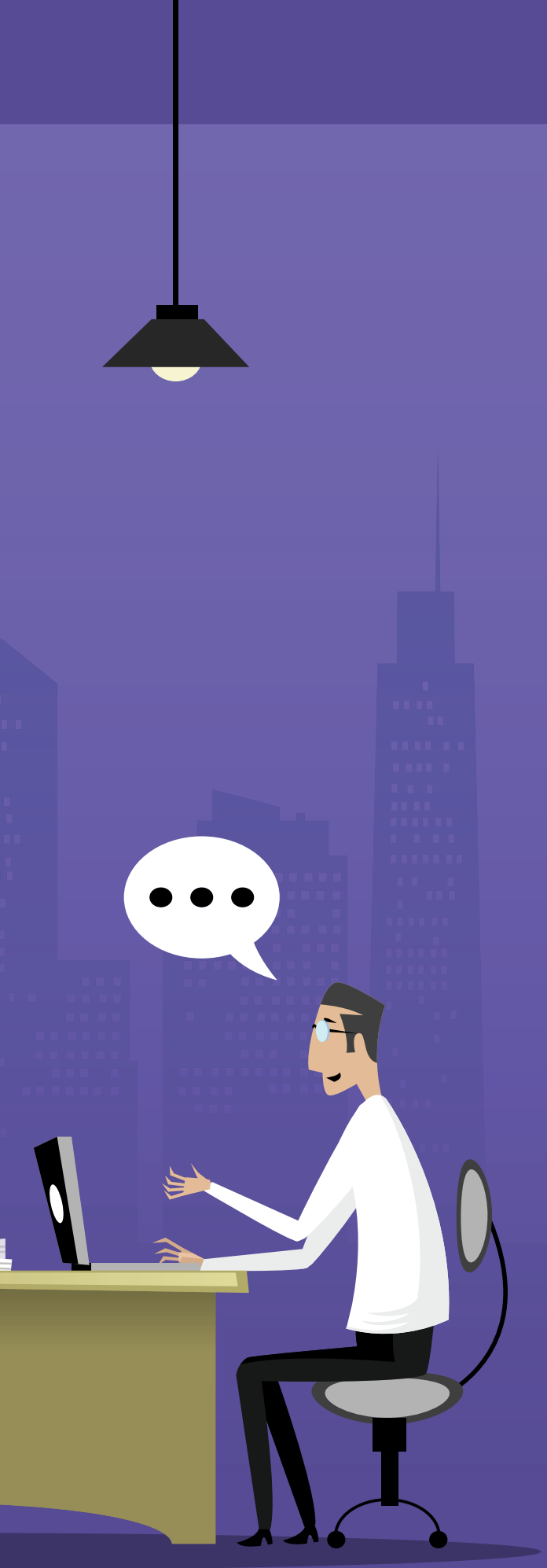
Discover, Devise and Deploy

Plotting a plan with basic process improvement tools in a lab setting | by Charles E. Holman

Just the Facts

This fictitious story introduces how the design and development of performance metrics and the use of basic process improvement tools can assist the overall effectiveness of a lab production environment.

The story follows a manager as he teaches his team the power of measurement and statistics to implement process improvement and sustain change.



"Tell me how you measure me, and I will tell you how I will behave."

If you've been in quality for some time, you may have heard this quote from Eliyahu Goldratt tossed around when management develops metrics. With that in mind, consider this: What if measurements, or performance metrics, didn't exist to determine whether a system or process was performing or behaving well?

In the spirit of the late Goldratt, here's a fictitious story—based on real events—to introduce how the design and development of performance metrics, and the use of basic process improvement tools, can assist the overall effectiveness of a production environment.

Opening the box

A manager named Jack opened the organization's suggestion box and discovered several comment cards. Jack was hired recently to address a problematic precision measurement equipment laboratory (PMEL) that calibrates and certifies test, measurement and diagnostic equipment (TMDE).

Jack was a technical expert with a background in varying TMDE disciplines. He was a young, smart and motivated leader who had successfully progressed through the corporate ranks and ran PMELs throughout the country.

After solving a rather complex workload capacity issue in a PMEL at a plant in Maine, corporate leaders decided to send him to the "black eye" of their portfolio in Gilroy, CA, which had a recent outbreak of customer complaints.

Based on the data collected from the comment cards, Jack discovered several issues:

+ The PMEL production control section's customer support satisfaction was poor, and customer response to requests was slow.
+ Unscheduled and unpredictable customer demand frequently caused long wait times during check-in or pick-up of TMDE.
+ The process of checking-in TMDE was time consuming and led to traffic bottlenecks in the waiting area.
+ Overdue TMDE, or TMDE that exceeded calibration intervals, was not turned in to the PMEL, and equipment pick-up by customers wasn't timely.

Improvement process

As a result of this data, Jack decided to put together a continuous process improvement (CPI) team. The CPI team

was formed to tackle the identified issues, as well as the objectives and goals listed in the project charter shown in Table 1. To formalize this improvement process, the CPI team documented the charter, also included in Table 1.

The CPI team identified the business needs and justification for improvement. After consulting with the corporate office and performing several customer surveys, the business needs (listed in Table 2) were documented.

As expected, the process improvement event moved forward, and change seemed to be in the air. The PMEL staff, however, became agitated and decided change was not required after all. Despite the feedback received, members of the production control section argued that, contrary to the feedback responses, "customers were unruly" and "had no concept of what really happens behind closed doors."

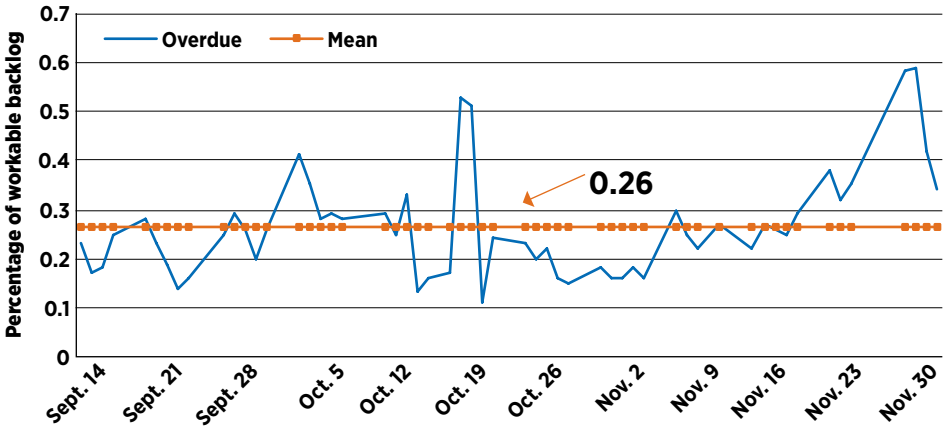
With this in mind, Jack challenged the production control section to measure its current process for overdue TMDE and plot factors on a run chart as time vs. percentage of workable backlog, and customer wait time (CWT) as time vs. average minutes of wait time per customer.

Paul, a 15-year employee with a strong disposition against change, accepted the challenge and agreed to gather the data and involve the CPI team when developing the charts.

After 75 days, Jack requested an update on Paul's run charts. Hesitantly, Paul sent Jack the charts (Figures 1 and 2) with an added mean metric from the CPI team.

FIGURE 1

Overdue TMDE run chart with mean



TMDE *= test, measurement and diagnostic equipment*

Capability analysis needed

The charts confirmed Jack's worst suspicions: Things were out of control! Jack asked the CPI team to perform a capability analysis. Not everyone on the team was up to speed with the concept, so Jack needed to do some training and teach the team the tool.

"Capability analysis is generally based on calculations that assist in determining whether a process or system is stable and requires improvement," Jack told the team in his best teaching voice.

"Math!" cried one team member.

"Yes, we are going to use math to help us solve our problems," Jack replied.

After a few days, the team provided the following results:

Overdue TMDE—The CPI team and management decided overdue TMDE should account for 0.1% or less of the workable backlog. The average for overdue TMDE was calculated to be 0.26%. Based on the data, the standard deviation for overdue TMDE was 0.107%. The upper limit, or maximum allowable overdue TMDE, was 0.1%.

Using the calculation $C_{pk}(u) = \frac{0.1\ (USL) - 0.26\ (Xbar)}{3 * 0.107\ (\sigma)}$, the result is ~ −0.49. This is indicative of a process that requires much improvement. The standard for C_{pk} is 1.3 or greater.

Note that the standard deviation for the process exceeds the upper limit within less than one sigma. This process requires a complete modification to improve consistency of overdue TMDE.

TABLE 1

Project charter

Project objectives and goals	Metric	Baseline	Goal
Reduce PMEL CWT. Increase equipment throughput in scheduling. Reduce the amount of TMDE items that are overdue for calibration. **+ Reduce CWT by 75%.** **+ Reduce overdue calibration 50%.**	**+ CWT.** **+ Overdue/ workable backlog.**	**+ 1.5-hour wait.** **+ 0.3% of workable backlog.**	**+ 20-minute CWT.** **+ < 0.1% of workable backlog.**

CWT *= customer wait time* ***TMDE*** *= test, measurement and diagnostic equipment* ***PMEL*** *= precision measurement equipment laboratory*

CWT—Recent customer surveys and feedback identified that customers would like a wait time of 20 minutes or less. The average for CWT was calculated to be 48.41 minutes per customer. Based on the data, the standard deviation for CWT was 23.13 minutes. The upper limit, or maximum allowable CWT, was 20 minutes.

Using the calculation $C_{pk}(u) = \frac{20\ (USL) - 48.41\ (Xbar)}{3 * 23.13\ (\sigma)}$, the result is ~ −0.41. This also is indicative of a process that requires much needed improvement. The standard for C_{pk} is 1.3 or greater.

Note the standard deviation for the process exceeds the upper limit. This process requires a complete overhaul from the ground up.

Jack was ecstatic. He finally had the data-driven proof that showed significant issues in the production control section that required much improvement. Additionally, because it was his CPI team that was made up of PMEL employees who identified the problem, it was easier to build consensus for any future process improvements.

Under further instructions and directions from Jack, the CPI team was instructed to produce a flowchart diagram to provide a pictorial representation of how TMDE flows through the PMEL. The flowchart started from the trigger event that notifies the customer (the owning work centers) to bring TMDE in for calibration and ended with the customer picking up calibrated TMDE. Figure 3 (p. 40) provides an example.

After completing the flowchart, the CPI team was provided another CPI tool, the fishbone diagram. Armed with the gathered data and flowchart, the team identified the causes or potential causes that could or had resulted in overdue TMDE and long CWTs. After generating a list of possible causes, the CPI team placed each of the causes under the following categories to better isolate where the true root cause might be found:

1. Equipment.
2. Process.
3. Personnel.
4. Environment.
5. Measurement.
6. Material.

The CPI team produced the fishbone diagrams shown in Figures 4 and 5 (p. 41).

The change process

Jack sat back on a Wednesday afternoon and looked out his office window. The CPI team had been working hard, and the tools produced thus far were beginning to build a sense of urgency for change within the PMEL walls. It was at this time he decided to call in his management team to discuss possible morale issues within the PMEL as a result of potential change. As a result, Jack found that everyone agreed the best way to help bring change into

TABLE 2

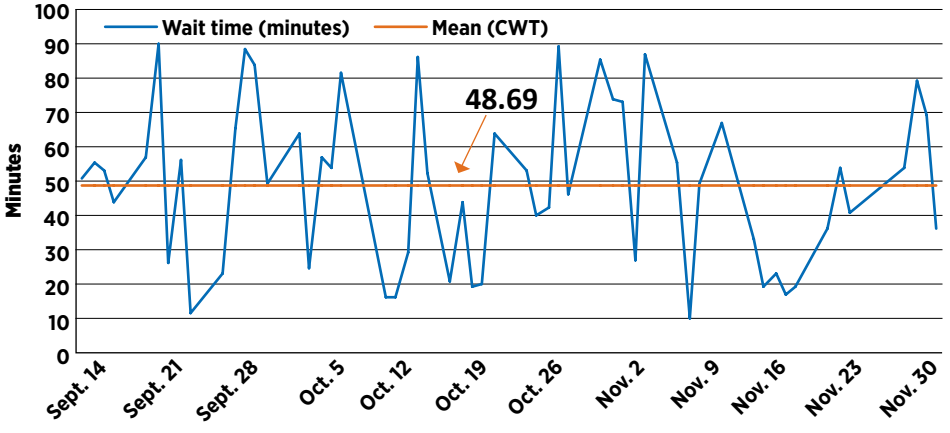
Business needs

Business need	
	Customer impact: **Customers have severe wait times due to the lack of assigned drop-off times. Furthermore, the summation of all variables, internal and external, has caused an increase of time in status. This means TMDE is delivered to external customers in a reasonable time.**
	Shareholder impact: **Reduce operational expenses by reducing variability in the production control section while decreasing inventories of regular calibration due, regular calibration overdue, overdue scheduled maintenance and unscheduled maintenance of TMDE. Overall, identify and eliminate all unnecessary constraints in an effort to exceed customer expectations and mission demands.**
	Employee impact: **Production control section employees have no standard of work to perform the tasks required as outlined in corporate standard operating procedure 10.4.5. The lack of written or published processes has led to reactionary interpretations of local policies. This has led to a hostile work environment with low job satisfaction and poor quality performance from production control technicians. Furthermore, no formal training in customer service has led to employee-customer confrontations that have been elevated to superiors for resolution.**

***TMDE** = test, measurement and diagnostic equipment*

FIGURE 2

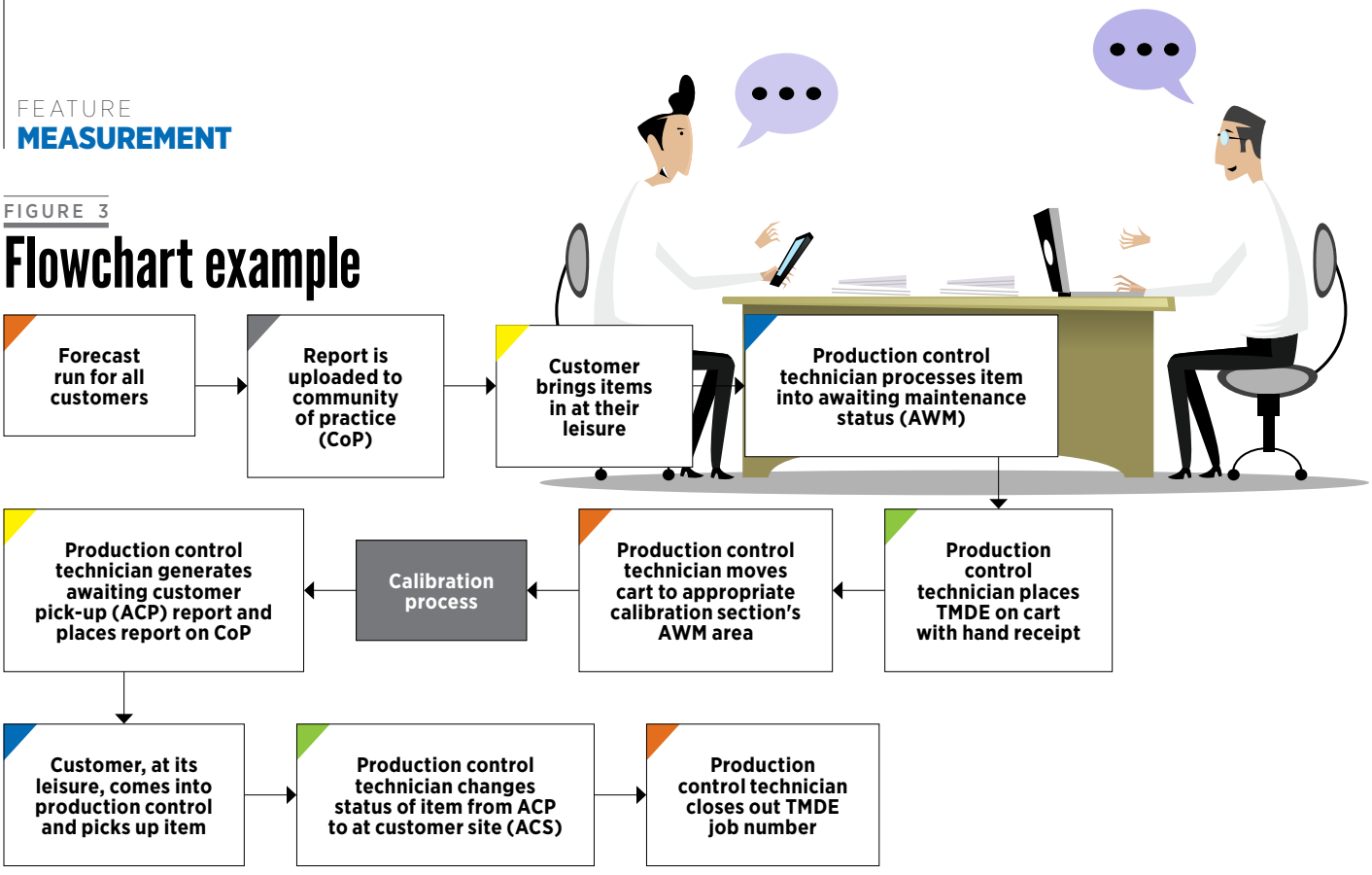
Customer wait time run chart with mean



***CWT** = customer wait time*

FIGURE 3

Flowchart example



TMDE *= test, measurement and diagnostic equipment*

the PMEL was to let those personnel who performed the process actions daily be involved with the CPI team. This way the personnel could see firsthand where an issue was and potentially add much-needed insight when developing a solution that everyone would agree on. After the management team left Jack's office, he turned to the window and began to smile against the sunshine. He had been here before and it felt like he was back in Maine, where he enjoyed one of his greater process improvement successes.

Next, the CPI team assembled for an "effects for action" meeting, in which the team evaluated all potential causes for each effect identified during the fishbone diagram development. After the information was reviewed, some on the CPI team began to bicker about next steps. "How do we decide which cause generated which action or effect?" one team member asked. Jack, having gone through this scenario a dozen times, suggested using the almighty dollar.

"I am going to give each of you $100. I want you to place the amount of money you would be willing to pay to fix any or all causes. You don't have to put all the money into one cause. You can disperse as you see fit based on level of importance. Two rules, though: You must spend all the money and I want you to write the spending break-out on a separate piece of paper so that no one else can see your results," Jack said.

Each member grabbed a separate piece of paper, marked down all the causes for each effect and dispersed his or her $100 appropriately. Jack collected the pieces of paper and began to tally the numbers. Once complete, he sent his team on break and went to his office. Confused and curious, the CPI team members decided to follow their boss instead.

In his office, Jack turned on his computer and opened a file called "Pareto analysis." On the screen was a chart on one side of the field and blocks to enter data on the other. At the top of the field read "Pareto chart." Jack explained that a Pareto chart takes collected data and provides a chart that can assist in identifying the 20-80 problem or solution. Jack entered the first set of data from the CWT causes and produced the chart in Figure 6 (p. 42).

Paul saw the chart and asked, "So, you're not

TABLE 3

Overdue TMDE result

Group	Original process—overdue TMDE	New process—overdue TMDE
N	**55**	**13**
Mean	**0.264**	**0.05**
Standard deviation	**0.107**	**0.029**
α =	**0.05**	**0.05**

TMDE *= test, measurement and diagnostic equipment*

making this stuff up?"

"What do you mean?" Jack responded.

"Well, I mean, all these tools you're teaching us are basically building on one another and telling us a story. You didn't just make this stuff up. There is a science to process improvement. I always thought it had to be super-complicated," Paul said.

Jack grinned and looked back at his computer to finish entering the data for overdue TMDE.

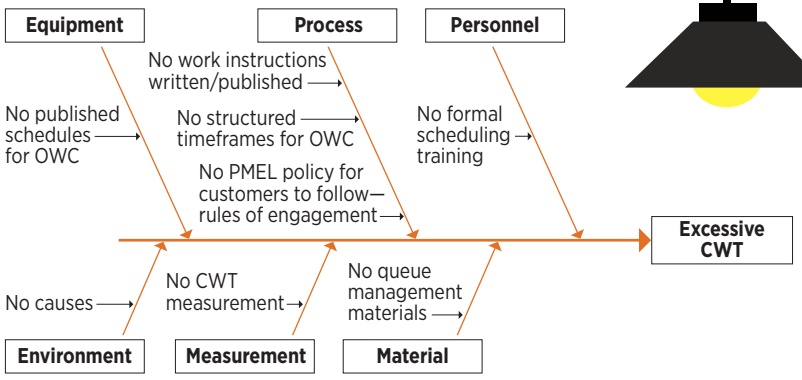
Ready for implementation

The CPI team was now ready to produce actions for implementation. After formally presenting the actions for implementation to Jack, the team members were eager to see the results.

Satisfied with the CPI team's presentation, Jack decided to move forward with the requested change actions.

FIGURE 4

Fishbone diagram—CWT



CWT *= customer wait time* ***OWC*** *= owning work center*
PMEL *= precision measurement equipment laboratory*

After a few weeks, Jack requested a run chart to show whether there was a noticeable change in overdue TMDE or CWT. Since the changes, Jack had not received any verbal feedback and the suggestion box was empty.

Paul, whose normally negative behavior had changed recently for the better, came into Jack's office with an unusually wide smile. "I bet you're going to like this, sir!" he said. Paul produced the following report:

Overdue TMDE—The improvements made to the original, unstable process showed significant results. The results from the comparison tests are shown in Table 3.

Overdue TMDE synopsis—The results from the data showed the process improvement team should reject the null hypothesis. Further analysis showed the two processes are completely different. The new processes will yield significant improvement.

Using the calculation $C_{pk}(u) = \frac{0.1\ (USL) - 0.05\ (Xbar)}{3 * 0.029\ (\sigma)}$, the result is ~0.57. Compared to the previous test result of ~ −0.49, the process is trending toward stability. The CPI team recommends continued monitoring over the next 75 days to capture enough data to solidify implemented actions.

CWT—The improvements to the original, unstable process showed significant results. The results from the comparison tests are shown in Table 4 (p. 42).

CWT synopsis—The results from the data showed the process improvement team should reject the null hypothesis. Further analysis showed the two processes are completely different. The new processes will yield significant improvement.

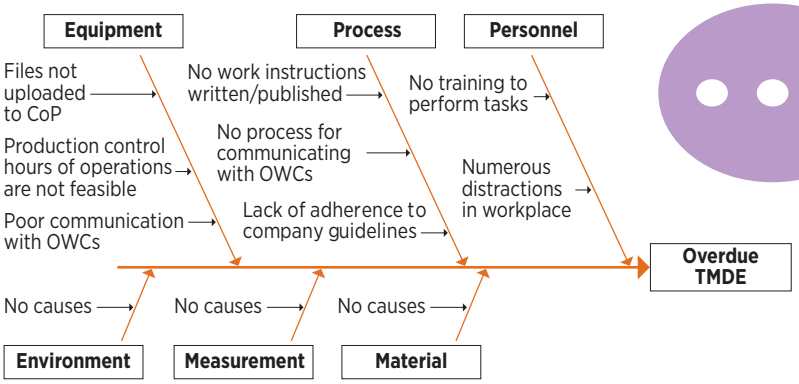
Using the calculation $C_{pk}(u) = \frac{20\ (USL) - 10.385\ (Xbar)}{3 * 4.764\ (\sigma)}$, the result is ~0.67. Compared to previous test result of ~ −0.41, the process is trending toward stability. The CPI team recommends continued monitoring over the next 75 days to capture enough data to solidify implemented actions. See the run charts in Figures 7 and 8 (p. 43).

Culture change

It was the end of a very enlightening last fiscal quarter. Jack had watched a group of employees successfully tackle a

FIGURE 5

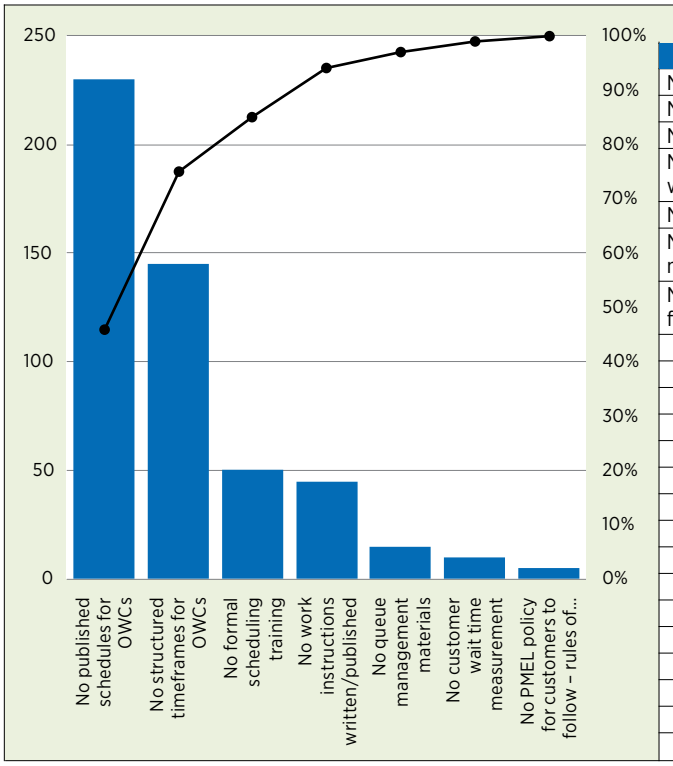
Fishbone diagram—overdue TMDE



CoP *= community of practice* ***OWC*** *= owning work center*
TMDE *= test, measurement and diagnostic equipment*

FIGURE 6

Pareto analysis—customer wait time



	total: 500	
No published schedules for OWCs	230	46%
No structured timeframes for OWCs	145	75%
No formal scheduling training	50	85%
No work instructions written/published	45	94%
No queue management materials	15	97%
No customer wait time measurement	10	99%
No PMEL policy for customers to follow – rules of engagement	5	100%

OWC *= owning work center* ***PMEL*** *= precision measurement equipment laboratory*

problem and work as a team to solve it.

There was a sense of unity present within the doors of the Gilroy PMEL for the first time since he arrived.

As he was walking out of his office, Paul stopped Jack and remarked, "I can't help shake the feeling that we failed. Even though we are seeing a positive trend in the data with the new implemented actions, our C_{pk} (U) is still not showing greater than 1.3. Did we miss something?"

"This is continuous process improvement, not continuous process solving. The change in data was a success," Jack replied. "We need to monitor and assess our implemented actions and adjust accordingly over time. Our ultimate goal, however, is to satisfy the needs of the customer. I believe we are on the right track to do this—only because our CPI team was successful."

Paul let out a sigh and said "Thanks boss! Hope you have a good rest of the day. Thank you for all your help and I am looking forward to tackling some other areas of potential improvement within our PMEL."

After Paul left, Jack walked back into his office and shut the door. He sat at his desk and looked at his reflection in the window as the sun began to set on the horizon.

"We did it! We are doing it! We will be better!" Jack stated in a quiet, mantra-like voice. The shadows were changing in Jack's office as the sun disappeared over the horizon. "We did it! We are doing it! We will be better! We did it! We are

TABLE 4

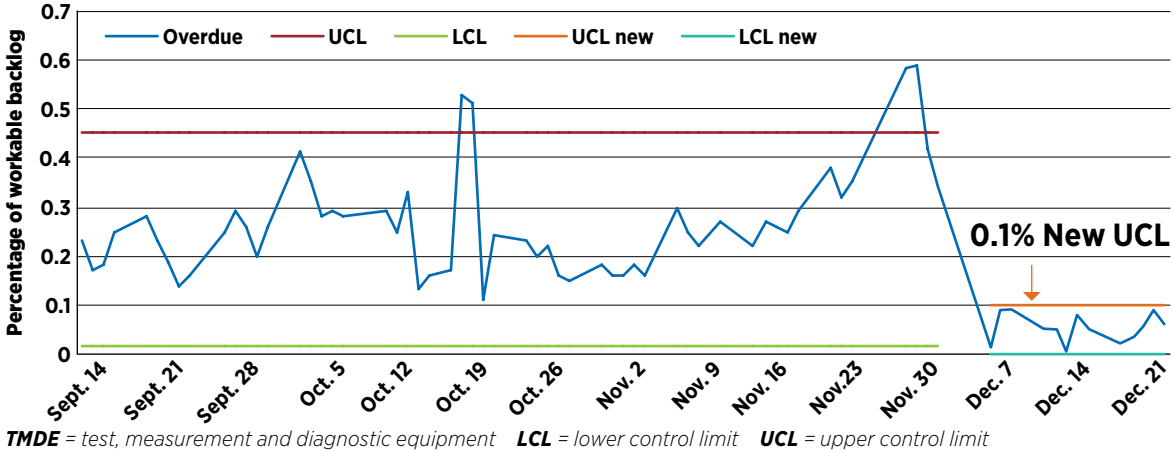
CWT improvement results

Group	Original process—CWT	New process—CWT
N	**55**	**13**
Mean	**48.691**	**10.385**
Standard deviation	**23.222**	**4.764**
α =	**0.05**	**0.05**

CWT *= customer wait time*

FIGURE 7

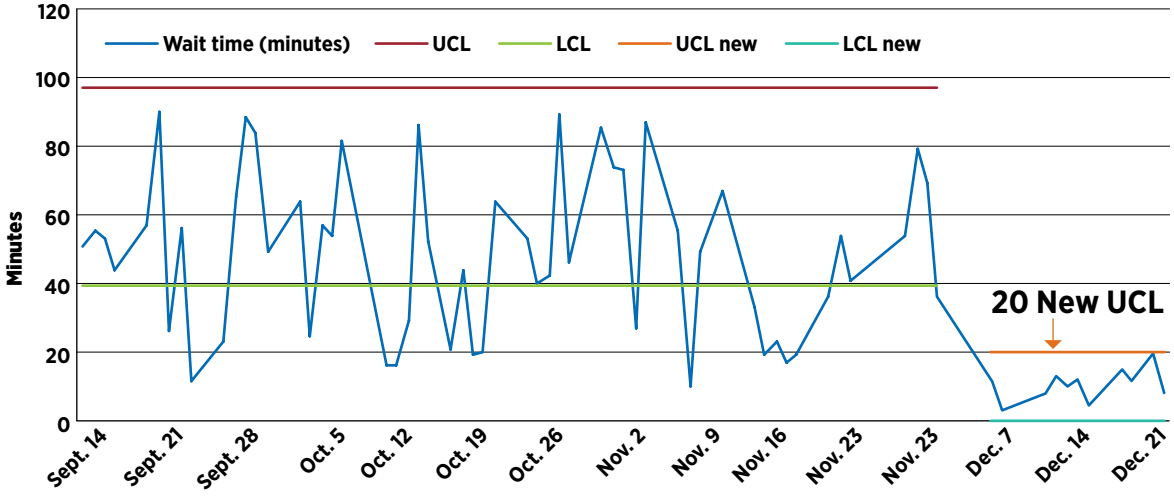
Overdue TMDE control chart



TMDE *= test, measurement and diagnostic equipment* ***LCL*** *= lower control limit* ***UCL*** *= upper control limit*

FIGURE 8

CWT control chart



CWT *= customer wait time* ***LCL*** *= lower control limit* ***UCL*** *= upper control limit*

doing it! We will be better!"

Jack looked down at a stack of documents with the cover sheet titled "Workload Demand Report." It was a report from the company that added a significant workload to the Gilroy PMEL scheduled for the next fiscal year, which started in September. In the report, the Gilroy PMEL would take on more work from other PMELs in the company's portfolio, but no additional manpower would be authorized.

"Here we go again," Jack muttered. On to the next challenge. QP

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