Module 4: Quality Management Basics (Statistical Process Control)

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4.01 Learning Objectives

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After completing this module, you should be able to:

1. Describe principles that help guide quality management activities
2. Use the Plan-Do-Check-Act cycle to coordinate work and implement change
3. Explain the differences between quality control and quality assurance
4. Create a SIPOC diagram to help visualize work as a process
5. Explain the role that metrics and statistics play in measuring and controlling work processes
6. Apply analysis and planning approaches to quality
7. Explain how the Seven Basic Quality Tools are used to monitor and control quality processes
8. Use the Seven Basic Quality Tools to process and sort non-numerical data
9. Use the Seven Basic Quality Tools in combination to create powerful plans and solutions to quality problems
10. Describe various quality management programs
11. Employ quality management tools based on a brief case study

4.03 Video: Quality Management and Statistical Process Control

This assignment does not contain any printable content.

4.04 Quality Management Principles

Quality Management Principles

Projects that fail to meet requirements are a waste of time and resources. Team members may put in long hours and significant effort, but if they are not aligned to meet expectations, they aren't achieving effective results. To guarantee that this doesn't happen to your projects, you'll need to institute some form of quality management to ensure that the work on your project provides high value to its stakeholders.

The International Organization for Standardization (ISO) has developed several quality management principles to guide practices and to help you frame your quality management activities. By using these principles as you implement your quality processes, you'll ensure that you take a holistic view of quality management and maximize its effectiveness. All of the tools mentioned in the following table will be further explained throughout the course.

A focus on customers

Organizations should work to understand customers' current and future needs and strive to meet or exceed those needs. This focus on customer satisfaction will lead to increased loyalty from customers, which in turn will lead to an increase in revenue and market share as customers return for repeat business.

Lean processes are important when focusing on the customer. Lean processes focus on eliminating anything that does not add value to customers or satisfy the customers' needs. Another useful tool when focusing on the customer is the **Plan-Do-Check-Act Cycle**. This cycle can be used to work with the customer to create the best possible product available.

A commitment to strong leadership

Quality management activities and programs require strong leaders who will ensure that teams are disciplined in their approach and remain aligned on clear goals and objectives. Having a strong leader to guide activities will increase the team's understanding of its objectives and minimize miscommunication among project participants.

Tree Diagrams and **Process Decision Program Charts** are two tools that are useful in strong leadership. Tree diagrams can be used to define the structure of a company, as well as the duties and responsibilities of the people in it. Process Decision Program Charts are a type of tree diagram that breaks down a project into different activities and helps mitigate risk.

Engaged colleagues

People at all levels of the organization must be fully engaged and involved in the pursuit of quality to maximize its benefits to the organization. Fully involved participants will be more motivated and committed to project success and continued improvement.

The **Interrelationship Digraph** is useful when engaging colleagues because it shows the far-reaching impact that an individual or a team can have on the other different areas within the company's operation.

A focus on process

When resources are looked at and managed as a process, results are easier to manage and achieve. A process approach also helps to create consistent, predictable outcomes and uncovers opportunities for improvement.

A **Supplier-Input-Process-Output-Customer** (SIPOC) diagram is very useful when focusing on the process of managing resources. An SIPOC diagram will show all of the elements that can influence a process before the process has started.

A systems approach

When adjustments are made, their impact on the whole system should be analyzed because a change in one part of the system may affect other parts as well. This systems approach will help to ensure consistency and efficiency among organization-wide activities.

A very useful tool that approaches the business like a system of interconnected parts is the **Interrelationship Digraph** which is useful in understanding the possible impact of a change.

A commitment to continuous improvement

Every individual in the organization should be committed to increasing their skill and performance on a regular basis.

This commitment should benefit both the individual and the organization by increasing skills and effectiveness.

The **Plan-Do-Check-Act Cycle** is an important tool when committing to continuous improvement. This cycle can be used to create the best possible process or product. **ISO Certification** can also be useful for a company as it states that a company is dedicated to quality practices and is continually working to ensure that it is producing at the highest level possible.

Dedication to fact-based decision making

By ensuring that decisions are based in fact, organizations can be sure that options are chosen because they are best for the project and organization. These informed decisions reduce bias and foster trust in decisions and plans.

A **prioritization matrix** helps a team prioritize their options statistically before determining the best possible fact-based outcome. **Six Sigma** can also be useful making fact-based decisions when looking at quality because it measures the performance and determines areas that need improvement.

A collaborative relationship with suppliers

A relationship with suppliers that benefits both parties will encourage interaction and a sharing of expertise that may not otherwise be present. This integration and cooperation should result in an increase in flexibility and speed and a decrease in costs for everyone involved.

The **Network Diagram** can be a useful tool for supplier relationships because it defines what is needed at the beginning of the process.

Incorporating these principles into your quality management activities should improve the capability and performance of quality processes and help you realize benefits that you might not have realized otherwise.

The Plan-Do-Check-Act Cycle

The Plan-Do-Check-Act cycle (or PDCA cycle as it is commonly known) is a four-step method for testing hypotheses and solving problems. The cycle is based on the scientific method—develop a hypothesis, run an experiment, and analyze the results—to help gather information and test options before implementing changes on a large scale.

The cycle includes four steps:

- the *Plan* step, where you identify a problem and develop plans to solve the problem
- the *Do* step, where you run an experiment to see if your plans will work on a small scale before you implement them on a larger scale
- the *Check* step, where you analyze the results of your experiment and decide if they can be improved in any way
- the *Act* step, where you enact the change on a larger scale, making it a part of normal operations

4.05 Example: Using the PDCA Cycle to Coordinate Work

Example: Using the PDCA Cycle to Coordinate Work

Lincolnshire Bank & Trust has been serving patrons for over 50 years but would like to expand its business by developing a new Internet service that would appeal to online customers. The bank knows that a new, up-to-date service would attract new clientele and help it challenge its larger competitors for market share.

Lannie Bostwick, an experienced project lead, is asked to develop this new service to help Lincolnshire cross over into this market. Bostwick agrees to run the project but only after being assured that she can hand-pick the people she wants for her project team. She gathers a diverse and talented group of people that can quickly assess and plan the work of the project.

After a brief discussion of the project's intent, the team gets down to work. They brainstorm several ideas and record them in the following list:

- Design a safe and efficient site and service
- Roll out the new service to a subset of customers
- Record any problems encountered (by customers and within the system)
- Develop new reporting and review procedures for the banking staff to follow
- Develop additional policies and processes to correct for any problems that happened
- Survey customers to gather feedback about the new service
- Evaluate the ability of the bank's current third-party IT company to develop the Internet service
- Administer a new training program for the banking staff
- Track any changes to legislation to ensure that the system remains in compliance
- Measure the effectiveness of newly instituted training programs
- Improve the training programs
- Set a timeline for the development and implementation of the new service
- Make adjustments before opening the service up to all customers

Bostwick pauses for a moment, then asks for the team's opinion. "Now we have to coordinate this stuff into some sort of action plan. What if we used the PDCA cycle? We could place each of the ideas into the correct PDCA step so we'd have a process to follow."

Solution: PDCA Cycle

The *Plan* step should include the following ideas:

- Design a safe and efficient site and service
- Develop new reporting and review procedures for the banking staff to follow
- Evaluate the ability of the bank's current third-party IT company to develop the Internet service
- Set a timeline for the development and implementation of the new service

These four ideas would help the team develop an effective plan for the new service.

The *Do* step would contain the following bullets:

- Roll out the new service to a subset of customers
- Record any problems encountered (by customers and within the system)
- Administer a new training program for the banking staff
- Track any changes to legislation to ensure that the system remains in compliance

Each of these ideas describes an action that the team could take to test their thoughts before implementing them on a large scale.

The *Check* step should involve:

- Surveying customers to gather feedback about the new service
- Measuring the effectiveness of newly instituted training programs

These steps would help the team check the results of their pilot program.

Finally, the *Act* step would entail:

- Improving training programs
- Developing additional policies and processes to correct for any problems that happened
- Making adjustments before opening the service up to all customers

These three ideas would let the team make corrections and standardize their achievements before continuing the pilot program or opening the new service to all of the bank's customers.

Once this cycle of PDCA is complete, it can begin again with either a new focus for a new hypothesis or to determine the effectiveness of past cycles.

4.06 Quality Control vs. Quality Assurance

Quality Control vs. Quality Assurance

Quality management involves both quality control and quality assurance but these terms can be confusing because they are often used interchangeably. There are, however, distinct differences between them, as shown in the following table:

	Quality Control	**Quality Assurance**
Focus	Uncover defects so they can be fixed	Prevent defects from occurring
Purpose	Assess performance and recommend corrective action	Assess capability and recommend preventive action
Level	Basic—recognize problems so they can be fixed	Advanced—understand the intricacies of the system and predict outcomes
Major Activities	Inspection and repair	Training
Change Response	Reactive—take action once the problem has occurred	Proactive—take action before the problem can occur

Quality management is not an "either-or" proposition—you don't have to choose between quality assurance and quality control. Instead, you should strive to incorporate both into your quality improvement processes.

Quality control uses observed data to determine the changes that have to be made to a process or procedure. Quality assurance uses projected data to make the best possible model or procedure before that model or procedure is applied. In either Quality Control or Quality Assurance, data is used to improve Quality Management by having a greater understanding of the related procedure and its outcomes.

The combination of these two techniques gives you the best possible results by managing quality on two fronts. Refining your processes (quality assurance) will ensure that fewer defects are produced and will increase confidence that the outcomes you expect to see will actually be reflected in your results. But even with the best quality assurance processes in place, defects can still occur. Incorporating quality control measures on top of your quality assurance activities will ensure that these defects don't make it to the customer and will also alert you to gaps in your quality assurance processes that must be closed.

4.07 Example: Quality Control vs. Quality Assurance

Example: Quality Control vs. Quality Assurance

Northeast PLASTICS

Ted Danziger is the new quality control manager for Northeast Plastics, a small plastics company outside of Akron, Ohio. He has been hired to guarantee that the company's finished products will meet customer specifications and to manage the inspection process to spot any flaws. Northeast Plastics has a robust quality control system in place, but the company is still experiencing quality problems, even after spending a substantial amount of money on the issue.

The founder of Northeast Plastics, Caleb Barnes, likes to think that his company is a "precision manufacturer." Barnes is convinced that the key to quality is making sure that the machines are properly maintained and calibrated—in his words, "If the machines are working right, then Northeast Plastics is working right." The company spends a lot of time and money calibrating the production equipment but still sees errors in its finished products. As a result, the company has to inspect all of the pieces they produce to detect errors before they are shipped to customers. When errors occur, the flawed pieces are reworked if possible; if the flaws are too great, the pieces are discarded or recycled.

Danziger quickly notices that Northeast Plastics' quality can vary dramatically. Preliminary data shows that there are times when the molding machines are not calibrated correctly, and the weekend shifts seem to produce more errors than the weekday shifts.

Northeast Plastics had just landed a large contract producing plastic parts for an automotive company. Danziger notices on the first day of production that some of the parts are showing hairline cracks, so he meets with the production manager, Alice Provencher, to discuss the problem.

"It's not a machine error," Provencher says. "All of the machines were recently recalibrated—and double-checked. I'm pretty sure it's the feedstock we're using. The consistency seems to be off a little bit."

Danziger realizes that the only way to increase the quality of the company's products is to incorporate quality assurance activities into its operations. He's sure that Northeast Plastics needs to analyze its entire process—from beginning to end—and be proactive in tackling its problems.

Danziger's Quality Assurance Approach

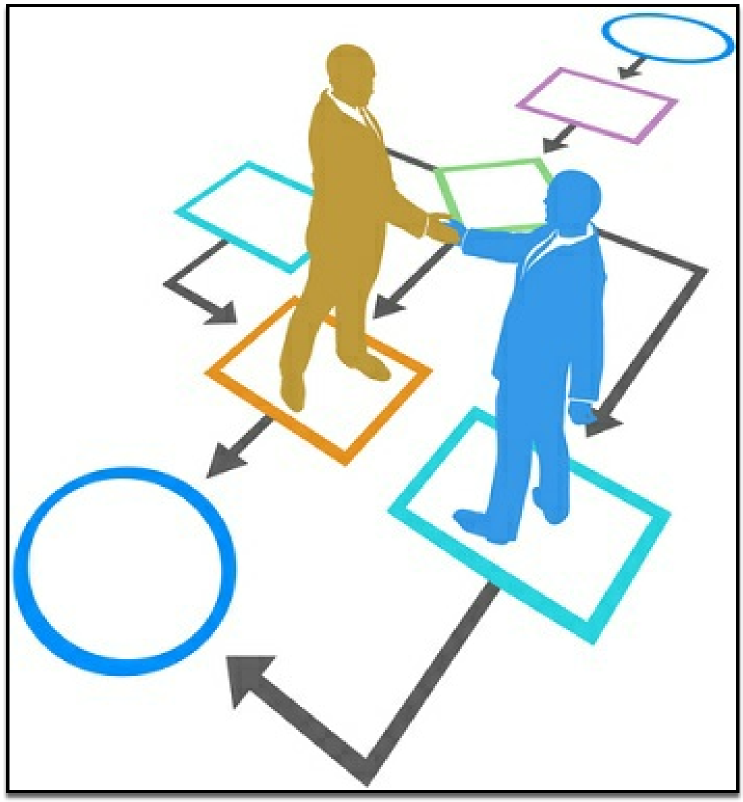
To review, Northeast Plastics has spent a lot of time and money on its quality control practices, but the current system is obviously not enough—the company is still experiencing problems. The machines have recently been calibrated, and the products are regularly inspected, but defects are still happening.

Danziger has some initial data to help him make his case. His preliminary information suggests that there is an underlying factor at work affecting the output from different shifts—even though both shifts are using the same equipment, the number of errors produced varies. And he has anecdotal evidence that the raw material being used is not adequate for the job. The quality control practices that Northeast Plastics has in place—recalibrating the equipment and inspecting output—will do nothing to help fix these problems.

However, incorporating quality assurance activities into operations will prevent defects like these from ever happening. Ensuring that all members of the production staff have adequate training and managing the quality of incoming materials will go a long way toward preventing defects *before* products are made; this should result in significant savings as the costs associated inspection and rework will be avoided. And integrating preventive actions may streamline the production process to the point where lengthy inspection and rework steps could be eliminated entirely. Danziger decides that Northeast Plastics would then realize benefits in both cost *and* time by incorporating quality assurance activities like these into their program.

4.08 SIPOC Diagrams

SIPOC (Supplier-Input-Process-Output-Customer)



One way to ensure that you are viewing your process as a whole is to create a SIPOC diagram. A SIPOC diagram allows you to see all of the elements that could influence the process before work is begun. It helps you define the boundaries of your operations by providing a high-level view of the complete process, from supplier to customer. (SIPOC is an acronym that stands for Supplier-Input-Process-Output-Customer.)

A SIPOC diagram will help you understand how process elements fit together. It ensures that you take a broad view of work instead of focusing only on the internal work that you and your team do. It guarantees that you'll take into account the quality of the work and materials that suppliers provide to the process, as well as how the outputs of the process are perceived and used by customers. It prevents you from viewing the process only from the team's point of view and stops you from optimizing work to satisfy only the internal process stakeholders.

A SIPOC diagram is usually created in a left-to-right format, with columns for each part of the diagram.

To see what information is included in a SIPOC diagram, click on the blue areas in the chart below:

S Supplier	I Input	P Process	O Output	C Customer

...are t... orga... will ... ervic... materials that the process will use to create results. Suppliers can be listed as generic roles or as specific individuals if that information is available.

Inputs are the services or materials that suppliers provide. Inputs can be recorded as raw materials, service activities, or anything that will trigger processes to start.

Processes are high-level descriptions of the work that will produce the results. Processes are often listed in a "verb + noun" format (such as "Create text") and may be shown as a flowchart to illustrate the order of the process steps.

Outputs are the results that will be produced. Outputs may be described as tangible products or as services provided.

Customers are the intended users of the outputs that will be produced.

When creating a SIPC ... pment. Asking key project participants to ... le angles and ensures that importan ... to discuss the process and explain it...

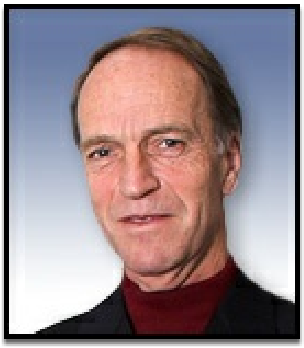
4.09 Example...

Example: Using a...

Judge Neil Oslund took off his reading glasses and sat back in his office chair. He had seen too many lawsuits like this one—two people who starte... and defendant.

Cary Mulford and Matt... Mulford and Garnett had been friends for y... they knew each other, they decided to...

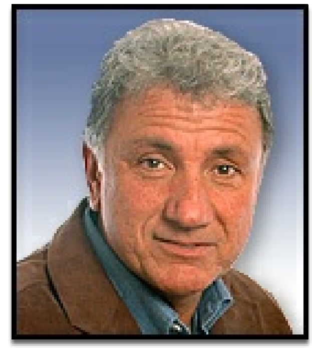
The problems in the project started early. Garnett tried to save some money by buying the project's raw materials from an online supply company. Mulf... regularly, but Garnett wouldn't listen, even j... materials. Angry at what he felt was an in... This caused an argument between the... and Mulford would



make it work.

Garnett's supplier was late in delivering the materials, so Mulford was forced to make adjustments to finish the job in time to start his next one. A lot of the materials delivered would not work with the initial design, so Mulford decided to "correct" the plan but didn't check with Garnett before making changes. When the job was finished, Garnett complained that the work was sub-par and the yard did not meet his requirements. Mulford argued that if he had been allowed to do the job the way it was supposed to be done, they wouldn't have had lousy materials to work with and wouldn't have had to piece together the parts to make it work. Mulford said that, based on the conditions he was forced to work under, he was surprised that it came out as well as it did.

Garnett refused to pay Mulford because the job did not meet his expectations; he felt that Mulford still had work to do to "do the job right." Mulford said that he had agreed to re-landscape the yard and, since that's what he did, the job was done.



Mulford sued to receive payment for the work he completed; Garnett countersued to get Mulford to complete the work they agreed on. Now it was up to Judge Oslund to resolve this issue.

What could have been avoided if a SIPOC Approach had been taken?

Mulford and Garnett failed to take into account how actions in each part of the process would affect the process as a whole. A SIPOC diagram would have allowed them to view the entire process and ensure that the parts would work together to meet the objectives.

In the fragmented process:

- The **suppliers** were late
- The **inputs** were of low quality and would not work in the initial design
- The **process** step was optimized to complete the work without worrying about the output or customer
- The **output** was pieced together without checking with the customer
- The **customer** was not satisfied with the final product

Had they chosen to use a SIPOC diagram, Garnett and Mulford would have seen that their focus on the individual project elements may have worked in isolation, but when taken together, their actions impeded the project as a whole and resulted in a failed venture.

4.10 Statistics, Metrics, and Quality

Statistics, Metrics, and Quality

Quality management practices often rely on measurements and statistics to quantify information and evaluate results. These measurements and standards help project participants look at processes objectively and provide a simple way to gauge improvements and progress.

Some quality management methodologies use statistical process control (SPC) to help teams monitor work and ensure that processes work to the best of their ability. SPC relies on metrics to illustrate results and to analyze the root cause of any deviations from plans. These metrics provide an objective way for teams and stakeholders to:

- compare performance to a standard to see if corrective action is needed
- expose trends in performance data
- forecast performance
- show whether improvement practices are effective
- make informed decisions

By employing SPC methods, a team can reduce the need for inspection by ensuring that quality is "built into" the process instead of "added on" to the end of the process. By making quality improvement activities an integral part of a process, SPC prevents mistakes from being incorporated into an entire batch of a product and also reduces the rework that would be needed to fix the product before it could be released to the customer.

Sampling

Metrics help teams measure process results, but it may be impractical (or even impossible) to measure every result that a process produces. Testing every product may be too expensive or time-consuming or may destroy the inventory you are producing. (For example, if your organization creates cupcakes, tasting every one that you make to see if it is good would result in a corrupted product that you wouldn't be able to sell.)

To resolve this problem, teams often employ sampling techniques to help them measure results. Sampling involves choosing one (or several) of the outputs generated from a process as representatives of the entire group. Tests are then run on these samples and findings are extrapolated to represent the entire group.

The samples chosen should be selected randomly, with each unit having as much chance of being selected as any other unit in the group. By randomly selecting samples, you'll help to ensure that the testing is unbiased and truly represents the whole group of results.

Attribute and Variable Data

Before you begin to collect samples and test results, you'll have to decide how specific you need the data to be, then weigh this need against the cost and effort to collect relevant data. Quick data collection or decreased cost may allow you to collect attribute data, while a demand for more-specific data would require that you collect variable data.

Attribute data is collected to show whether a result meets a requirement or not. Think of this information as answers to a "yes or no" question or a "pass/fail" test. The responses are limited ("yes" or "no"), and results are absolutes—they either fit the response or they don't.

Attribute data allows you to evaluate and analyze information quickly but requires judgment and skill on the part of the evaluator. Attribute data may also require a bigger sample size but the additional time it takes to collect this information is often offset by the reduced amount of time to evaluate and analyze the data collected.

In contrast, variable data tests *how well* a result meets a requirement. Variable data allows you to evaluate information as part of a range rather than as an absolute—results can be rated on a scale (at any point between 0 and infinity, including decimals).

For example, a company produces 5-pound bags of flour. They are trying to determine the actual production weights for their bags of flour. If the company were to use attribute data, they could determine the number of bags that have at least 4.8 pounds of flour. The bags either have greater than 4.8 pounds of flour, or they do not have 4.8 pounds of flour. If the company were to use variable data, they could take the weight of each bag and determine the mean and standard deviation of the production weights.

Variable data provides more information than attribute data but often takes more time and effort to evaluate and analyze.

Common Cause Variation vs. Special Cause Variation

Variations occur in all processes, but it is important to distinguish between the variation that occurs naturally as part of the process and an abnormal variation that affects results.

Very few processes work flawlessly; most experience some range of results due to variables that can't be controlled or that wouldn't be worth the added expense to control. These common cause variations are accepted as part of the normal process because they fall within the amounts that users will tolerate. For example, if a company producing five-pound bags of flour weighs their assembly line results and finds bags that weigh 4.9 pounds or 5.1 pounds, they would likely accept the variation as the "normal" result of the inconsistencies in the packaging process. Because the variation is so small and would likely be tolerated by customers, they would be unlikely to make significant changes to the process. To eliminate these common cause variances, they would have to "change" the system, maybe by purchasing new machines that would have finer control over the measuring or packaging process. This disruption and cost may not be worth the benefit they would gain by eliminating this type of variation.

If, however, tests suddenly show that bags are being produced that weigh three pounds or seven pounds, the company can assume that something unusual or unexpected has occurred to affect the process or system. These unusual results would likely be caused by special cause variation—the results are not caused by the "natural" variation or "normal" inconsistencies in the process; something abnormal must have occurred to create such a large discrepancy in results. To eliminate this special cause variance, the organization would have to "fix" the system by eliminating the cause of the abnormal results in the process or system.

It is important to note that, before distinguishing common cause from special cause, the system or process being evaluated must be stable and capable of creating repeatable results on a consistent basis. In other words, you must know what "normal" is before you can decide if a variation is "abnormal." Only after you understand the natural inconsistencies in the process can you focus on fixing the aberrations that are causing unexpected results.

4.10.1 Control Limits

Control Limits

There are expectations for the output of any system or process. The product is expected to have certain characteristics. For example, a customer expects hamburger patty from a fast food restaurant to weigh a certain amount. A movie-goer expects a movie theater's audio to be at a certain volume. A visitor expects a hotel's shower to have a certain amount of water pressure.

Consumers rarely expect a product to hold an exact measurement. If the movie is one decibel higher, or the water pressure is diminished by a fraction of a percent, it will go unnoticed. Often, there is a range of acceptability for a process. When ordering a quarter pound burger, a consumer does not expect the burger to weigh exactly 0.250 pounds (4.0 ounces), but rather there are constraints that must not be surpassed. The consumer may expect the burger to weight between 3.0 and 5.0 ounces. As long as the burger falls within this range, the consumer's expectations are met.

These constraints of a process's output are called control limits. The upper constraint of a process is known as the upper control limit, while the lower constraint is the lower control limit. An upper control limit and a lower control limit are usually equidistant from the mean. Because they are the same distance from the mean, these control limits are usually designated as a certain number of standard deviations from the mean. The most commonly used distance is 3σ: the upper control limit being three standard deviations above the mean, while the lower control limit is three standard deviations below the mean.

Example

Bob is the owner of a chain of restaurants: Beefy Bob's. He has decided to quantify the burger sizes to meet customer demands better. He wants to use control limits to measure the sizes of his signature burger. Bob needs to find the upper control limit and lower control limit of the burgers' size.

Bob knows that the upper control limit and a lower control limit are usually equidistant from the mean. He decides to use the most commonly used distance from the mean, which is 3σ, or three standard deviations:

$\bar{x}$ = mean burger weight

σ = standard deviation of burger weight

upper control limit (UCL) $= \bar{x} + 3\sigma$

lower control limit (LCL) $= \bar{x} - 3\sigma$

So, to determine the control limits, Bob first needs to find the mean and standard deviation of his burgers' weight. After collecting a large sample and analyzing the burgers' sizes, he finds the following results:

$\bar{x} = 4.0$ ounces

$\sigma = 0.333$ ounces

Now, Bob has all of the information he needs to determine the control limits. From the mean and standard deviation of the burger sizes, Bob calculates the upper and lower control limits:

upper control limit (UCL) = $\bar{x} + 3\sigma$ = (4.0 ounces) + 3(0.333 ounces) = **5.0 ounces**

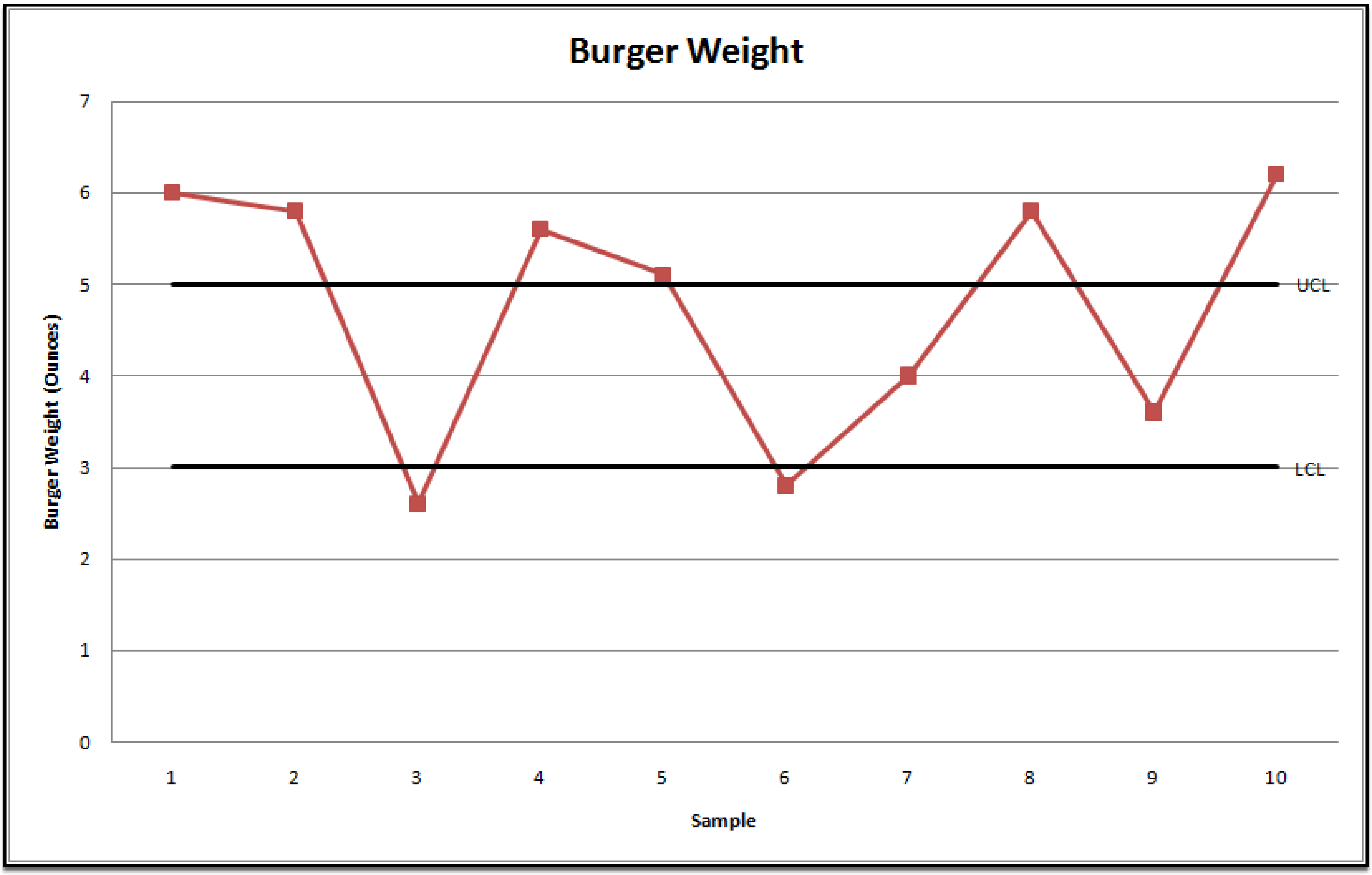
lower control limit (LCL) = $\bar{x} - 3\sigma$ = (4.0 ounces) - 3(0.333 ounces) = **3.0 ounces**

Therefore, Bob determines that his signature burger must always weigh between three and five ounces. The upper control limit for the weight of a burger's patty is 5.0 ounces, while the lower control limit is 3.0 ounces. Therefore, if a customer orders a burger from Beefy Bob's, but receives a burger that weighs greater than 5.0 ounces, that is not acceptable. This burger is too large. Similarly, if a customer receives a burger that weighs less than 3.0 ounces, that is also not acceptable, as the burger is too small.

Bob decides to pilot his control limits at the Portlandtown location of Beefy Bob's. He collects a random sample of patties being produced at this Portlandtown restaurant. The results are in the table below.

Burger	Burger Weight (Ounces)	Upper Control Limit	Lower Control Limit
1	6.0	5.0	3.0
2	5.8	5.0	3.0
3	2.6	5.0	3.0
4	5.6	5.0	3.0
5	5.1	5.0	3.0
6	2.8	5.0	3.0
7	4.0	5.0	3.0
8	5.8	5.0	3.0
9	3.6	5.0	3.0
10	6.2	5.0	3.0

To further digest this data, it can be helpful to see it graphical form. Below is a graph of the burger weights with the Upper Control Limit (UCL) and Lower Control Limit (LCL) shown. As we'll see later in this Module, this graph is known as a control chart.



These results are very disappointing. Bob is extremely dismayed. He found that eight of the ten burgers measured were not within the control limits. Burgers 1, 2, 4, 5, 8, and 10 are above the upper control limit of 5.0 ounces. These burgers are unacceptably large. Burgers 3 and 6 are below the lower control limit of 3.0 ounces.

As a result of this analysis, Bob realizes that far too many of these burgers are outside of the control limits. Their size is unacceptable. He does not want his product to be so variable and feels that customers should be able to expect a certain size burger when they order. Therefore, Bob initiates a retraining program for his burger cooks.

The beef arrives at the restaurant in bulk, so the burger chefs are responsible for molding the patties into the correct size and shape. After the retraining, Bob will measure the burger sizes again. If the burgers still have unacceptable variance in their size, Bob will have to determine whether to replace some of his burger cooks or whether to purchase equipment to standard the burger sizing process. All of these informed business decisions are made as the result of a statistical study using control limits.

4.11 Ishikawa's Seven Basic Tools of Quality

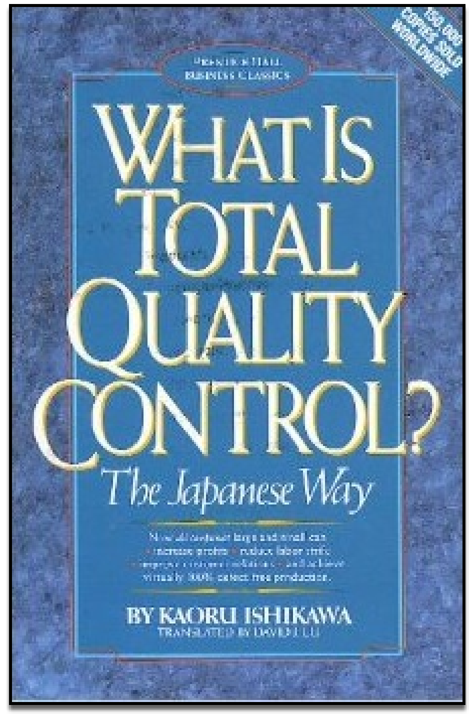
Ishikawa's Seven Basic Tools of Quality

Kaoru Ishikawa, a Japanese university professor, described seven tools that teams can use to manage quality issues in their organizations.

Ishikawa claimed that these seven tools could be used to solve 90%–95% of the quality-related problems organizations see. The tools can be used independently or in combination to quickly uncover issues and to develop ideas to regulate quality problems. In many cases, the outputs of one tool become the input to another tool to allow practitioners to dig deeper into problems and develop more-effective solutions.

The tools are simple, graphic representations of data that help teams address problems and uncover the factors that contribute to those problems. The tools were designed to be simple to learn and easy to understand so that an average worker with little or no advanced training could use them effectively.

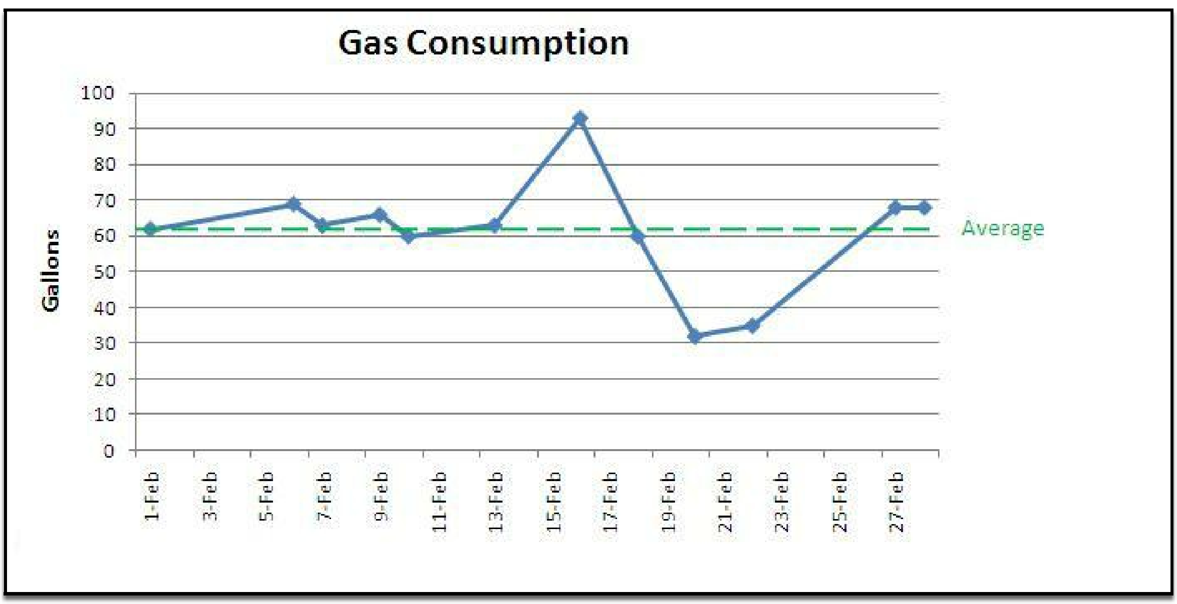
Ishikawa's seven tools are described in the subsequent assignments. In each case, consider how and when you would use the tool.



4.11.1 The Run Chart and Control Chart

The Run Chart

A run chart is a simple way to illustrate performance measurements over a period of time. Team members collect measurements and plot them as data points on a graph, then connect the points to shows trends or aberrations in performance. These trends or aberrations can be investigated to see if corrective action needs to be taken to address root causes or problems.



Be sure to use intervals (e.g., hours, days, weeks, shifts, etc.) that occur naturally in the process or that provide you with the information that will be most helpful in your analysis. Consider using random sampling techniques if plotting all of the measurements would be too difficult.

With a completed run chart, you can more easily visualize the data and assess the quality of your testing results. Analyze the chart for trends and aberrations.

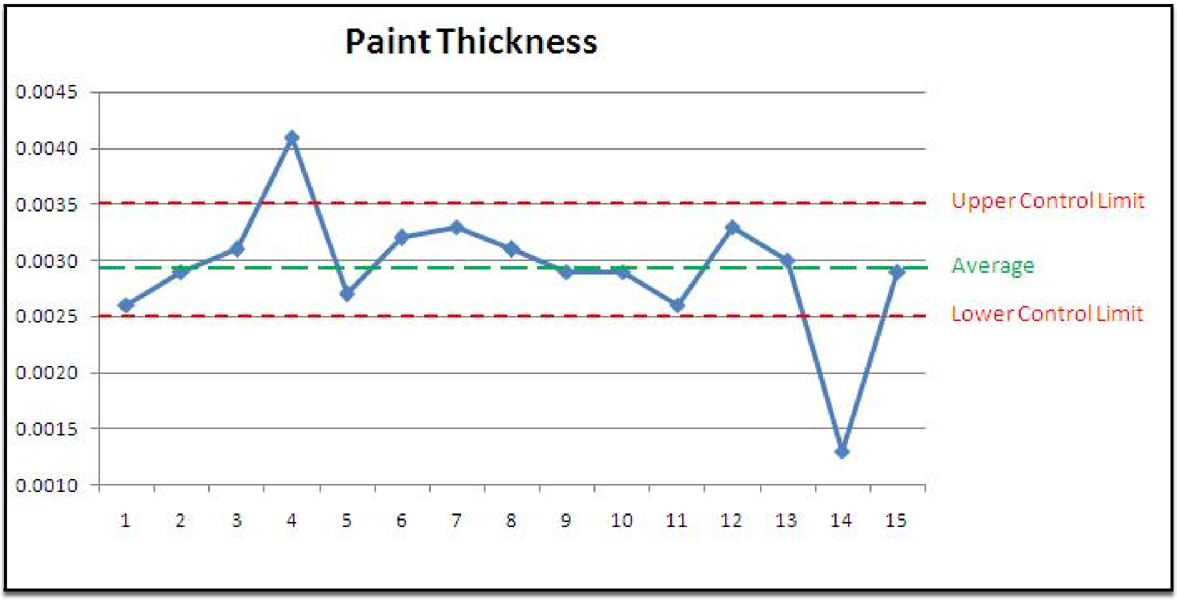
Run charts are a good way to share information with stakeholders and to verify the results of any corrective action you have taken. They are also helpful for comparing data when information from multiple processes is compiled on one chart.

The Control Chart

A control chart is a modified run chart—it shows the performance of a process over time, but it also includes limits or constraints that a process should not exceed. These control limits track the maximum value (the upper control limit) and the minimum value (the lower control limit) that the process must perform within. (Some organizations also develop additional limits that act as an early detection or warning system when the process is close to its limits.) Often, the upper and lower control limits are drawn at a number of standard deviations from the mean. This is just one approach in determining the values of the control limits. By tracking performance in relation to these control limits, practitioners can detect more-subtle variations than those detected in run charts, allowing them to make adjustments sooner to correct problems and avoid missteps.

Carefully monitor any points that approach or exceed the warning limits but have not yet exceeded the control limits, as they may be indicators of upcoming problems. Be especially careful to address any points that fall outside of the control limits.

Control charts are especially helpful in distinguishing special cause variation from common cause variation due to their increased focus and more-critical evaluation of data. By providing more-refined data, control charts will alert you to potential problems and "hidden" issues that may not otherwise be evident.

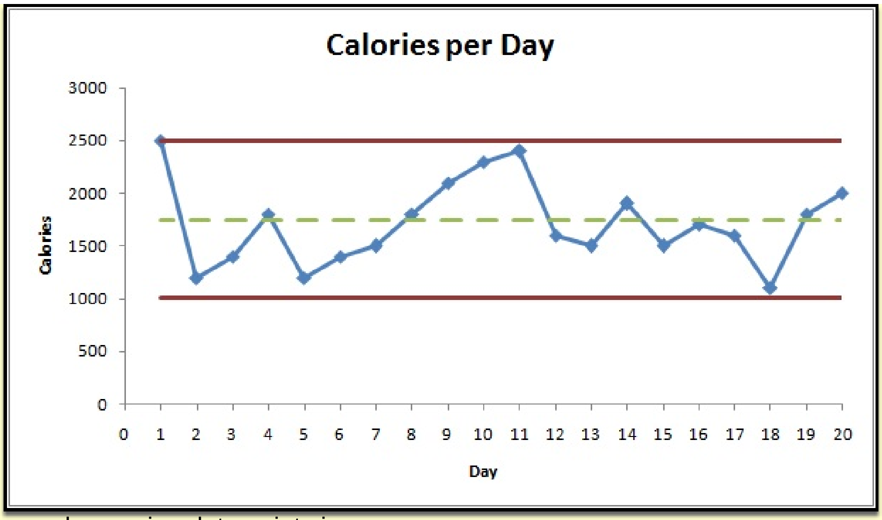


Rules for Interpreting These Charts

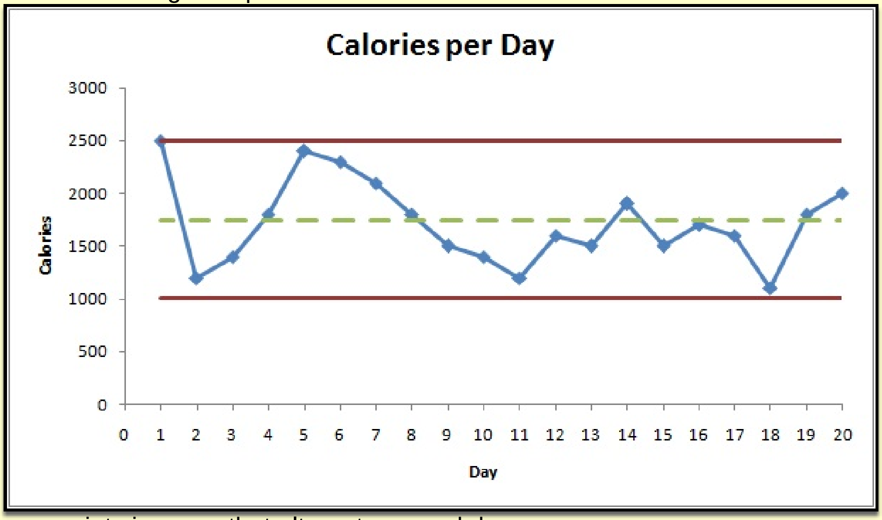
The trends revealed in run charts and control charts may be signs that a process is encountering some form of abnormal variation, but these trends may be difficult to recognize, especially if they are hidden within the "normal" variation on the charts.

To help you see these trends and evaluate the data you plotted, use the following rules to quantify the information you collect:

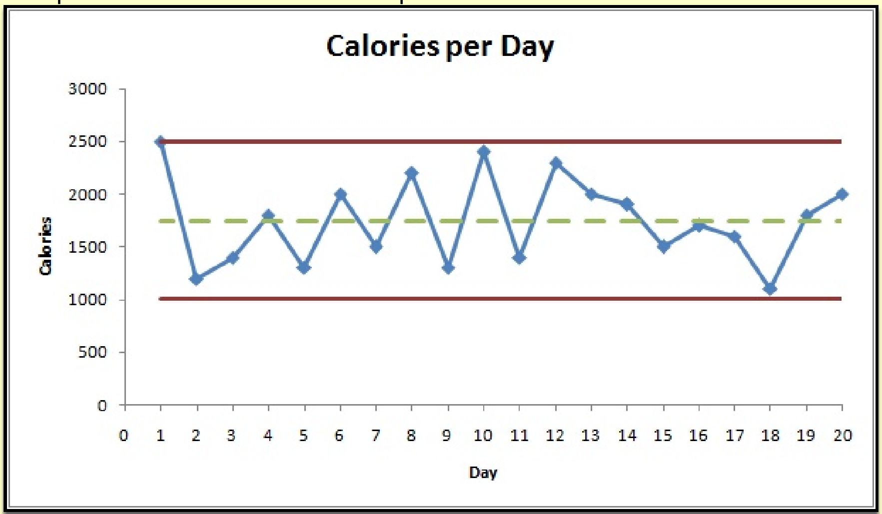
If your run chart or control chart shows any of the trends or aberrations listed below, be sure to analyze your process for special cause variation:
6 or more increasing data points in a row



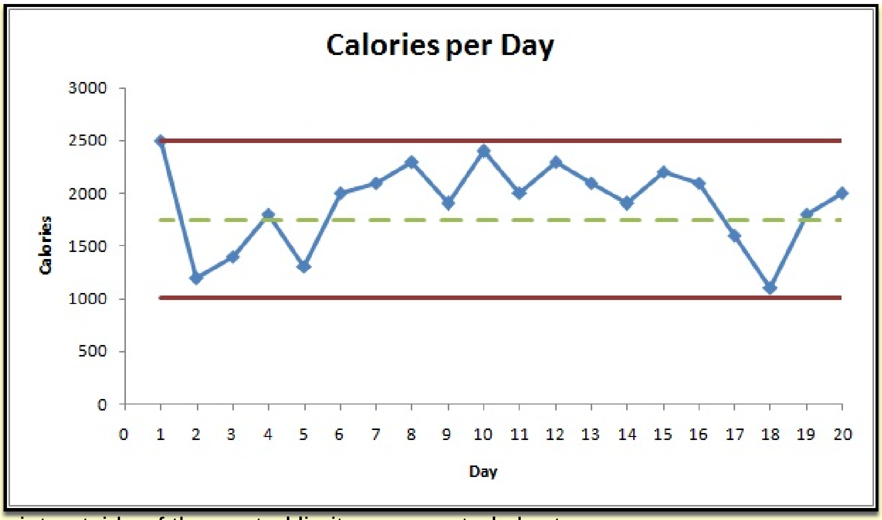
6 or more decreasing data points in a row



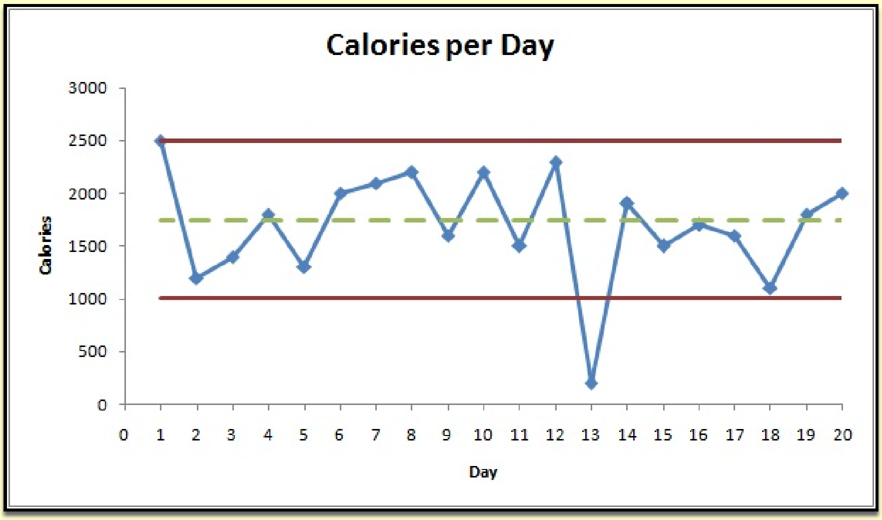
8 or more points in a row that alternate up and down



9 or more points in a row on one side of the center (average) line



Any point outside of the control limits on a control chart



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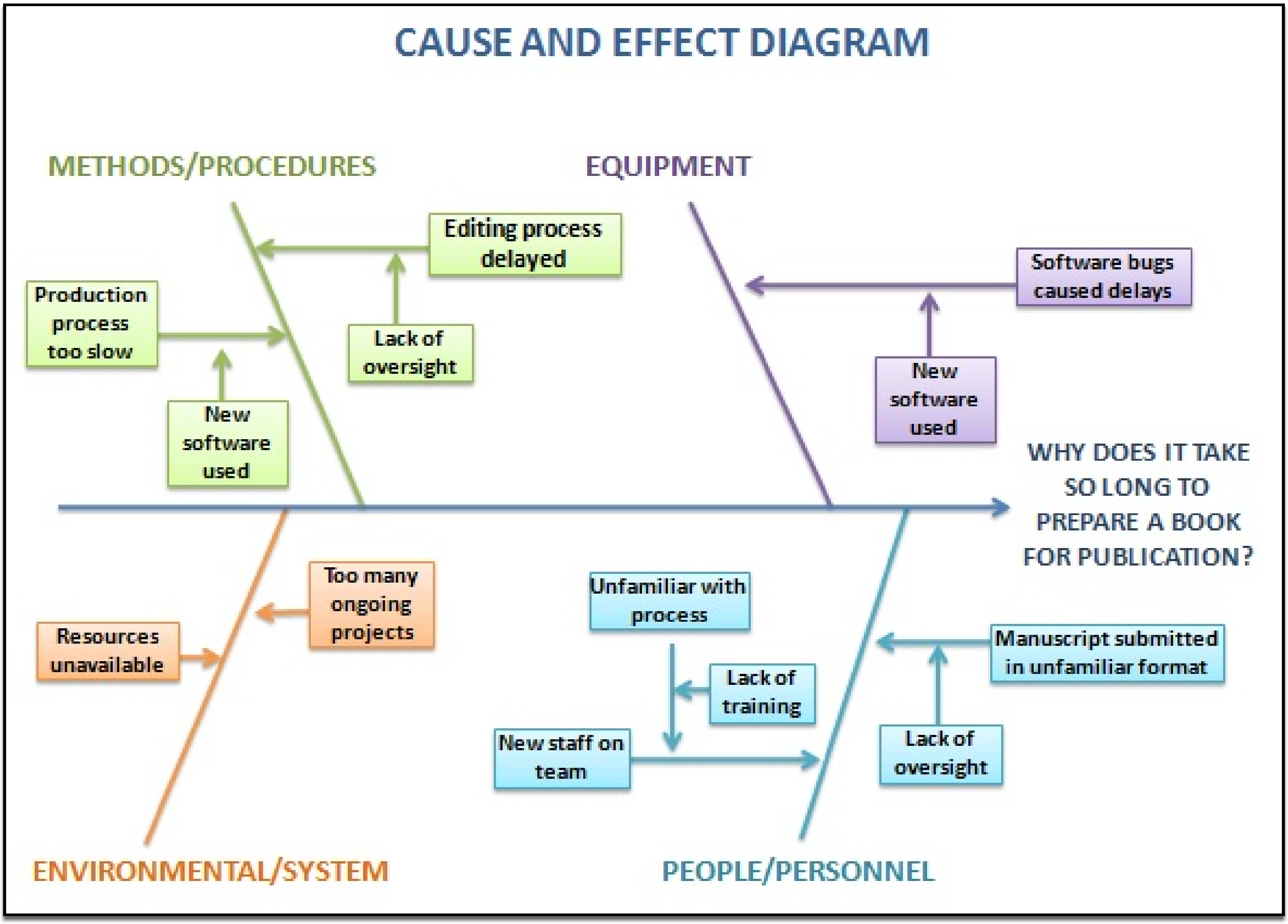
A ... can be examined for s ... of the primary and underlying factors that cause an event or problem, allowing teams to drill down to find the problem's root cause.

The cause-and-effect diagram is often called a fishbone diagram because, as team members brainstorm ideas and continue to dig deeper into a problem, they record these ideas as smaller and smaller branches off of a central connecting line. When brainstorming is completed, this branching creates a diagram that looks like the skeleton of a fish.



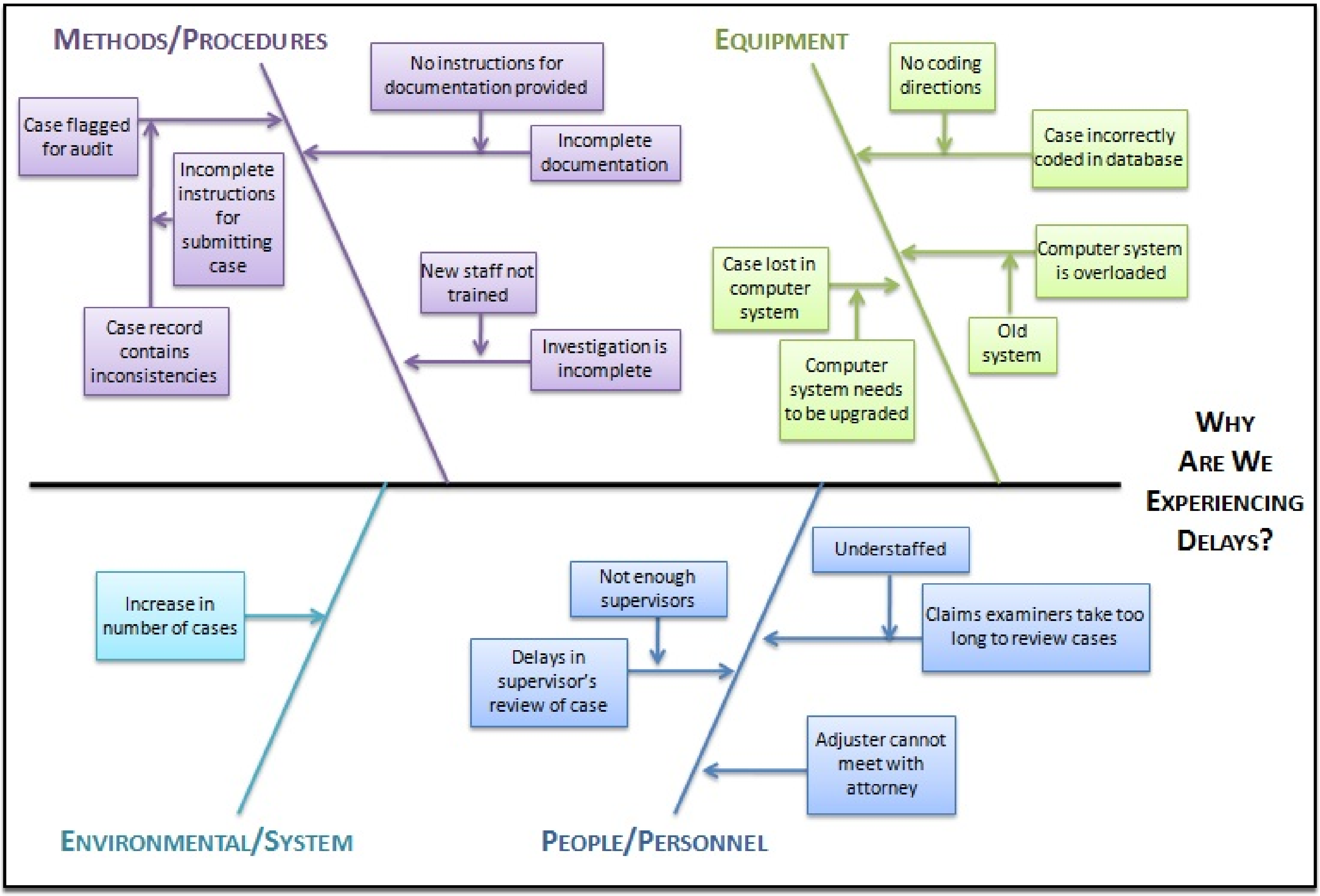
The number of branches you use will depend on the categories you choose as the main causes of the event or problem. There are many category headings that you can use, but the most common ones are based on 1) the methods or procedures used, 2) the equipment (tools and machinery) utilized, 3) the system or environment the project or process is happening in, and 4) the people involved in the work.

When ideas are put forth, add these ideas as smaller branches on the category branches, then continue to ask why these *new* ideas might contribute to the problem or effect. Add these new ideas as smaller and smaller branches, to develop more detail in your diagram. When participants can no longer think of additional ideas in a category, move to a new category and repeat the process.

When all categories have been investigated, analyze the diagram for similarities and relationships among the lowest level causes. Any similar or repeated ideas are strong candidates as root causes for the event or problem; be sure to investigate these ideas to see if correcting them will solve the problem.

Example

Fulham Insurance has seen a sharp rise in the number of cases submitted, so they hired several new appraisers and examiners to gather information in the field. However, even with these new hires, Fulham is still experiencing delays. Several customers have complained and are threatening to take their business elsewhere. Fulham's corporate office assigns their quality management team to investigate the issue and see if they can correct the problem before customers start to leave.



What areas should Fulham focus on to address the problem?

The diagram shows three recurring sources for the problem—a lack of direction or instructions, an inefficient computer system, and understaffing in important areas.

Several places in the diagram point to incomplete or missing instructions as a root cause of the problem; Fulham should review its current training program and augment areas that need assistance.

The company should also look to upgrade its computer system to avoid the technical problems that are contributing to the issue.

And although Fulham has added a number of new employees to its staff, it appears that these people were added in the wrong areas and are not helping the organization fully resolve claims any faster. The firm should look to add office staff to address this factor.

4.11.3 The Flowchart

The Flowchart

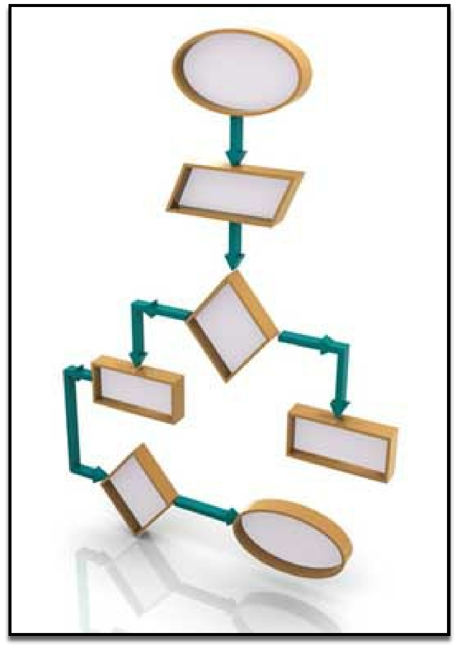
A flowchart is a graphic representation of the steps that make up a process. By seeing how all of the parts of a process connect and fit together, practitioners can identify redundancies and problem areas in their work and develop plans to correct them.

Flowcharts can be created as very high-level diagrams that show basic process steps or as very detailed charts that project participants can use to focus on individual steps and see where bottlenecks or other problems could occur.

Some flowcharts use columns or rows to help practitioners compartmentalize work or to designate steps that are assigned to a specific person or department. Teams may also use flowcharts to document a process as it currently exists and compare it to one that shows an ideal condition, to see where corrections can be made and processes can be streamlined.

Use symbols like the ones in the table below to represent the parts of the process.

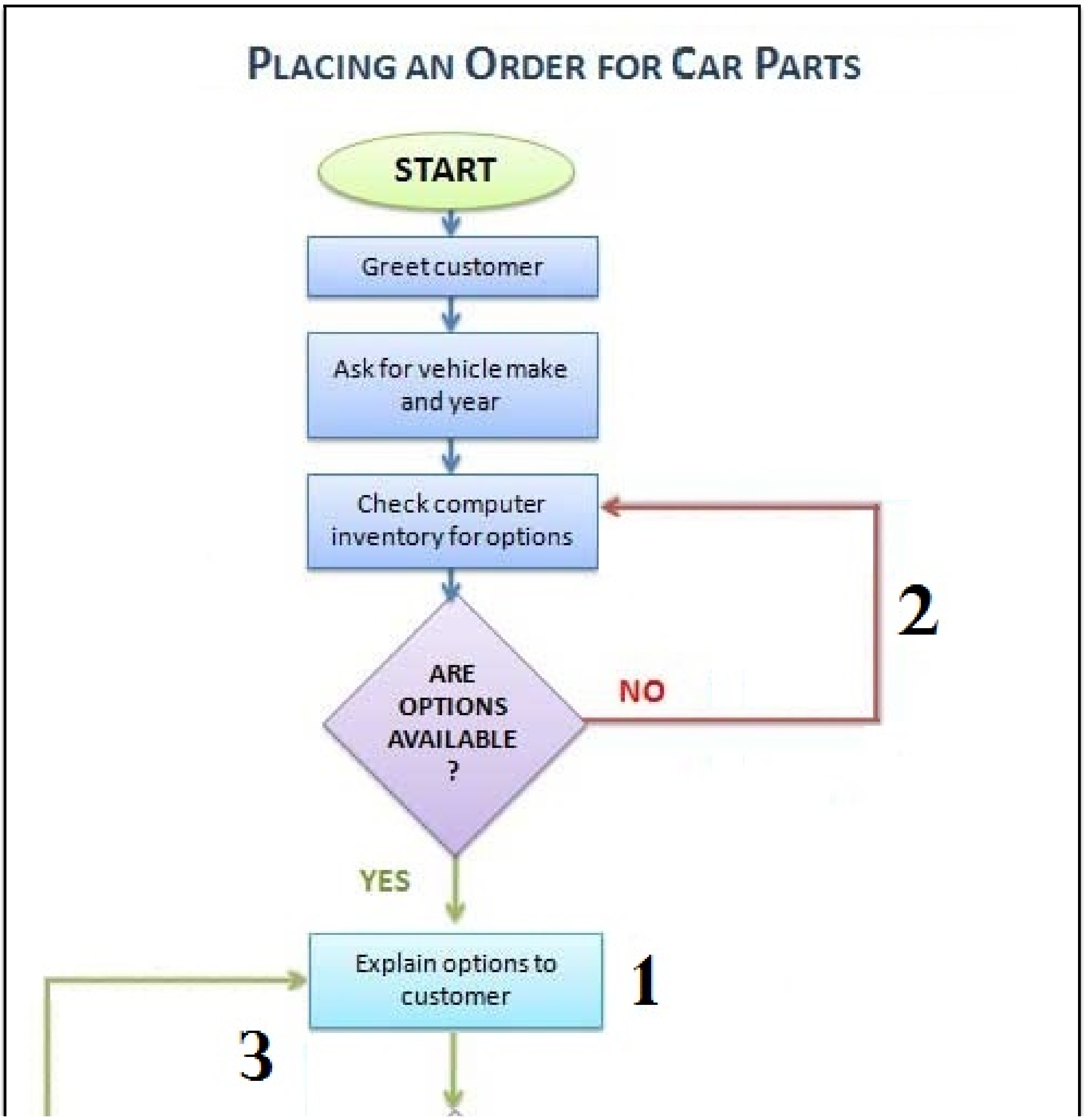
Symbol	Explanation
	Use ovals to show the beginning and end points of the process.
	Use rectangles to show each process step. Describe each step in a "verb + noun" format ("Measure amount" or "Cut materials").
	Use diamonds to indicate points where a question needs to be answered or a decision must be made. Use a "yes/no" question to describe the point ("Will this delay the project?" or "Has this been approved by the corporate office?"). Make sure that all decision point answers lead to a subsequent step or loop back to a previous step in the process.
	Use inverted triangles to indicate a waiting area or build up of inventory.

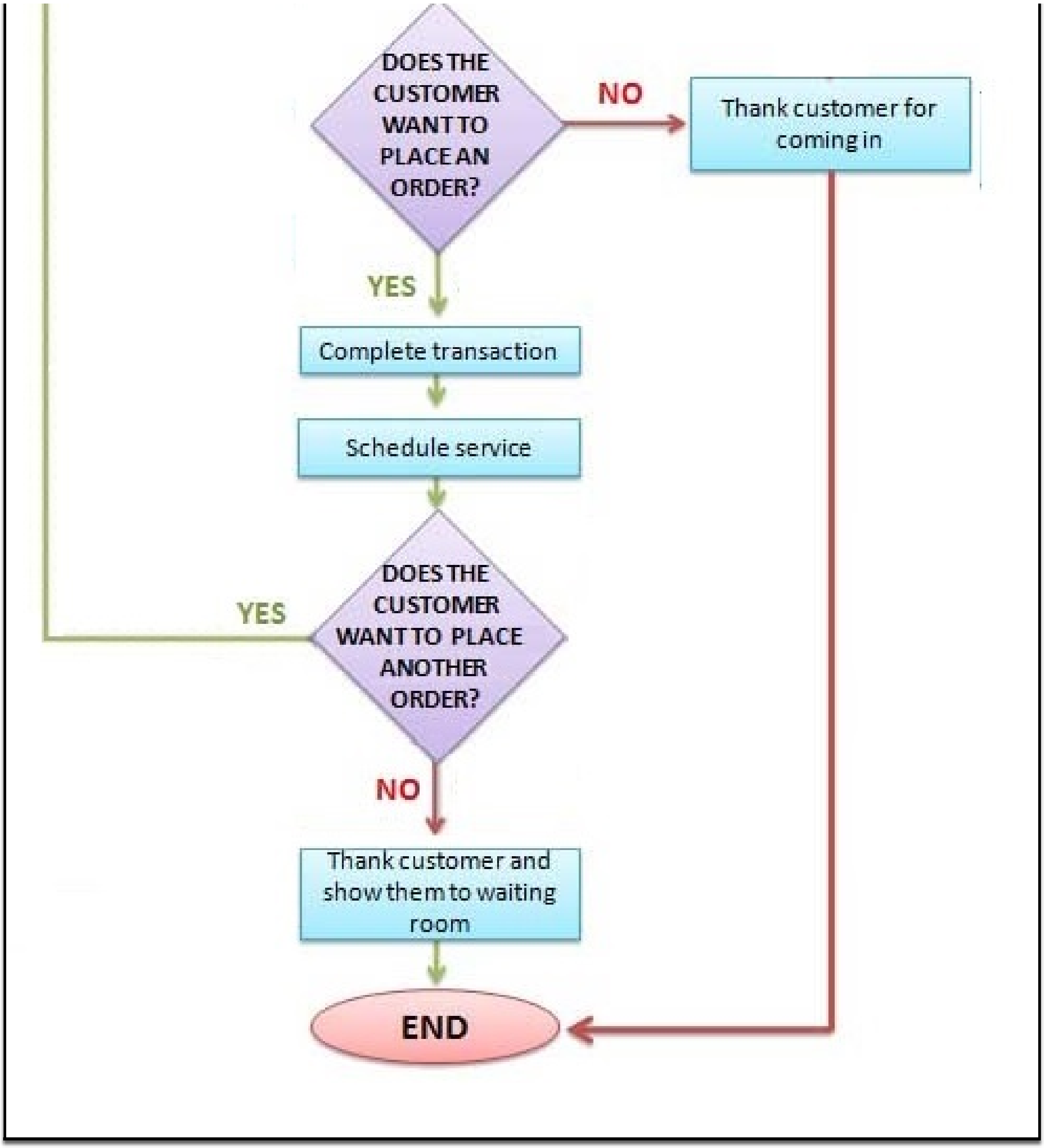


If you are using columns or rows to separate work into compartments, place the symbols, so they align in the correct row or column. Connect the symbols with arrows to show the sequence or order of the steps.

With a completed chart, look for bottlenecks, inconsistencies, redundancies, or other problems. Develop action plans to correct any issues or to help you refine the process.

Flowchart for Inefficient Company

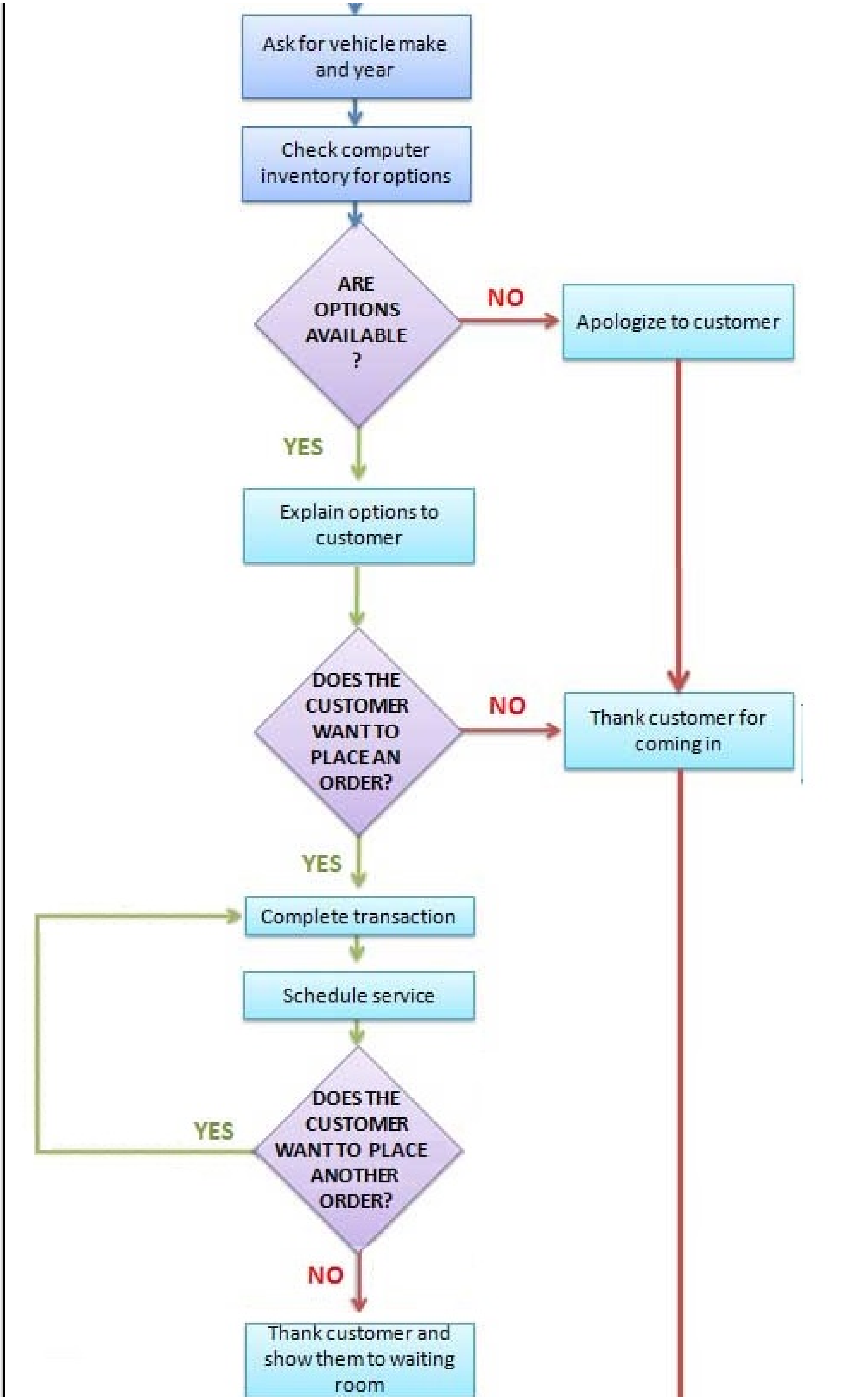


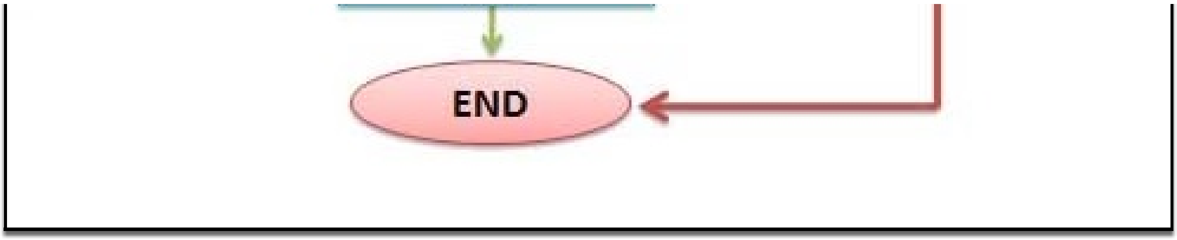


At point 1, there could be a bottleneck because there are multiple sources contributing work which could cause the whole operation to stall. At point 2, there is an inconsistency as there is no reason to repeat to "Check Computer Inventory for Options" if it was just determined that there were not. This will lead to a never-ending loop. At point 3, a redundancy occurs because the options have already been explained and it has already been determined that they would like to place another order.

If a company were to look at their operation and reworked some of the processes, the next flowchart could be the new system.

Corrected Flowchart and Process


Ask for vehicle make and year
Check computer inventory for options
ARE OPTIONS AVAILABLE ?
NO
Apologize to customer
YES
Explain options to customer
DOES THE CUSTOMER WANT TO PLACE AN ORDER?
NO
Thank customer for coming in
YES
Complete transaction
Schedule service
DOES THE CUSTOMER WANT TO PLACE ANOTHER ORDER?
YES
NO
Thank customer and show them to waiting room



4.11.4 The Check Sheet

The Check Sheet

A check sheet is an easy way to collect and tabulate data. It is a structured form or table that practitioners use to count how many times an event or problem happened or to record when or where something happened.

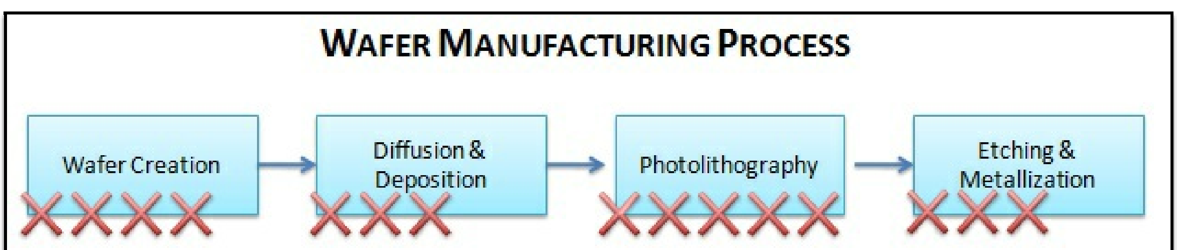
Check sheets are easily adapted to any need and can be as simple or as complex as necessary. Some teams create simplistic tables to track data in clear-cut categories, while others create more complex matrices or draw pictures of a part or process and keep count of the defects or occurrences directly on the image they created.

Check Sheet: Table Format

CUSTOMER SERVICE CALLS

	DATE					
Category	5-Mar	6-Mar	7-Mar	8-Mar	9-Mar	**TOTAL**
Product Features	𝍸 III	𝍸	𝍸 II	IIII	𝍸 III	**32**
Product Availability	𝍸 I	𝍸 I	𝍸	𝍸 II	𝍸 I	**30**
Product Problems	III	IIII	III	𝍸	III	**18**
Cost	𝍸	IIII	𝍸 II	𝍸	𝍸	**26**
Billing	𝍸 𝍸	𝍸 III	𝍸 𝍸	𝍸 III	𝍸 𝍸 I	**47**
Other	𝍸 II	𝍸 I	𝍸 II	𝍸	𝍸 IIII	**34**
TOTAL	**39**	**33**	**39**	**35**	**42**	

Check Sheet: Graphic Format



A check sheet ensures that everyone collecting data is compiling and recording it in a similar way. Providing a structured form for recording information enhances consistency in the collection process and makes the analysis or import of the information into a subsequent evaluation process quicker and easier for all involved.

4.11.5 The Histogram

Histograms and Bar Charts

To learn more about histograms, please review 2.15 Histograms and Bar Charts

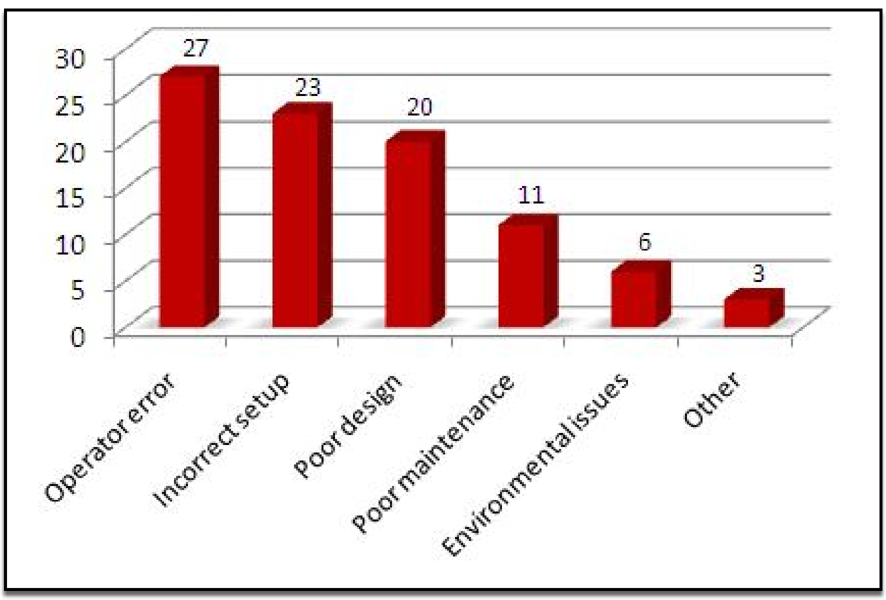
4.11.6 The Pareto Chart

The Pareto Chart

A Pareto chart is a bar chart that sorts data into categories, then prioritizes those categories to help project teams identify the most significant factors or the biggest contributors to problems. By focusing on the factors that contribute the most to problems, practitioners can make quick and meaningful improvements to processes and work.

The Pareto chart is based on the 80/20 rule, which states that 80% of quality management problems are the result of a small number (about 20%) of causes. By concentrating your efforts to fix these "vital few" causes, you can quickly produce the greatest impact on work in the most cost-effective way possible.

The distinguishing characteristic of a Pareto chart is the prioritizing or rank-ordering of the chart's columns to highlight the most important factors or categories on the chart. The bars on the chart are arranged in descending order, with the most important category or highest priority on the chart's far-left side. As you move from left to right across the chart, the categories decrease in priority or importance, making it easy to see which factors should be addressed first to provide the greatest potential for improvement.



Focus your initial attention on the two or three largest bars in the chart; addressing the issues that these bars represent usually provides the greatest potential for improvement. If your chart does not show prominent differences among the heights of the bars, consider new categories or ways to segment the data and replot the chart.

Pareto charts help you quickly select corrective actions or set goals for your improvement efforts. Identifying and focusing your improvement efforts on the vital few causes you uncover will help you:

- See which problems you should focus on first
- Prioritize work and decide where to direct your improvement efforts
- Plan corrective actions that will result in the greatest payoff
- Avoid wasting resources on trivial factors or causes

By focusing on the most common causes of problems or defects, you can quickly align resources and prioritize work to significantly upgrade your quality management efforts.

4.11.7 The Scatter Diagram

The Scatter Diagram

To learn more about the scatter diagrams, please review2.16 Graphic Displays: The Scatter Diagram.

4.12 Video: Decision making with the Seven Quality Tools

This assignment does not contain any printable content.

4.13 Quality Management Programs

Quality Management Methodologies and Programs

Organizations often combine ideas, concepts, and tools into a methodology or program to help guide their quality management efforts. Several of these methodologies have become quite successful in helping companies manage and improve quality efforts and have been formalized into systems that other organizations have adopted and implemented.

Some of the more-popular quality management methodologies are listed below.

Lean

> Lean practices focus on eliminating anything that does not add value for customers or satisfy their needs. By eliminating all of the "fat" that has been incorporated into operations, Lean processes streamline work and improve quality, ultimately boosting the organization's bottom line.
>
> Lean views work from the customer's perspective so anything that does not add to the customer's experience and satisfaction is viewed as waste that should be eliminated. Waste is removed from *all* of the activities in a process so the *entire stream* of activities is enhanced and optimized.

Six Sigma

> Six Sigma practices are steeped in the application of metrics and statistics to help evaluate and control the variation found in processes. Eliminating this variation increases an organization's ability to meet requirements by stabilizing outputs and improving the capability of its processes.
>
> By continually measuring processes and outputs, Six Sigma practitioners monitor organizational work, then suggest improvements to reduce defects and improve efficiency and effectiveness. These improvements are then incorporated as part of an improved process to help increase reliability and to improve organizational quality.

Lean Six Sigma

> As the name implies, Lean Six Sigma is a combination of the two methodologies listed above. It combines the streamlining and waste-elimination concepts of Lean practices with the variation- and quality-control ideas of Six Sigma.
>
> By combining Lean's focus on enhancing customer value with Six Sigma's optimization of process work, Lean Six Sigma simultaneously reduces inefficiency, accelerates production, and increases quality.

Design for Six Sigma

> Advocates of the Design for Six Sigma (DFSS) methodology do not wait to correct inefficiencies in processes—they incorporate Six Sigma practices into their work as they *design* the processes they'll use in upcoming activities. By taking a proactive approach to quality management, DFSS ensures that variation is minimized from the outset of a project, eliminating the need for corrective actions later in project work.

ISO Certification

> The International Organization for Standardization (ISO) established a certification program that guarantees that an organization is dedicated to quality concepts and is continually working to ensure that it is producing the highest level of quality possible. The certification shows that an organization has a quality management system in place to monitor and

control quality issues and is continuing to meet the needs of customers and stakeholders with high-quality products and services.

The methodology that an individual organization chooses to follow will depend on its resources and abilities, its corporate culture, and the environment that it works in. Organizations often take parts of several different methodologies and combine them into new programs that best meet their needs. Whatever way an organization chooses to address quality, it should work to embed the necessary practices and concepts into its culture so that quality management becomes part of its work each and every day.

4.14 Lean Systems

Lean Systems

Lean is more than a simple collection of tools; it is an interconnected system that focuses an entire organization on creating the value that customers want in the most efficient and effective way possible.

In an effective Lean system:

- Practitioners work continuously to eliminate the defects and rework in their systems
- Material and information is pulled by downstream processes in the system
- Value-added work is enhanced and non-value-added work is minimized
- Resources (including employee skills) are maximized to the greatest extent possible
- Inventory is minimized and delivered just-in-time
- Problems are quickly identified at their source and resolved as soon as possible
- Quality, productivity, performance, cost reduction, and information sharing are continuously improved

In short, Lean aims to make the process of delivering value simply by using the fewest possible resources in a fully effective way.

Lean is focused on the "customer." It is important to remember that a customer is not always external. In the contexts of processes, a customer is whoever is receiving the outputs of your process. For further exploration of this concept, examine the slideshow below.

Problem-Solving

Lean uses concepts to expose problems and to streamline delivery throughout the *system*, rather than in *individual departments or pockets*. Lean practitioners view the problems they uncover as "opportunities" that allow them to refine and improve their work. As such, Lean isn't about fixing problems superficially and quickly; it is about immediately containing a problem—so it doesn't affect other parts of the system—and then digging to find the problem's root cause to ensure that it doesn't happen again.

Delivering Value

Lean organizations build reliability, adaptability, and flexibility into their processes so they can deliver superior performance for customers, employees, and stakeholders. Lean practitioners look at work from the customer's point of view in an attempt to continually uncover (and ultimately remove) any waste that they believe customers would not pay for.

Lean organizations also reconfigure the relationships they have with their supply chain partners to expand their efficiency further along supply chains and deliver even greater value to customers and stakeholders.

Freeing Up Resources

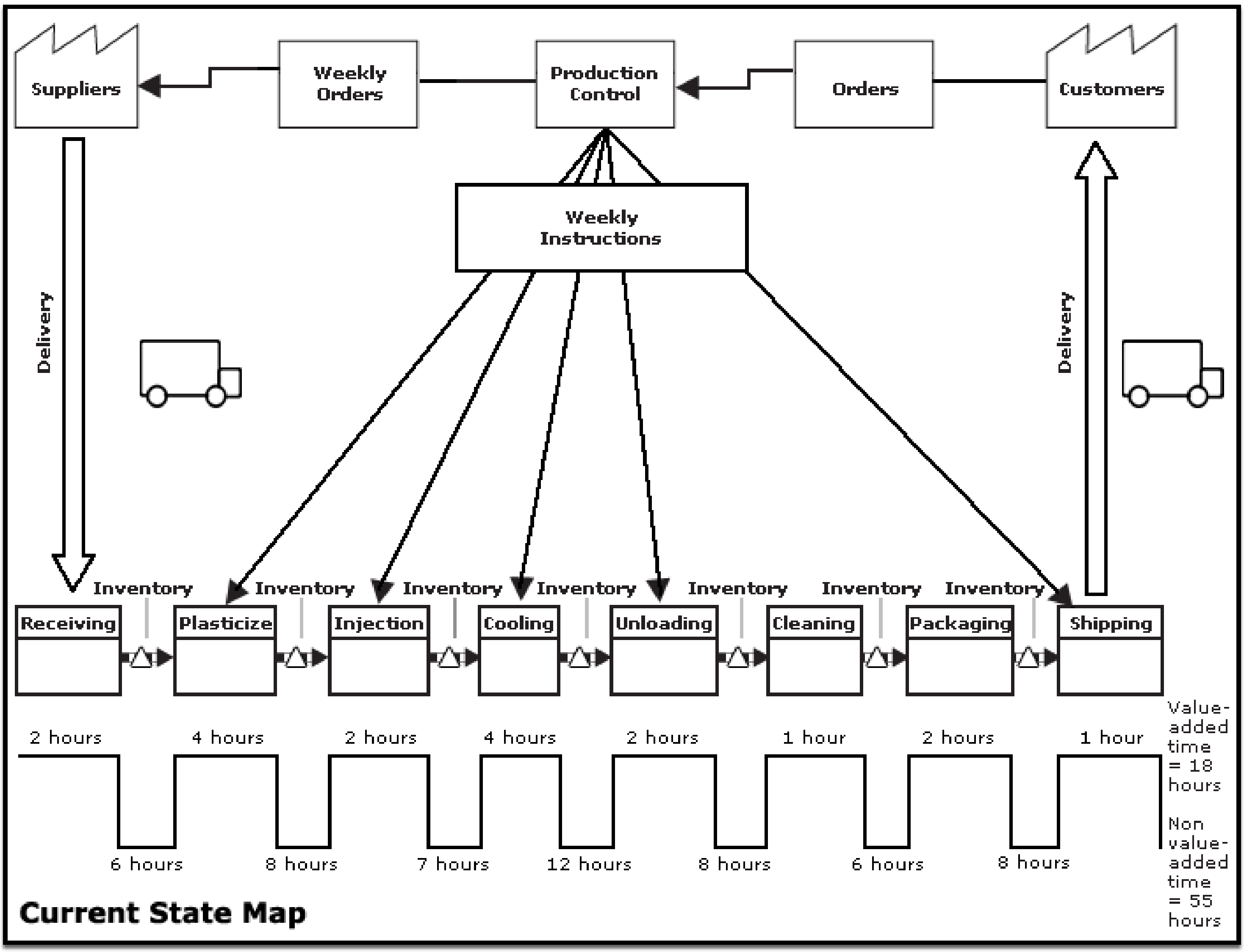
Lean frees up capacity within an organization to allow businesses to provide more value. By eliminating any activities that do not add value for customers and perfecting those activities that do provide the results that customers are looking for, Lean organizations free up capital and resources, which allows them to dedicate these newly liberated resources to the results required by customers.

Value Stream Mapping

One of the best ways to view a lean process within a system is to look at a value stream. Value streams contain all of the steps, processes, and communication involved in the production of goods or services. A value stream shows the value-added and non-value-added work in all organizational processes (from the influx of raw materials to the delivery of finished goods to customers), making it a "systems approach" for looking at—and refining—the work that an organization needs to do. By focusing on the entire end-to-end enterprise for producing results, the value stream encourages *system flow* rather than *process* or *individual flow*.

Value streams are often depicted in value stream maps. A value stream map is a diagram that illustrates the material flow, information flow, and cycle time for all processes in a system. These maps show *where* the waste in a system is located and help to uncover the *sources* of that waste. The illustrative nature of these maps makes it easy to see where disruptions, delays, and unneeded activities occur so they can be quickly and efficiently removed.

When evaluating value streams, organizations generally create current state maps and future state maps. A current state map allows practitioners to see how processes are presently working so interventions can be designed to improve the system. A future state map shows what the process or system will look like after improvements have been made. Some organizations also choose to create ideal state maps, which show how a "perfect" system would look.



4.14.1 The "Lean House"

The "Lean House"

The ideas and concepts embraced by Lean practitioners are often depicted as a house with two pillars, like the one illustrated below.

Click on each of the terms in the graphic for a quick description of each concept. (Concepts will be discussed in

greater detail throughout this course.)

Review Checkpoint

To test your understanding of the content presented in this assignment, please click on the Questions icon below. If you have trouble answering any of the questions presented here, you are always free to return to this or any assignment to re-read the material.

4.14.2 Just-in-time

Just-in-time

Lean systems are designed to produce and deliver exactly what customers need, at the precise time it is needed, and only in the specific quantity requested. This "just-in-time" delivery and production practice allows Lean organizations to continue to meet customer requirements using the fewest possible resources and at the lowest possible costs. The concept is often paraphrased as "providing customers and stakeholders with the *right parts* in the *right place* at the *right time*."

Just-in-time (JIT) ensures that resources, time, and effort are not wasted producing (or delivering) products or services that are not immediately required. The ultimate goal of just-in-time systems is continuous flow—moving one unit or piece at a time to the next process step or workstation as determined strictly by customer (downstream) demand. Continuous flow enables the delivery of correct results each and every time, all while holding the lowest level of inventory possible.

The Building Blocks of Just-in-time

The concepts of continuous flow, pull, and takt time are essential to the creation and continued functioning of just-in-time practices. Material must move consistently and smoothly (continuous flow) only when requested by downstream participants (pull). Production and delivery is coordinated to match customer demand for goods and services (takt time) so that results are delivered *exactly when and only when* needed—not sooner nor later than requested.

These practices allow you to limit any work-in-process and to reduce inventory but require precise coordination between the delivery of resources to each workstation and the production of results; any disconnect or miscommunication between these activities will disrupt or derail the just-in-time system.

Exposing Problems and Enhancing Quality

A just-in-time system exposes problems as they occur and makes the waste in systems highly visible; when just-in-time processes are working correctly, it's easy to see exactly when and where problems are occurring because extraneous processing steps are easily apparent and things are out of place or not available when needed.

Just-in-time systems also force teams and organizations to ensure high quality in the results they produce; because results are required at an exact time to satisfy customer demand, there is very little time available (and often no time at all) to rework or redo things that are not functioning correctly. Because of this scarcity of time, products and services that are passed down the value stream must be complete and of high quality each and every time they are created.

Expanding JIT throughout the Value Stream

A true Lean system expands the just-in-time concept throughout each of its value streams, all the way back to the suppliers of raw materials and incoming products to its production processes. In fact, many Lean organizations encourage and train their suppliers to adopt Lean principles, to further expand this waste-removal and production-optimization methodology as far as possible. This expansion then ensures even greater satisfaction for customers as more and more value is delivered at even lower costs.

Review Checkpoint

To test your understanding of the content presented in this assignment, please click on the Questions icon below. If you have trouble answering any of the questions presented here, you are always free to return to this or any assignment to re-read the material.

4.14.3 A Change in Culture

A Change in Culture

Lean Culture

An effective Lean implementation requires more than just an application of tools - it requires a change in the mindset of everyone involved. All Lean practitioners need to understand that the continuous improvement of activities is everybody's responsibility and, as such, everyone must remain constantly vigilant for improvement opportunities. All parties will need to continue to search for ways to improve the quality, productivity, performance, and interaction in all aspects of their work. They'll need to build on the previous improvement efforts of their colleagues, to optimize the work in their value streams. And they'll have to continue to challenge themselves every day to meet their organization's long-term goals. The leadership and management professionals in a Lean organization will need to assure all involved parties that their opinions and concerns will be taken into account as decisions are made. Work will need to be balanced and coordinated, to allow for level production and to prevent over- or under working any one particular work area. Management will need to train and trust their employees to make good decisions in a timely manner, to ensure that operations continue to flourish. They'll also need to encourage workers to rely on their teammates to help in solving problems and achieving objectives, rather than escalating all issues to a higher authority or waiting for instructions before taking action. Everyone in a Lean organization will have to learn to think of the system before they think of their individual work area or sphere of influence. They'll have to work hard to ensure that any changes implemented in work cells do not adversely affect other parts of the value stream. And all activities need to be made as transparent as possible, to help in making effective and informed decisions and to ensure that all parties involved understand why decisions are being made in the way that they are.

4.15 Six Sigma

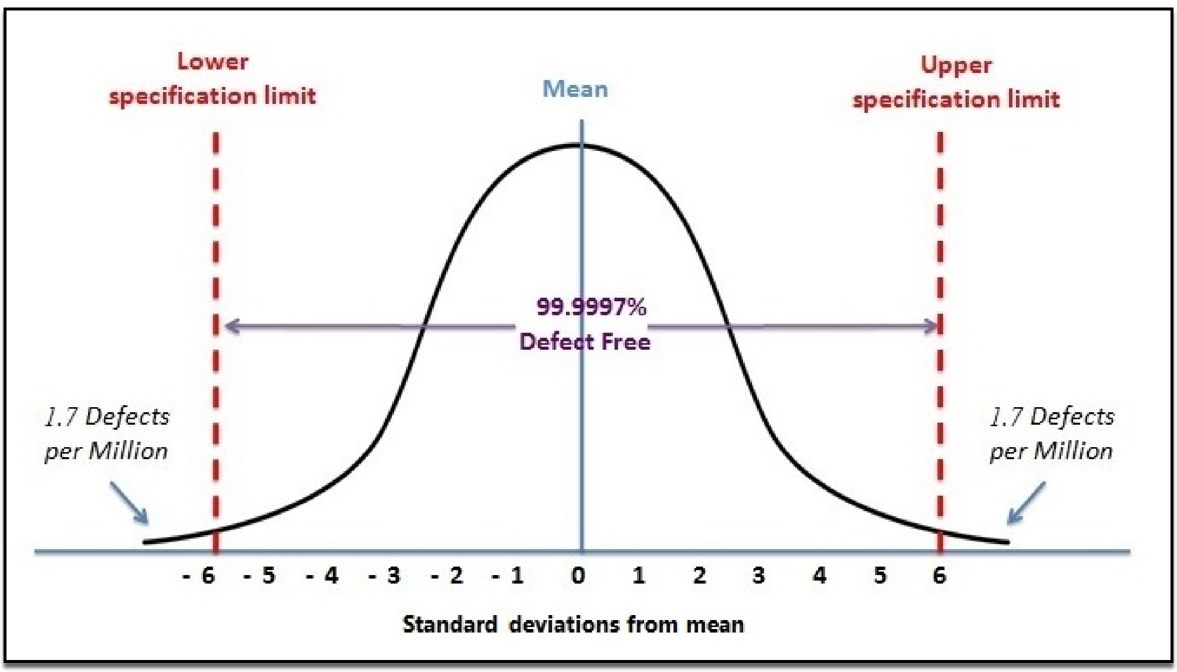
Six Sigma

Six Sigma is a highly disciplined, data-driven approach for improving quality. The Six Sigma methodology focuses intently on facts and statistics, allowing practitioners to quantitatively measure performance and progress as corrections are made.

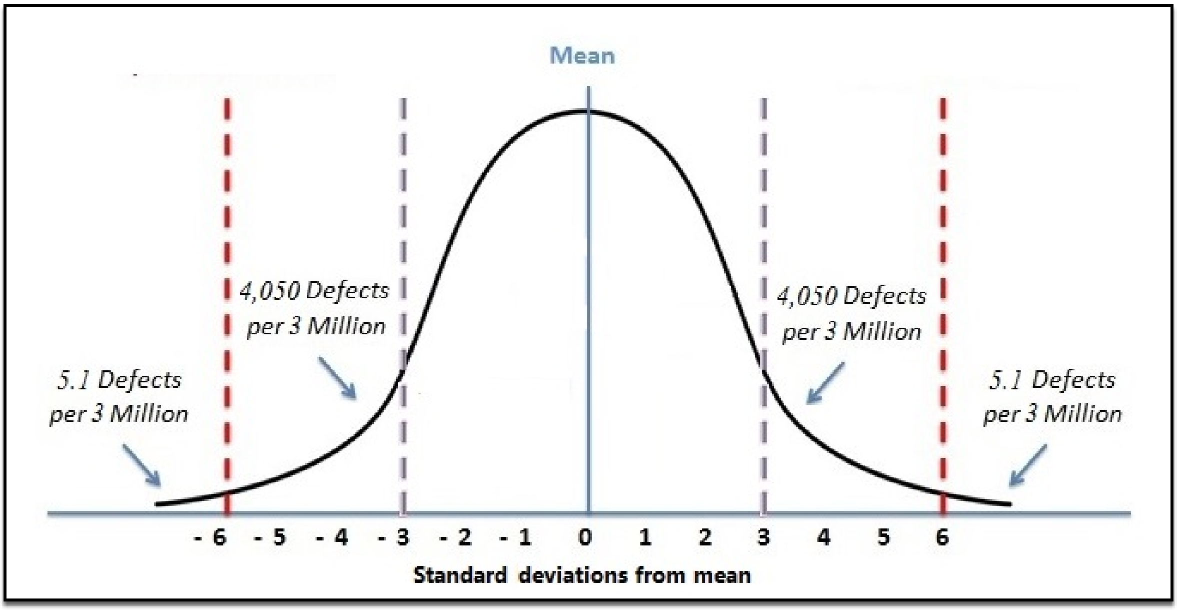
Six Sigma uses short, clearly defined projects with specific, measurable targets to continuously improve process work. In these projects, processes are refined and optimized to eliminate the variation that causes defects and mistakes as operations are completed.

Aiming for Perfection

Six Sigma teams are essentially striving for perfection by looking to improve processes to a "six-sigma" level of quality. This six-sigma level is a statistical concept that places six standard deviations between the mean (or average) value for quality outputs and allowed limits on a histogram used to measure results. Processes working at a six-sigma level are 99.9997% defect-free (or only 3.4 defects per million process outputs). By using this high sigma level as a benchmark for reducing mistakes and systematically eliminating the defects that endanger processes, practitioners can increase process capability and achieve superior performance in their work.



An example of Six Sigma could be a soda company that sells 3 million servings per day. If this soda company used a Six Sigma program for soda defects, only 10.2 soda defects (3.4 / million) would occur per day. If a three-sigma program were used by this company, then 8,100 defects would occur per day.



The DMAIC Framework

Six Sigma employs a five-step framework to analyze an existing process and to incorporate changes that will improve its ability to meet requirements:

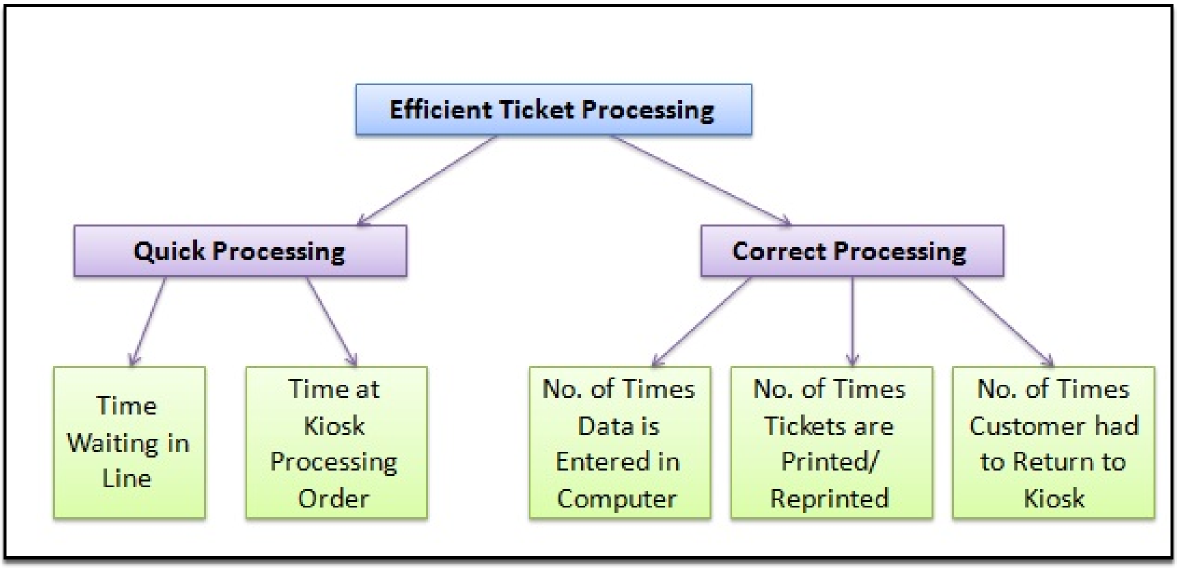
DMAIC Step	Explanation
D	**Define** the project's purpose and scope, and collect the customer requirements (i.e., the Voice of the Customer) Tools: control chart, Pareto chart, run chart, SIPOC diagrams
M	**Measure** the work's current state and uncover existing problems Tools: control chart, flowchart, histogram, Pareto chart, run chart
A	**Analyze** any problems found and use data to expose root causes Tools: cause-and-effect diagram, Design of experiments, interrelationship digraph, scatter diagram, tree diagram
I	**Improve** processes by implementing solutions to optimize the current state Tools: network diagram, control chart, histogram, Pareto chart, Plan-Do-Check-Act cycle, prioritization matrix, run chart
C	**Control** the new processes and monitor them to maintain any advantages gained Tools: control chart, Plan-Do-Check-Act cycle, run chart
Source (for the Tools listed): Brassard, Michael, Lynda Finn, Dana Ginn, & Diane Ritter. The Six Sigma Memory Jogger II: A Pocket Guide of Tools for Six Sigma Improvement Teams. Salem, NH: Goal/QPC, 2002. Print.	
Note: Six Sigma practitioners develop different opinions about where to use different tools. The tools listed in this table are some of the recommended tools for each step but do not necessarily need to only be used at their steps or are the only tools that Six Sigma practitioners use.	

Implementing this framework stabilizes and improves key processes and increases quality in process outputs. By refining and optimizing processes, the five steps also reduce the costs associated with variability and rework and help teams predict upcoming process results with greater accuracy.

All of the aforementioned tools help to ensure that processes and outputs are structured to meet the requirements that customers and the organization deem to be most important. These important requirements are the Critical To Quality characteristics (CTQs) that represent the attributes that internal and external customers use to evaluate the quality of process outputs. Appropriately addressing these measurable characteristics in process results will increase customer satisfaction and enhance customer loyalty.

Tracking these CTQ characteristics is made easier through the use of a CTQ tree. The CTQ tree is a tree diagram that breaks customer needs or expectations down into values that can be measured and monitored. The customer needs (at the top of the diagram) are related to specific, measurable data (at the bottom of the chart) that will show whether these needs are being met.

A CTQ Tree: Purchasing Tickets

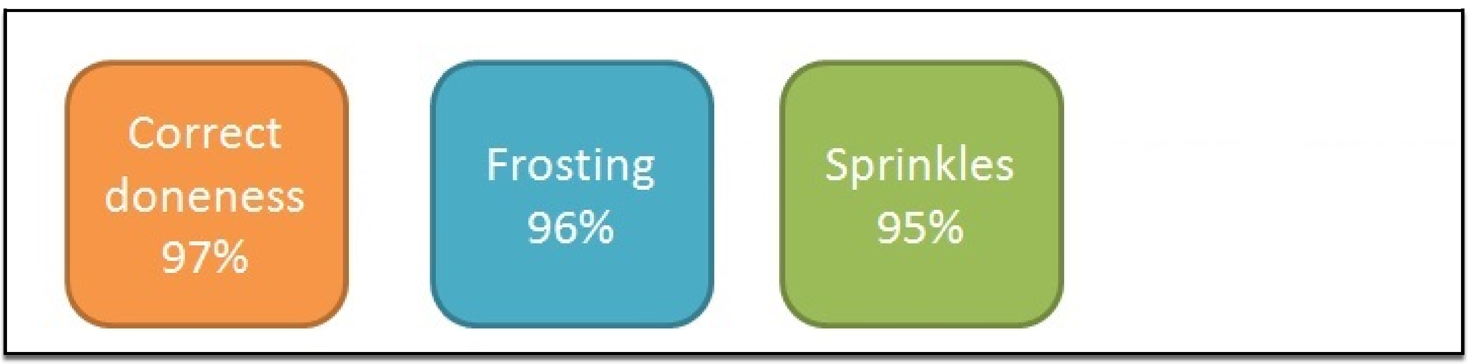


4.16 Reliability

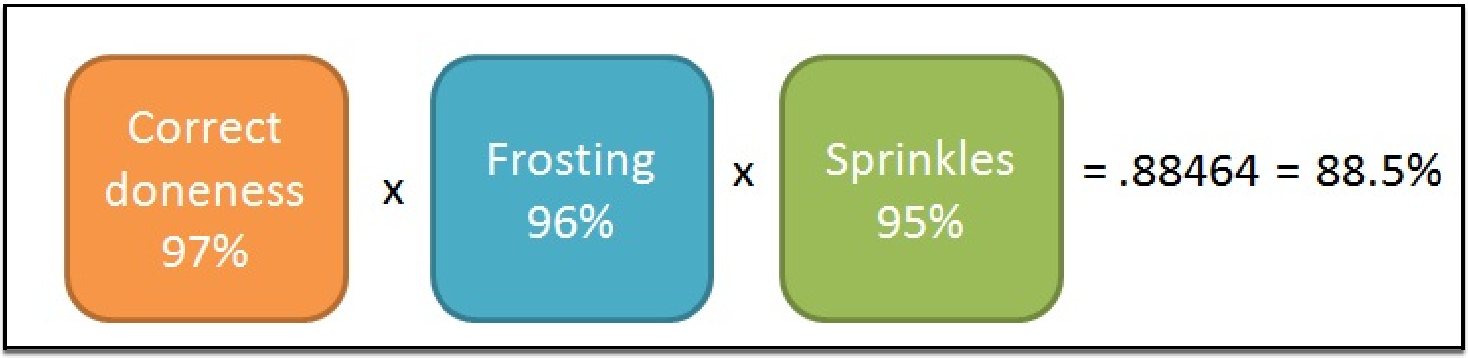
Reliability of a System Series

System reliability is important in any instance where the success of the whole system relies on the success of each component. In other words, if any component fails, the system or process fails.

Consider, for example, a bakery that makes cakes. 97 percent of the cakes put into the oven come out of the oven at the minimum required level for cakes at this bakery. 96 percent of the cakes have the appropriate amount of frosting put on them. Finally, 95 percent of the cakes have an appropriate amount of sprinkles on them. To determine the reliability that a cake put into the oven is then sold to at least the minimum requirements of the bakery, one uses a system series.



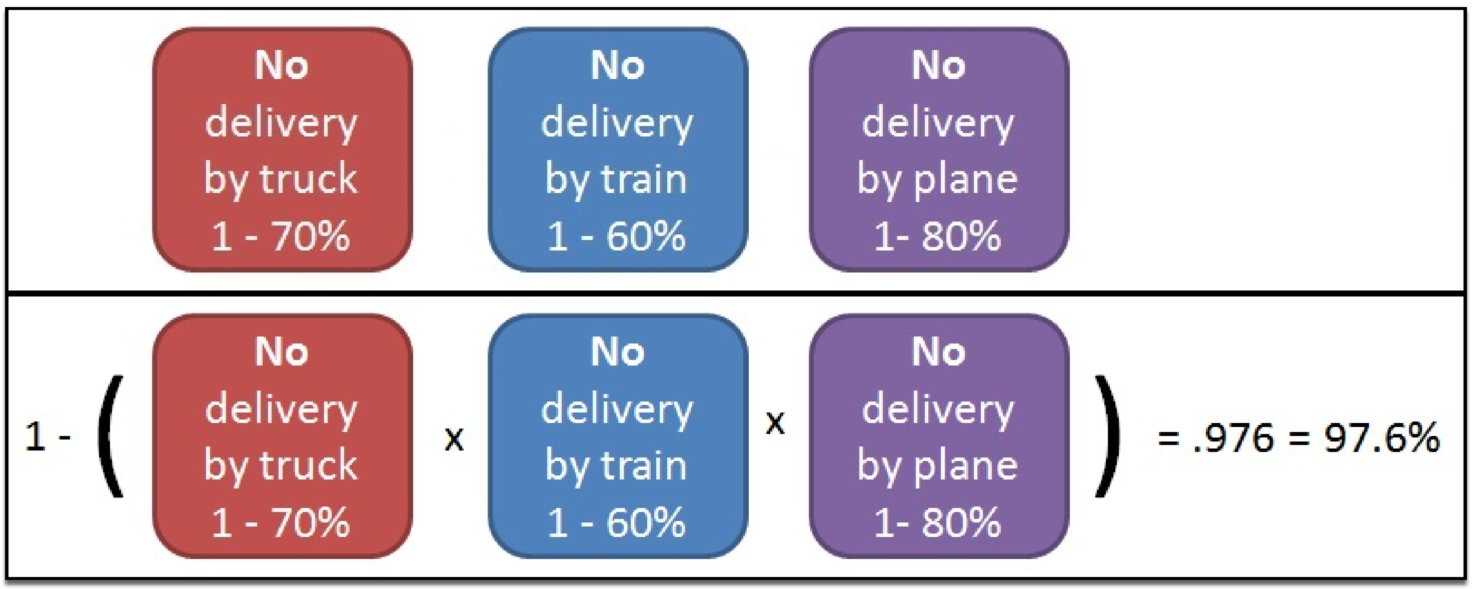
Reliability of Cake System = (likelihood of oven) × (likelihood of frosting) × (likelihood of sprinkles)



Reliability with a Parallel Process

In a parallel process, if any component works, the entire system works. All components have to fail for the system to fail. To determine the reliability of the system, multiply the likelihoods of each component in the system NOT working.

For example, a mechanic needs a certain piece of machinery in the next two days and therefore bought the same piece from a number of different suppliers, each with different forms of delivery. The likelihood that the mechanic will get this delivery by truck in two days is 70 percent. The likelihood that the mechanic will get it by train in two days is 60 percent. The likelihood that the mechanic will get it by plane in two days is 80 percent. To determine the reliability of this system:



4.17 Vocabulary Game

This assignment does not contain any printable content.

4.18 Flashcards

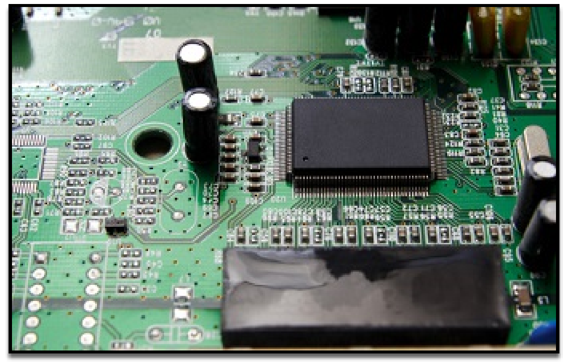
Flashcards

Term	Definition

4.19 Case Study: Solving Quality Problems in the Manufacture of Integrated Circuit Boards

Solving Quality Problems in the Manufacture of Integrated Circuit Boards

Anne Rose is the Production Manager of InTech which manufactures specialized circuit boards that control remote weather sensors. She oversees production activity on the shop floor which operates across two shifts, five days a week in order to produce sufficient output to meet demand for its customers. Weekend shifts, which are significantly more costly for InTech, are added when needed to catch up in cases when the plant experiences unexpected line delays or if significant levels of rework are required.



Over the past decade, the business environment has changed dramatically for InTech. The company's clients now expect almost flawless quality, flexible delivery schedules, while at the same time looking to drive costs down as much as possible. InTech grapples with stiff competition from other circuit board suppliers, including many companies in China that have been able to undercut them on price, particularly for systems that require more labor-intensive processes. In order to remain competitive, InTech has invested in specialized production machinery that can automate various tasks that populate and solder the boards, resulting in significantly better placement accuracy than if those processes were done manually.

To produce an integrated circuit board for its client, InTech buys unpopulated printed circuit boards from a specialized factory and adds specialized parts into the boards in a pre-determined format. While many competitors, particularly those overseas, use people to populate the parts on the printed circuit boards manually, InTech increasingly uses highly specialized machinery, operated by a skilled workforce, to apply the pieces to the boards with exceptional precision and repeatability.

InTech has found that its key clients are willing to pay a slightly higher price for this higher quality product, relative to the boards produced in China. However, this distinction means that InTech cannot afford to let the quality of its finished circuit boards slip; if they do, clients will have little incentive to pay their higher costs.

Signs of Problems

In spite of its reputation and state-of-the-art production equipment, InTech has recently had its share of problems. In recent months, Rose had been dealing with several clients who were upset about problems with "intermittency" — in other words, the boards worked properly sometimes but not all the time. Rose and her team had been working hard to replace defective boards and keep clients happy, but some were getting frustrating with the repeated problems. At least three key clients were threatening to switch to a Chinese supplier because, as one said, "If we're going to get this kind of reject rate, we might as well get it at 50% of the cost."

InTech's CEO and Chief Operations Manager were concerned about the situation as well. They deployed a team of quality experts to more thoroughly review finished products and attempt to improve their ability to find defective boards and determine the root cause of failures. In the four weeks since this escalated level of inspection had begun, the only thing that had changed was that the factory was now experiencing lower yields internally. Due to the enhanced finished board inspections, more finished circuit boards were being sent back from Quality Control to Rose's team for rework, adding to costs and overtime pay for workers needed to work the weekend shift to try to catch up on orders. Despite these trends, none of the quality experts had been able to determine the cause of the intermittency problems and the cause of the outright board failures, both of which contributed to low yields on the initial runs. As a result, the company's profitability was suffering.

Quality Analysis

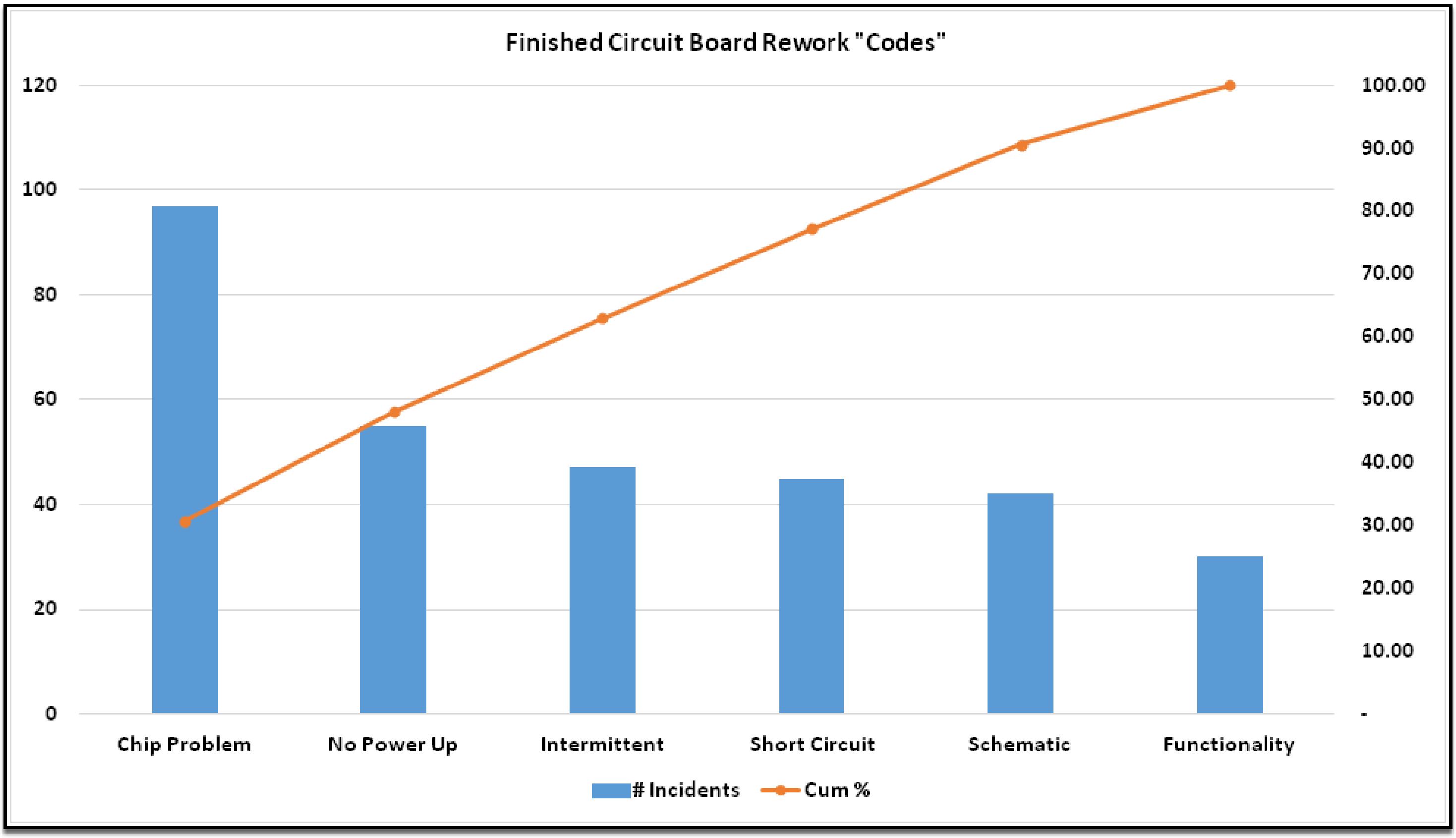
Rose knew that she needed to act quickly to solve both the intermittency problems on the customer end, as well as the low yields internally. Unless she could find a way to improve the first-run yields (process yield without rework) on finished circuit boards, InTech would continue to see mounting costs, missed deadlines and, potentially, continued complaints from or exits by clients.

Based on data collected during the past month by the Quality Control inspectors, one of the Quality experts compiled the following table that assigned a specific code to each finished circuit board that failed inspection and was sent back for rework. He grouped the codes into six different categories in order to find clues to the quality problems InTech was experiencing:

Cause of Rework	Number of Occurences
Board fails to power up	55
Board powers up but certain functions don't work	30
Board short circuits	45
Intermittent function	47

Chip problem	97
Incorrect schematic	42

The expert also prepared the following Pareto chart to determine the frequency of causes in the circuit board manufacturing process and determine where to focus quality efforts. He explained to Rose that, based on this analysis, they should look into the chip placement process for answers.

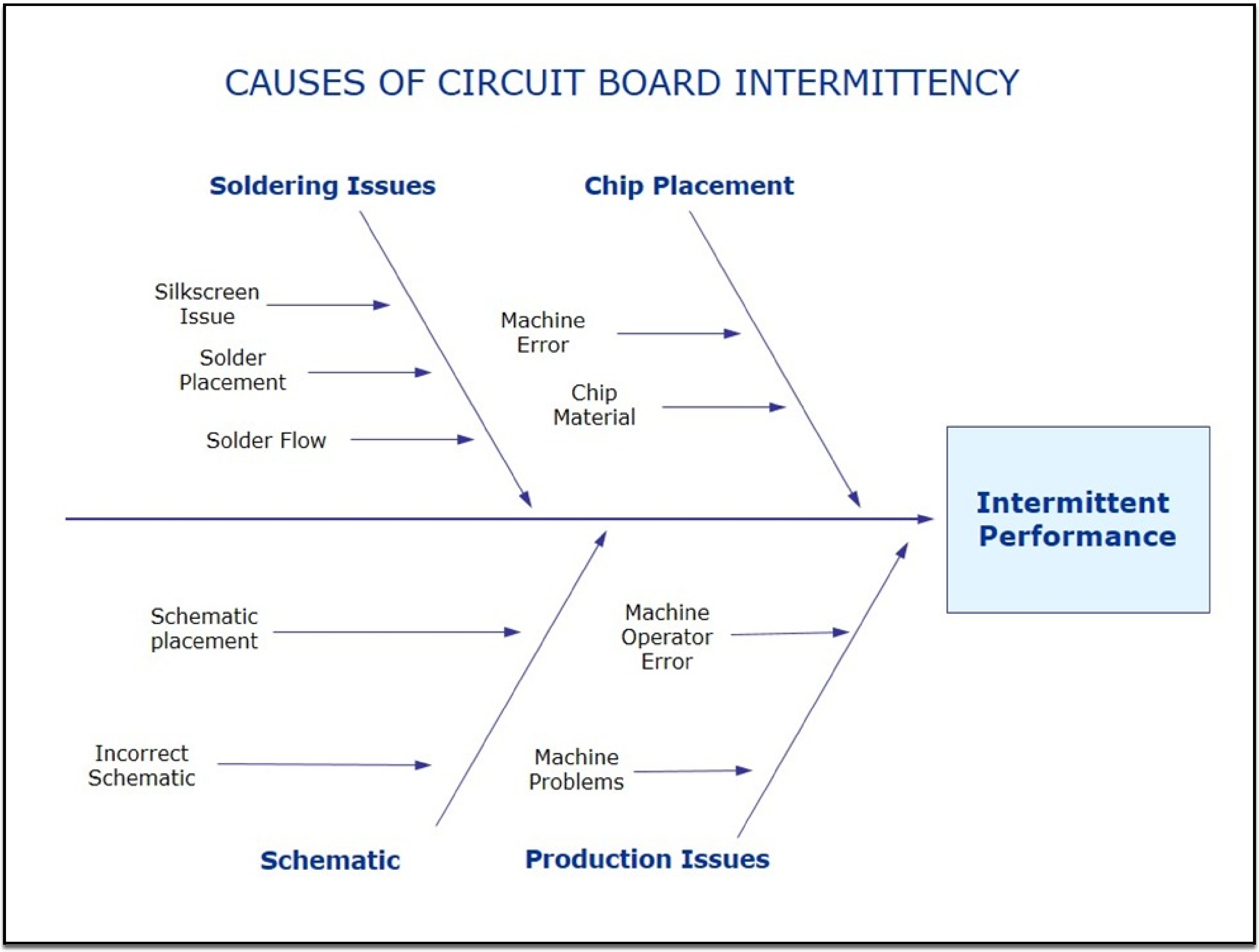


Rose studied the information from the Quality expert, but she was puzzled by the results. It didn't seem likely that chip placement would be causing their problems. Furthermore, chip placement was relatively simple and inexpensive to rework, compared to other problems that required more troubleshooting and repair. For example, a board that was returned for intermittency issues would take more time and resources to fix, likely incurring more need for weekend shifts and overtime pay.

At this point the production staff was frustrated with the data collection requirements imposed by the quality experts and no apparent improvements. The production staff believed most of the product variation and high rejection rates were beyond their control and that there must be some problem with the design and schematics. On the other hand, the Quality experts believed that the production staff was not following the production procedures and machine operation guidelines. Senior management was concerned that it was taking too long to resolve the production and quality issues and that clients were threatening to switch suppliers.

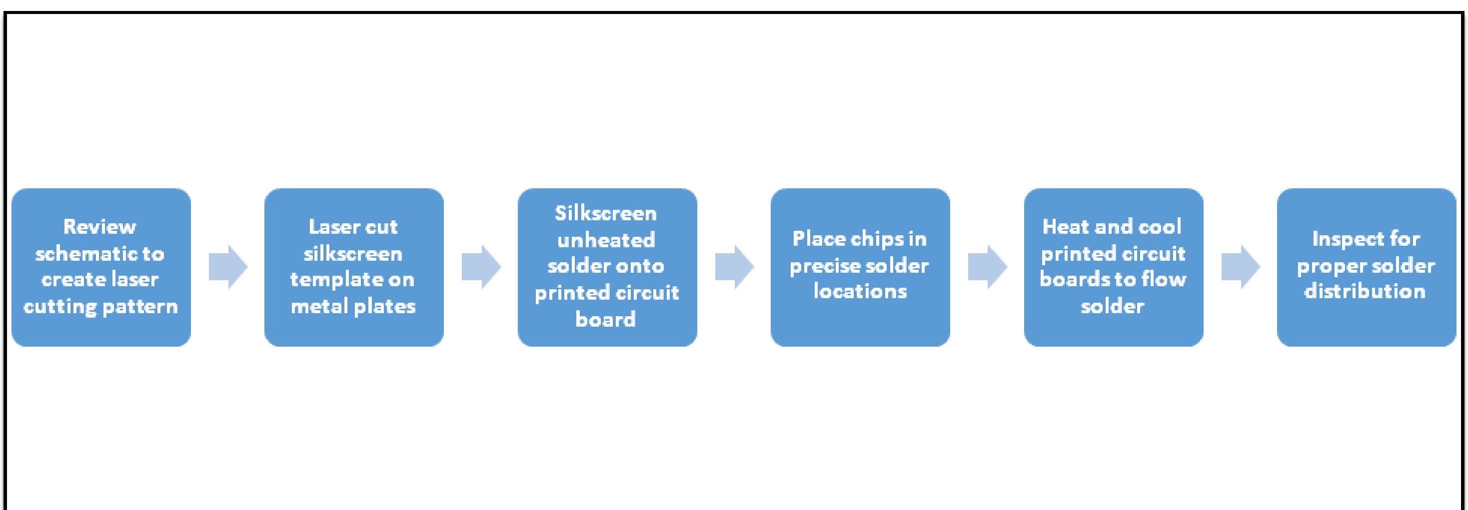
Root Cause Analysis

Rose realized that she and her team could not solve the circuit board challenges by looking at the problem the same way. The next day, she issued a questionnaire to everyone directly involved in the production of the finished circuit boards for their ideas and input on potential root causes of the intermittency experienced by clients.

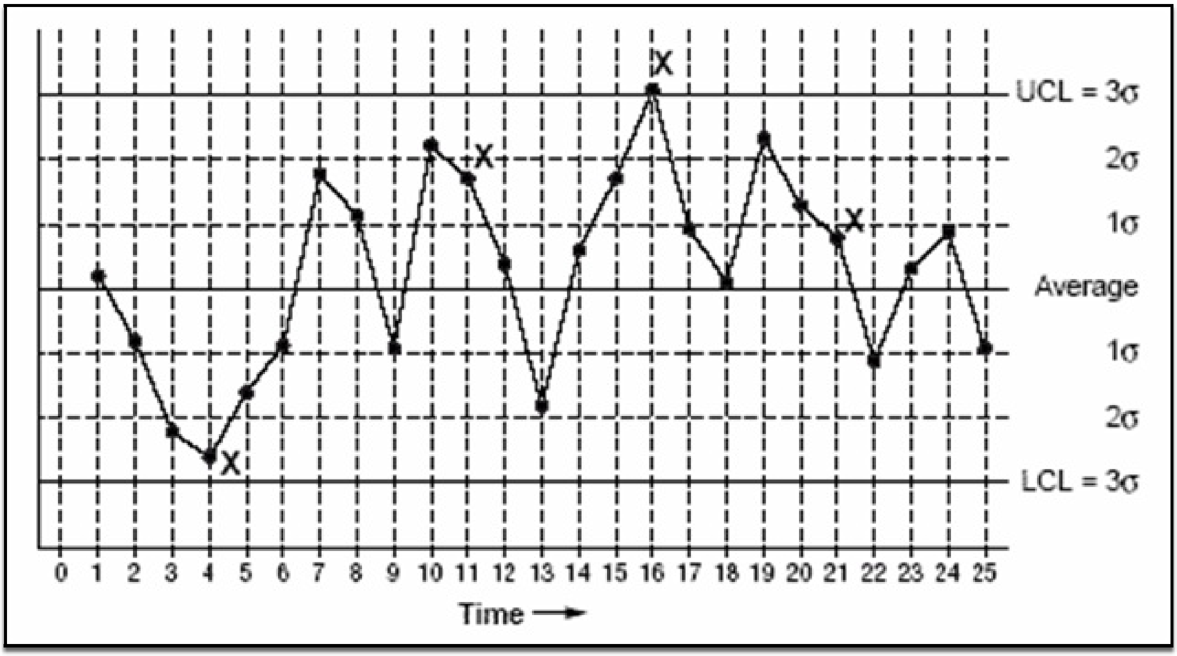


Rose and her team used this "Cause and Effect" diagram to brainstorm possible root causes for the intermittency problem. This helped them sort many possible ideas into several categories for deeper investigation.

After an in-depth discussion and review of the input that Rose had gathered from those involved in the production process, the team decided to drill deeper into the soldering process which is comprised of several key workflow steps:



For each of these steps in the soldering process, Rose assigned a member of her team to review the process, collect measurement data, and report on the degree of consistency and accuracy for each. Over the next week, team members inspected every aspect of solder placement and measured output. Before making any adjustments, they decided to conduct a statistical process control analysis to benchmark the degree of variation in solder placement from the schematic. To do this, they took samples of soldered boards and measured the distance from the actual center of the solder to where it was supposed to be, according to the schematic. The Upper Control Limit (UCL) and Lower Control Limit (LCL) on the chart below indicate the control limits for variation from the schematic. In other words, any solder center that is more than 1/10 millimeter (or three standard deviations) from where it is supposed to be is considered "out of spec" and likely to cause problems with circuit board function, such as the intermittency issue.



Additional statistical control testing revealed that instances of solder placement occurring beyond the control limits were happening frequently, approaching 20% of sampled output. Clearly, this was a problem that could likely have broader ramifications, including intermittent functioning for clients.

Rose's team turned their attention to the machines responsible for producing the pattern on the metal plates used in the silk screening process to apply the unheated solder. However, significant testing and re-calibration yielded little change in the solder placement results which still produced measurements greater than 1/10 millimeter from the expected location. As far as they could tell, the machines were working properly. The team was getting frustrated, clients were continuing to grumble, and Rose was worried about losing her job.

Then, during one of Rose's team sessions, one shift supervisor who had been assigned to review the solder heating process reported that he had noticed a lack of consistency in the flow of the solder as it melted. A closer inspection revealed that the melted solder was flowing unevenly as it was heated in and removed from the oven and that in some cases it wasn't entirely melting. This was causing inconsistency in the soldered connections, which seemed to explain the variance in measurements.

A thorough inspection of the oven that heated the solder confirmed that it was behaving erratically and, at times, failed to fully melt the solder to the expected temperature and consistency, resulting in unpredictable and ultimately costly problems downstream in the production process. Rose believed it was imperative to replace the standard conveyor oven with a specialized heating machine that would better control for the variation in heating now occurring in the oven. She believed strongly that this would contain the production problems and the intermittency issues on the customer end.

Rose knew that the new oven unit would be a significant capital expense for InTech, but she believed it was a necessary investment in maintaining product quality and consistency.

Question 1. If InTech were able to secure a short-term "trial" lease for a specialized batch heating unit to replace the unreliable conveyor oven, how could Rose and her team conduct an experiment to see if the new unit would be effective in fixing the soldering problems?

Question 2. Why did the Quality expert's Pareto chart provide misleading information to Rose's team about the cause of the production problems? How could they have constructed a more useful Pareto chart?

Question 3. When Rose presented her case for the new heating unit to senior management, they found the statistical process control charts difficult to understand. What is another way Rose could present the same information showing improved ability to keep measurement variances within control limits?

Question 4. In this situation, describe how inTech first realized it was having a problem.

Suggested/Sample Responses

Question 1:

After installing the new heating unit to melt the solder, the team could repeat the statistical control testing carried out previously using new samples of soldered boards. Based on the 20% "out of control" benchmark obtained previously, the team could analyze the improvement in results with the new unit. If the boards they inspect are now producing variations that are within control limits, they can easily justify the expense of the unit. Furthermore, the team can quantify the future savings from avoided rework costs and overtime weekend shifts to calculate a return on investment for the heating unit.

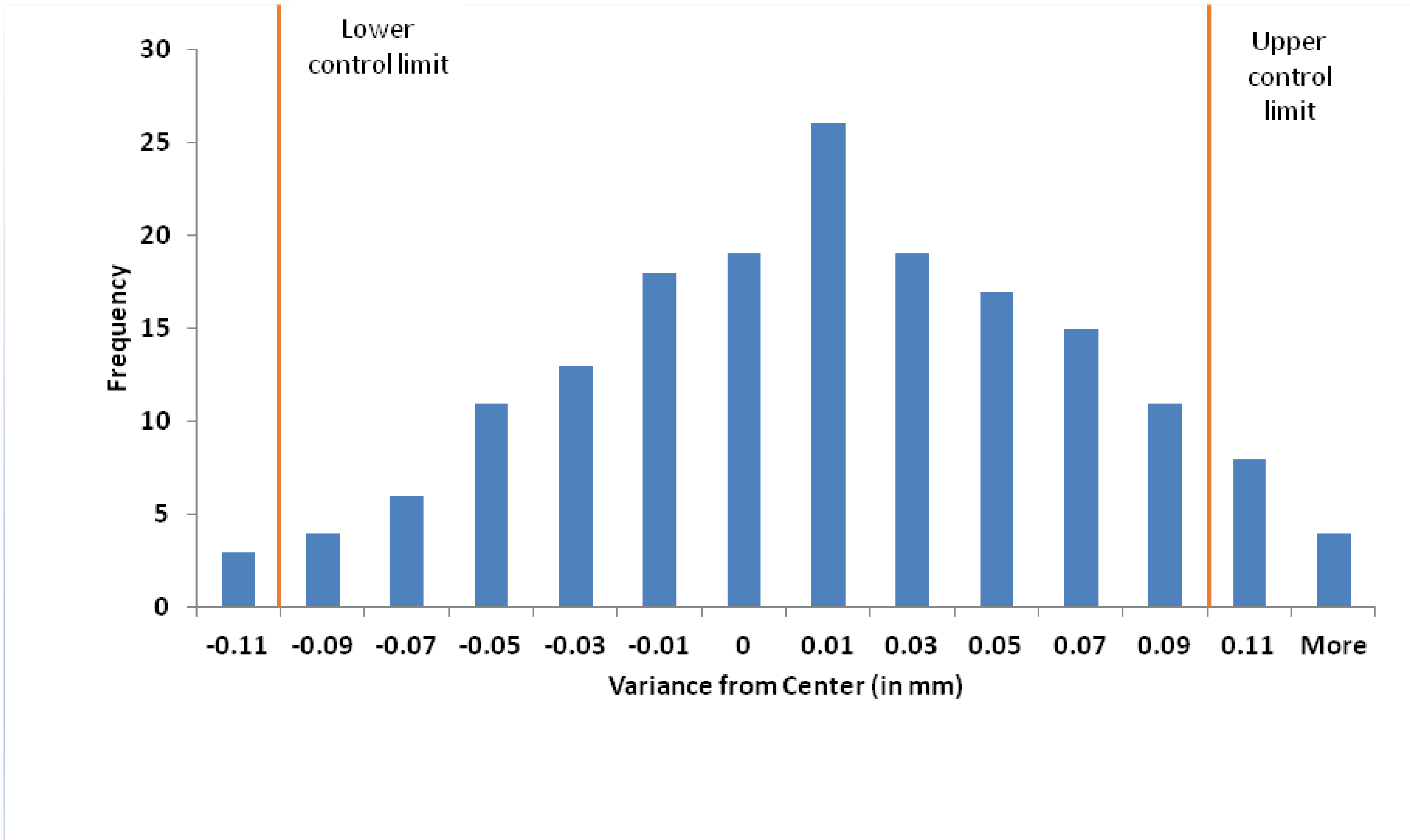
The company will also be able to see if the new unit reduces the reported intermittency from customers.

Question 2:

Instead of looking at the number of instances for types of reject code, the analysis should have considered the total cost for each type. For example, chip placement may have been cited more frequently as a cause for rework, but what if that type of rework is less extensive and costly than troubleshooting a board that doesn't power up or that powers up intermittently. It is important to include the data that is most important in driving the organization to the right goals — in this case, controlling cost and satisfying clients were paramount.

Question 3:

She could prepare a histogram showing the distribution of solder placement variances from the expected center. She could use the same before and after data to plot variances while indicating the upper and lower control limits. An example of such a histogram follows:



Question 4:

InTech first noticed problems when they experienced a drop in customer satisfaction. This was manifested in product rejects and the threat of decreased loyalty from customers. InTech realized that, unless they addressed quality problems in their manufacturing process, they would lose market share and profitability. In other situations, companies might realize they have problems internally before it is noticeable by the customer — in those situations, companies have the opportunity to engage in more preventive actions to fix quality problems before there is any impact to the customer.

4.20 Case Study: Quality Process Improvement in an Early Intervention Setting

Quality Process Improvement in an Early Intervention Setting

Michelle Reyes is the Executive Director for the Chelsea Center Early Intervention (CCEI), which provides specialized services to children under age 3, with developmental delays. As part of her role, she oversees Speech Language therapists, Occupational and Physical therapists and additional case workers who deliver direct services in homes and EI centers. Reyes oversees the entire process for each child's case from start to finish (intake through exit from the program) and is responsible for a significant amount of documentation, insurance billing, activity tracking, and reporting.

With increased emphasis on early detection of autism disorders and speech delays, the number of referrals and eligible children has steadily increased the number of ongoing cases at any given time. At the same time, the state has reduced its Health and Human Services budgets across the board, and like many local government agencies, CCEI has had to do more with less.

In the past two years, large caseloads and excessive workloads in many Early Intervention branches have made it difficult for therapists to serve families effectively. Reyes knows that the average CCEI caseload often exceeds recommended levels, sometimes by double or more. The complexity of cases requiring intensive intervention, as well as increasing administrative requirements, has further added to the caseworkers' demands. Reyes frustration stems from knowing that manageable caseloads can make a real difference in a therapist's ability to spend adequate time with children and families, improve staff retention, and ultimately have a positive impact on outcomes. In the current climate, she has repeatedly seen highly competent, caring staff burn out from the pressure and frustration at not being able to deliver quality service. With high turnover adding to existing staff burden, challenges retaining employees have only exacerbated a difficult situation.

Reyes knows that she needs to find the resources to hire more staff to ease this situation. She also feels confident that, with a moderate increase in her budget, she could afford valuable training and employee mentoring that that would help stabilize the staff and empower them to deliver quality services. The problem is that, in the current economic climate, there is little chance that CCEI will see any increase in budget allocation, and in fact, is likely to have its budget cut.

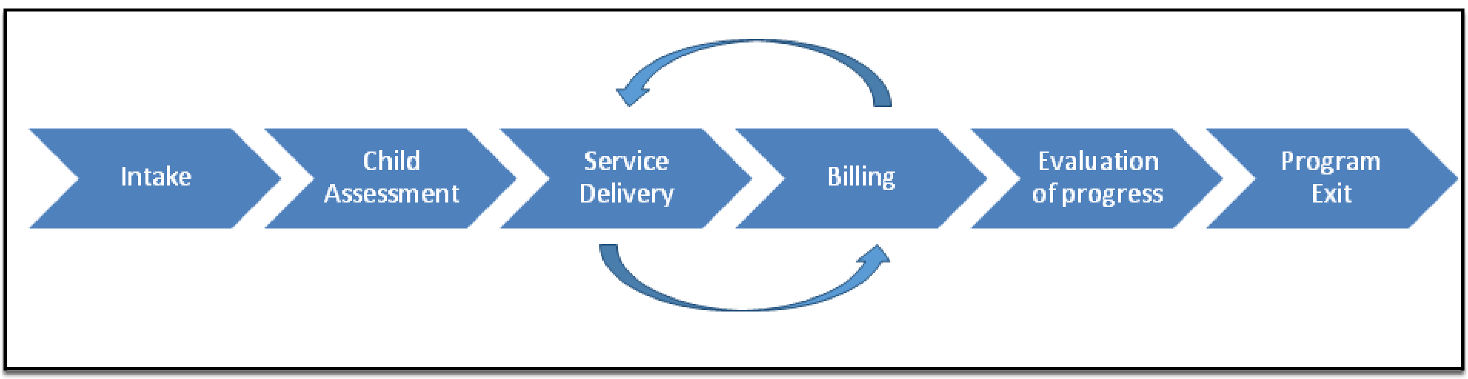
Other Ways to Find Resources

Reyes had the opportunity to attend a workshop on Quality Management in the Public Sector. She was pretty certain she knew what quality service for children and families looked like (the amount of time a competent therapist spent with families) and was even able to measure children's outcomes through numerous progress evaluations. Nevertheless, Reyes was intrigued to learn about Six Sigma, Lean and process improvement tools which she vaguely understood as methods to reduce waste and achieve cost efficiencies in a system. In spite of her skepticism that the workshop would be directly beneficial to her program, it actually stimulated a new trend of thinking that she was excited to share with her colleagues.

Engaging the Team in Process Improvement

Shortly after the workshop, Reyes organized a day-long working session with staff to share her thoughts on process improvement. By searching for efficiencies from within the agency itself, they could hopefully shift some spending to hiring and training of direct service providers, ultimately relieving the caseload pressures and burnout. She hoped to get them on board with a new way of thinking that might identify and eliminate waste and inefficiency and thereby free up much-needed resources. The goal was to create an environment where all staff could be actively involved in identifying improvement opportunities and using quality tools to deliver sustainable benefits.

After getting the group's buy-in to this idea, Reyes got the team's input to review all processes comprising a case, and to brainstorm ideas for quality and process improvement. They compiled the following case process steps:



Each of these steps proved to be quite extensive, involving different supervisors reviewing reports, evaluations and progress measurement. The team also noted that there was a great deal of document transfer, scanning, printing, mailing and physical transportation between CCEI and other EI agencies. The total intake process alone involved 8 non-direct service providers. They also noticed that these things brought significant delay to starting a child's services.

When Reyes and the team reviewed the other five steps in the process, they found similar instances of excess processing, duplication of work, document movement, resource usage and instances of unnecessary waste.

Bringing the Concepts of Lean Process Improvements to CCEI

After the offsite, Reyes returned to work energized by the possibility of looking for efficiencies and freeing up funds needed to support direct service providers and minimize caseloads. She turned her energy to conducting document reviews and data analysis, gathering stakeholder input, conducting site visits and phone interviews at other EI offices, in order to fully understand and document the current state of processes at CCEI. The billing process, in particular, showed evidence of the inefficient use of resources in duplicated requests for reimbursement, excessive amounts of paperwork, and necessary rework due to coding errors. Clearly, there was room for efficiency and savings here.

Reyes used her findings to map the billing process on a microlevel, using a SIPOC diagram to define the stages in this step:

Supplier	Input	Process	Outcome	Customer
EI Accounting Department	Claims submitted electronically	Insurer/Medicaid reviews, makes decision	Payment, denial, return for additional information or rework	CCEI program and service providers
	Claims submitted in writing/mail			

Reyes turned her attention to measuring "quality critical" metrics, specifically billing throughput time. She split this into waiting times, processing times, and rework time. Since measurements were needed for multiple locations and payer entities, she had to get the cooperation of people within those organizations. To collect measurements on the claims throughput time, Reyes and her team sampled every 20th claim over the course of a week, resulting in valid data on 45 claims.

- Average waiting time per file was about 48 hours
- Average processing time per file was about 12 hours
- Average rework time per file was 26 hours

By augmenting the SIPOC map with waiting, processing and rework times, Reyes was able to create a detailed map of the current state. On the map, she used red circles on the billing process chain to highlight where there were excessive instances of incomplete information, a repeated need for scanning, printing and mailing, and claims returned for more information or other rework. A significant portion of the waiting time was due to prepared claims waiting for approvals from a central EI office before submitting them for payment. Often these approvals took up to 36 to 48 hours, further delaying payments.

Reyes and her team realized a key action step to cut out unnecessary waiting time would be to consolidate as much of the billing process in one office, with authority granted to the office director to approve claims. She also believed there were opportunities to make better use of computer systems and available software to eliminate paperwork, improve billing accuracy and prevent rework.

Although the project team had clear ideas about how to improve the process to gain efficiency and achieve savings, Reyes organized another meeting to allow the accounting staff to come up with improvement measures themselves. This was designed to minimize resistance to change and give them a sense of ownership over the changes.

Ultimately, the team proposed 10 different changes to the billing process that could be implemented immediately.

Once improvements in the billing process were made, Reyes wanted to ensure that things didn't revert to their previous, inefficient state. To do this, she made sure to clearly define the new process and give frequent checks to ensure everything was proceeding smoothly. Within a short period of time, billing throughput time was reduced substantially, as was the amount of rework. The office dramatically cut the volume of printing and mailing through better use of electronic submittals. Finally, payments were received more quickly and fully, due to the improved coding accuracy.

While this improvement project was only the first step in improving efficiency at CCEI, the results had already brought dramatic impact to the bottom line, allowing Reyes to hire and train two additional therapists. She was gearing up for the next internal process improvement project, and her staff was eager to participate.

Question 1. What quality framework did Reyes employ to document, review and measure processes to improve quality output and efficiency?

Question 2. Which of the seven new tools described in this module would be most useful for Reyes and her team to deploy in future process improvement projects?

Question 3. What are some common pitfalls that can make these projects fail, and how did Reyes try to prevent these?

Suggested/Sample Responses

Question 1:

DMAIC framework. Define, Measure, Analyze, Improve, Control.

Question 2:

Any and all of the following answers apply:

1. An affinity diagram that would organize all of the verbal input (ideas, opinions, facts) from the offsite session. The team could use this structure to gather ideas, group them according to affinities or relationships with each other, and use the resulting groups as "strategic factors."

2. An interrelationship digraph that identifies and explores causal relationships among related concepts or ideas. It would help the team show the cause and effect relationship between factors in a process. This would help ensure that, in a complex system, the team is able to identify which issues are causing problems and which are an outcome of other action. It is also a way to identify key drivers and bottlenecks.

3. A tree diagram that breaks a topic (such as the billing process) down into its components. It expands a purpose into the tasks required to accomplish it. IT generates high-level goals or targets that must be completed to accomplish the purpose. Then it expands on each target to identify and define subordinate tasks to accomplish each target. In this case, Reyes could start with her primary purpose (reduce the cost associated with common CCEI processes to reallocate $$ on direct therapist service delivery) and identify the goals and sub-tasks flowing from that.

4. A process decision program chart that illustrates options for preventing or solving problems. It will help the team fully evaluate all potential solutions before choosing the best option. IT would also help Reyes maps out all contingencies when moving from the statement of purpose to its realization.

5. A prioritization matrix will also help Reyes evaluate the many potential process improvement areas according to how well they reduce cost and enable her to divert expenditures toward direct family services.

She could use the visual output of these tools (diagrams, matrices, etc.) to brainstorm ideas and display them prominently in work areas to keep everyone focused and aligned on the current tasks and objectives.

Question 3:

Any and all of the following answers apply:

1. Failure to include all key stakeholders (in this example, people involved in the billing process) in the assessment of the process and identification of areas for improvement. Reyes made sure to bring everyone together to brainstorm ideas, contribute to the SIPOC and process charts. This ensured that they would not feel defensive about the inadequacies in the current process and would be willing to participate constructively. She also involved them in the process of generating potential solutions. Even if their solutions were not all ultimately implemented, they could feel like they had a hand in the changes.

2. Forgetting about the "Control" Phase. Often teams go through all of the hard work of finding problems, identifying the best solutions, advocating for them and implementing them. But without ensuring that people continue to adhere to the new processes, it is easy to revert to previous habits, thereby losing all of the gains to productivity, cost savings and quality results. Reyes made sure to continue monitoring and measuring the new billing processes to make sure they were applied as planned and to check that staff were not falling back on old habits.

3. Insufficient data sampling. While it is not always possible to collect quantitative data on steps in a process, it is important to observe the activities in action, if possible, and take observations on a valid sample of instances. In this example, Reyes sampled data on every 20^{th} claim input, following it through all steps in the process and documenting the amount of processing, waiting and rework time to validate assumptions and ideas.

4. Looking only at isolated pieces of a complex system, while failing to see how they relate to the whole: Often it is easy to find a step in a process that, on its own, seems unnecessary and inefficient. But process and network diagrams are helpful in showing how that step might contribute to some other important function or otherwise behave in a "cause and effect" relationship.

4.21 Module 4 Printable PDF

This assignment does not contain any printable content.

4.23 Module Feedback

This assignment does not contain any printable content.