FIVE STEPS TO A MORE EFFICIENT OFFSITE FACTORY

A proven framework for streamlining any manufacturing process

A Special Report from DaVinci Consulting and OffsiteBuilder.com

by Daniel Small, Mechanical Engineer, MBA and Lean Six Sigma Black Belt

DaVinci CONSULTING OFFSITE BUILDER

The information provided in this e-book is for educational purposes only. It is not intended to be a source of financial or legal advice. Every company is different, and adjustments to a business strategy or plan should only be undertaken after consulting with a professional. The publisher and the author make no guarantee of financial or business results obtained by using this book.

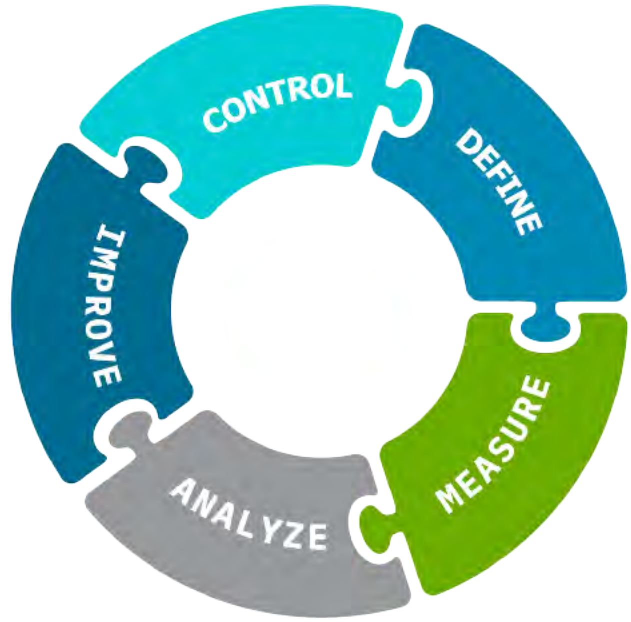
TABLE OF CONTENTS

INTRODUCTION: A FRAMEWORK FOR IMPROVEMENT

What is DMAIC and how will it help my business?

Chances are, your modular company's processes could be better. Perhaps your throughput isn't what it should be. Maybe you're getting eaten alive by callbacks and warranty work. Your labor costs may be unacceptably high. Or, maybe you just can't get the information you need, when you need it.

You're not alone—many companies face these challenges. And the obvious questions managers ask once they realize they have a problem are: "How do I go about making it better?" And, "where do I start?"



As an engineer, one of the things I love about Lean Six Sigma (and the reason I launched a business helping companies implement it) is that it offers a methodical, scientific procedure by which any process can be optimized—a "process improvement process," if you will.

It's known as the DMAIC ("duh-MAY-ick") cycle, and it lays out the steps, or phases, for improving any business process. They are Define, Measure, Analyze, Improve and Control. Each of the following chapters looks at one of these, but first I want to define them and give an overview of how they work together.

The definitions I use are from The Council for Six Sigma Certification's Black Belt Training Manual (aka "The Manual").

Phase 1: Define

The Manual defines Define as follows:

During a DMAIC project, the Define phase is concerned with identifying the problem, defining requirements for the project and setting goals for success.

This is where we decide what problem we're trying to solve. But while that may be obvious, it's not easy. Problems can be tricky to define, and if you get the definition wrong, then everything that follows will be compromised.

For example, perhaps you've noticed that your callback costs seem inordinately high. Once you've determined that you want to tackle this problem, you would identify a goal (say, reducing callback costs by 10%) and determine project requirements such as team members, quality metrics, project sponsor(s) and project duration.

Accurately defining a problem also includes deciding what success looks like, so we'll know it when we see it.

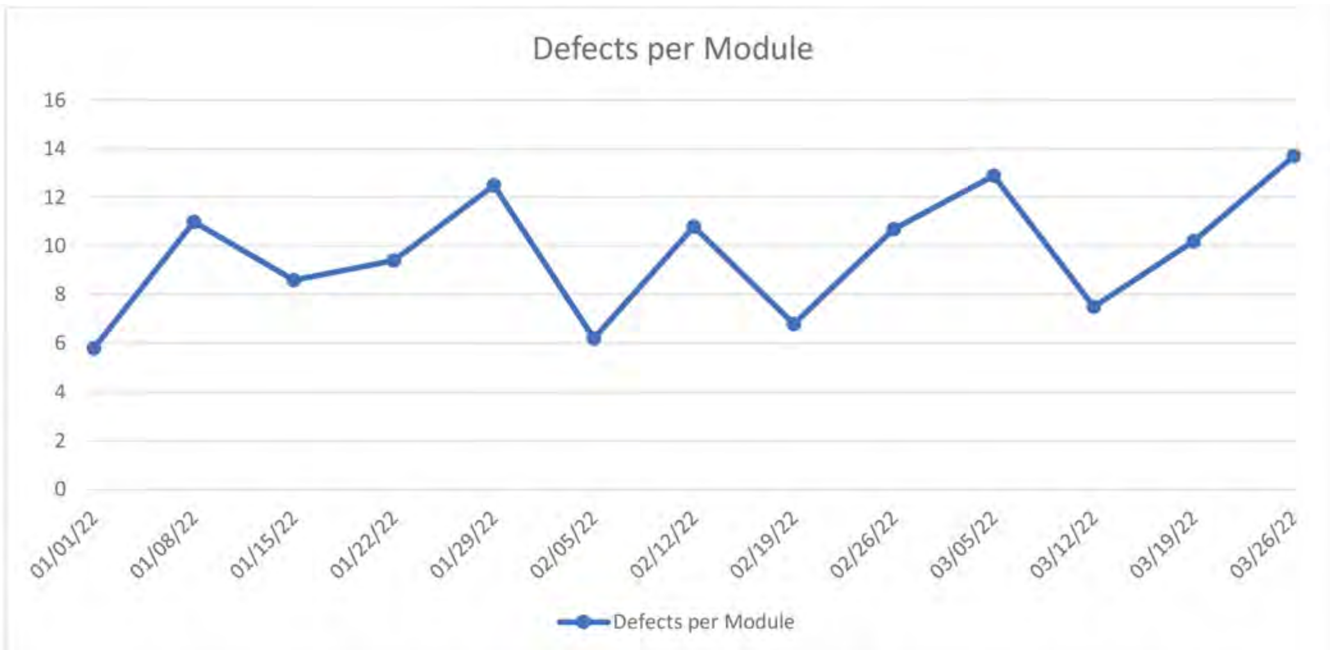
Phase 2: Measure

To be meaningful, definitions need to be fleshed out with data. According to The Manual:

The Measure phase is when teams use data to validate their assumptions about the process and the problem.

Once we've defined the problem and set goals to solve it, we begin gathering data on the current state of the process in question. I've found that few modular factories have this data, so this phase often means developing and implementing a data collection system.

In our callback costs example, the Measure phase might include establishing measurement systems to



Measurement includes tracking the number of defects per module over time

The Measure phase is typically quite detailed and lengthy, as the entire process improvement process relies on quality data inputs.

Once we have gathered enough reliable data, we can validate or revise the assumptions, problem statement, goals and definitions we identified in Phase 1.

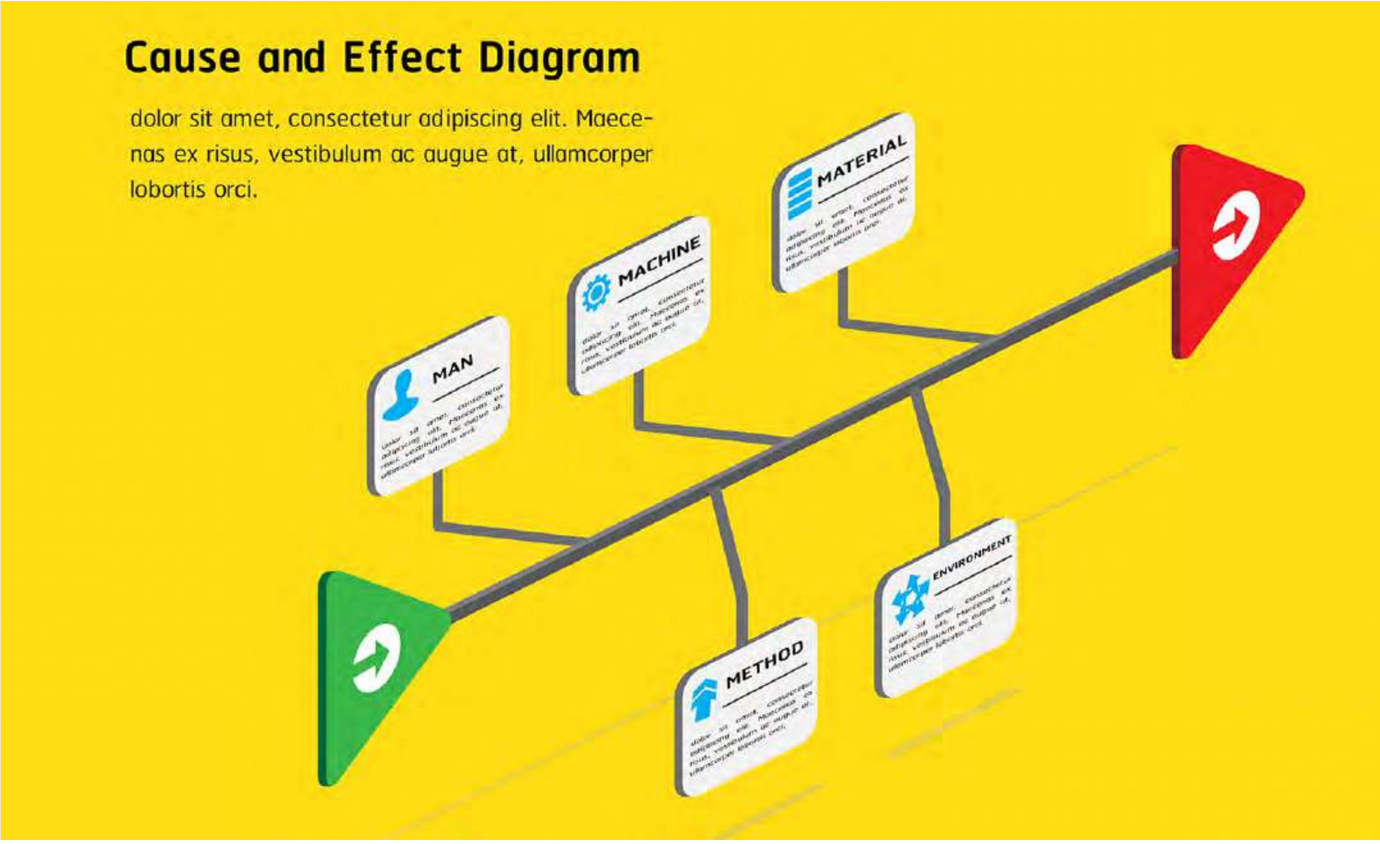
Phase 3: Analyze

The Manual defines this as follows:

During the Analyze phase, teams develop hypotheses about causal relationships between inputs and outputs, they narrow causation down to the vital few, and they use statistical analysis and data to validate the hypotheses and assumptions they've made so far.

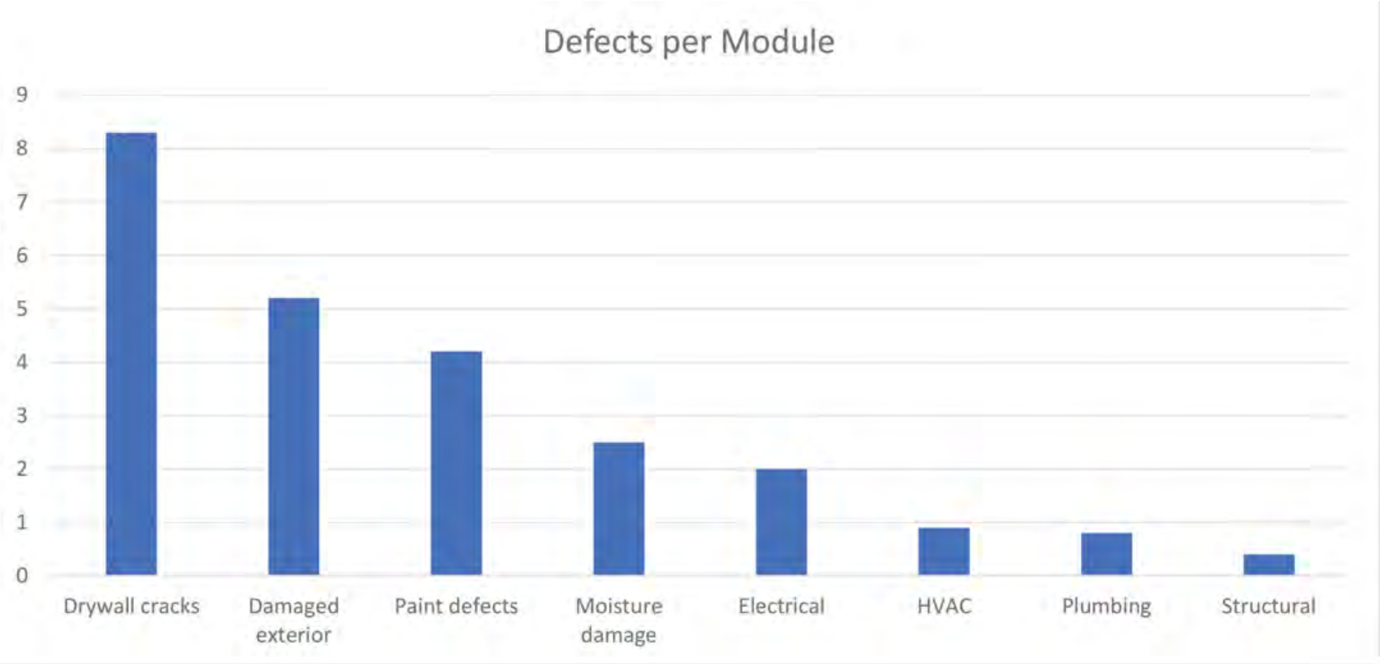
Here, we use statistical analysis to crunch the numbers we've collected in order to figure out the likely causes of the problem, or problems. Analysis can be quite involved and is usually performed and/or led by Lean Six Sigma Black Belts.

Returning to our callback costs example, this phase might include a root cause analysis using tools like a Fishbone cause-and-effect diagram to determine exactly what is causing the defects.



Example of a Fishbone diagram

Another useful tool in identifying and prioritizing root causes is a Pareto chart. This tool shows which root causes are responsible for the most failures, enabling efficient use of resources in addressing them.



Example of a Pareto chart

Phase 4: Improve

In this phase...

Teams start developing the ideas that began in the Analyze phase. They use statistics and real-world observation to test hypotheses and solutions. Teams also work to standardize solutions ... and ... start measuring results.

Once we know the likely causes of the problem or problems, we can develop and implement solutions, observe the results and iterate until we arrive at a solution. Once we've confirmed a working solution, we standardize it and begin measuring it.

For example, we might implement group ideation sessions with the process stakeholders (process owner, workers, customers, etc.) to formulate potential solutions to the most common root causes of module defects and the resulting callbacks. Once a likely solution (e.g. additional structural reinforcement to reduce strain at wall openings) has been selected for implementation based on cost/benefit and attractiveness analysis, a pilot would then be designed and implemented to test the theory.

NOTE: Sometimes, in the process of defining, measuring and analyzing the problem, we may discover that simply improving the existing process will not be sufficient, and that instead, a whole new process needs to be developed. Or perhaps the company would like to launch a new solution (product, service, etc.). In those cases, this Improve phase becomes a Design phase, where the team develops the new solution or process to address the unmet needs identified.

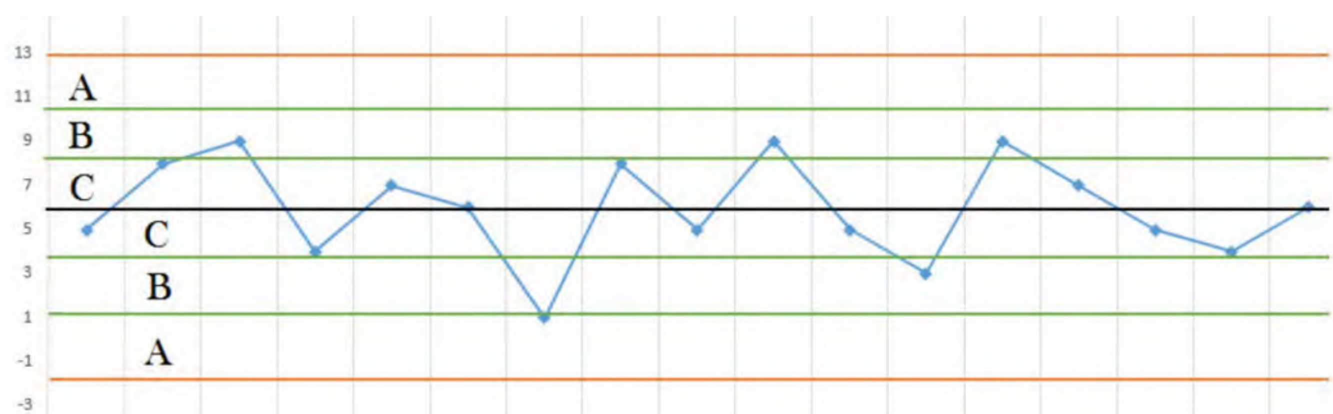
Phase 5: Control

According to the manual...

The control phase is where the project is transitioned to a daily work environment. Controls and standards are established so that improvements can be maintained, ... and ... the responsibility for those improvements is transitioned to the process owner.

This final phase is all about making sure the improvements we've worked so hard to identify, develop and implement in phases 1-4 stay implemented and continue to provide their intended benefits, permanently.

For example, once a solution or set of solutions is shown to be effective in improving process results, a control plan should be created to establish parameters, standard operating procedures (SOPs) and metrics to control the new, improved process going forward. The control plan often includes visual management techniques and statistical process control (SPC) charts.



This is a generic example of a process control chart. The black line in the middle indicates the specified/target quantity. The C, B, and A ranges represent increasing levels of deviation from the specification. Charts like these are used to monitor the results of an updated process over time, in order to catch and correct deviating trends quickly.

In the case of a new solution or process development rather than improvement, this last phase is known as Verify. In this case, it's used to confirm that the solution or process developed does indeed address the needs of the customer (whether internal or external).

An important part of finishing a DMAIC/DMADV project is team celebration and reflection. This provides immediate feedback and reinforces the practice, enabling continuous improvement to the continuous improvement program.

More to Come

The point is that you need not put up with sub-optimized processes and the issues they create. DMAIC provides a methodical framework for improving your factory and winning at modular. And that's not all: This same framework can be used to improve any process, including business development, design, preconstruction, accounting, HR, training and more.

The rest of this e-book delves further into each of these phases.

CHAPTER 1: DEFINE

How to launch a DMAIC effort

The essence of this first phase is captured by the most oft-quoted habit from Steven R. Covey's 7 Habits of Highly Effective People: "Begin with the end in mind." As with anything, success in improving a process begins with a clear definition of what we're trying to accomplish, what our objectives are, and how we plan to go about doing the work.

The Project Charter

The Define phase is where we create a Project Charter. This document lays out the road map and ground rules for the process optimization work ahead. It provides the structure and boundaries required for success.

For example, let's say you discover that your modules are suffering from an unacceptably high rate of drywall cracks and related callbacks and repair costs. You decide to correct the issue. Your first task would be to write a Project Charter that define the process improvement work.

The five key elements of a Project Charter are:

1. Problem Statement & Scope. What exactly are you trying to accomplish? What is the nature and scope of the problem that needs to be solved? How long is the project anticipated to last?

Perhaps as important as defining what is included in the scope of work is clarifying what is not included. It's very likely the process/sub-process you'll be working on is intertwined with adjacent and interdependent processes, so for the sake of clarity you need to delineate the work.

In our drywall cracks example, the problem statement might be, "Excessive drywall cracking in finished modules." This statement distinguishes the problem you will focus on (drywall cracking) from other defects or other problems, such as high cycles times for drywall finishing, or low cycle efficiency for drywall hanging.

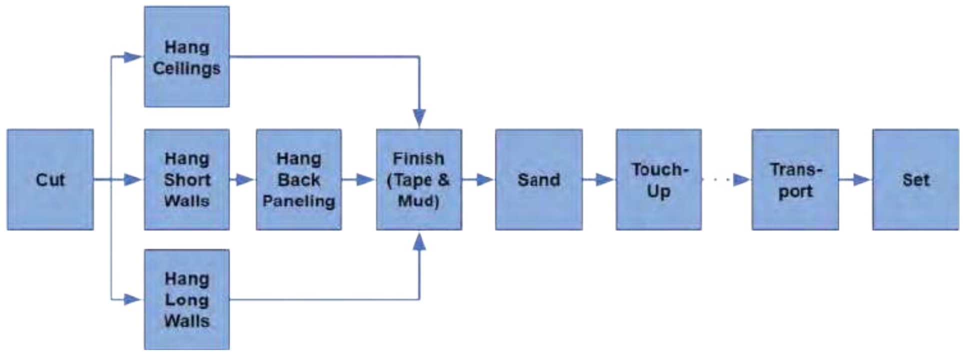
2. Team Members & Responsibilities. Process optimization requires focused, closely coordinated work from many people. To facilitate that focus and coordination, you need to clearly establish who will be involved in the project and what their roles and responsibilities will be. In addition, this part of the document should lay out ground rules like meeting frequency, attendance and participation, as well as communication procedures.

In our example, the likely team members might be the Production Manager, the Drywall Department Manager/Supervisor and the production teams for Drywall Hanging and Drywall Finishing. If necessary, the team can be expanded to include personnel from the Framing crew or even the Setting crew, if it's determined that those sub-processes are involved in the problem.

3. Process/Project Diagram or Map. One of the central tenets of Lean is that you need to visualize the work that needs to be done. Creating a diagram or map of the process to be addressed provides an invaluable tool for understanding and improving it. This map will be a reference for context, sequence, flow and other characteristics of the process as you move through the DMAIC project.

An initial, high-level version of a process map is on the next page:

4. Customer Information. You need to determine the sources, outputs and customers (internal and external) for the overall process and its major phases. In addition to your external, traditional customers (developer, builder, municipality, etc.), you have internal customers for various phases and sub-processes. Essentially, the owner of every phase in the process is a customer of the previous phase.



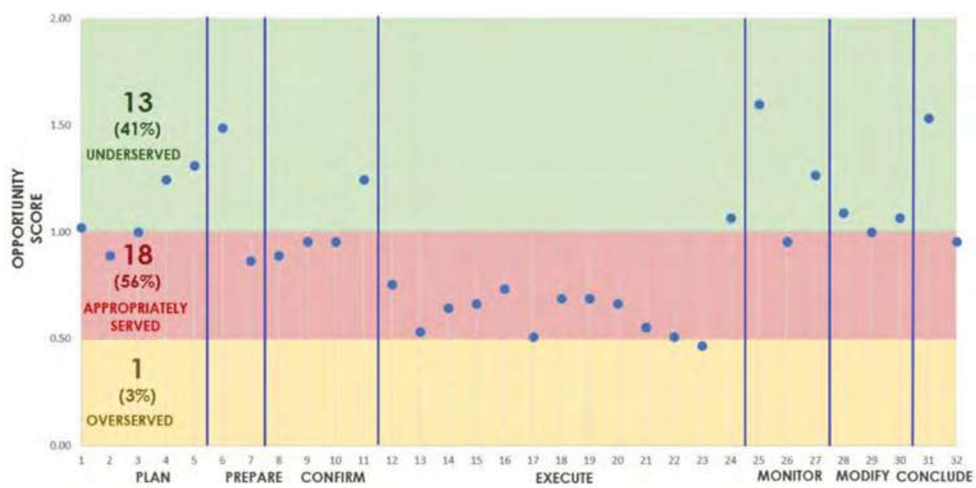
A process map flow chart

In the drywall cracks example, sources might be upstream processes like framing and cutting. Inputs would be materials like drywall, screws, mud, tape, labor and tools. The output would be a smooth interior enclosure surface. The internal customers would be the painters, trim crews, etc. External customers would include the transport, setting and stitching crews, the builder/GC, maintenance crews, etc. And finally, the traditional external customers: the developer and the building occupants.

5. Voice of Customer/Quality Metrics. This is where we define success. The goal of an effective process is to efficiently and cost-effectively provide customers with the highest possible quality of outcomes/solutions. In order to achieve that, it is essential that you understand and quantify your customers' quality metrics and unmet needs.

As a solution provider, one of your most important jobs is to become an expert in the jobs your customers are "hiring" you to help them accomplish (e.g., create cash flow via a multi-family building). Then you can provide a solution that helps them to do that better than any other solution.

Below is an example of a detailed quantitative customer needs analysis, showing the overserved, appropriately served, and underserved customer needs. This type of analysis uses data to determine which needs should be addressed first to add value for the customer, whether external or internal.



Quantifying customer needs

The Define phase is critical to success in process optimization and should not be skipped or taken lightly. Each part of the Project Charter requires careful consideration, open communication and research. The work put in here will pay off as you dive into the "meat" of the project.

Once the Project Charter is complete, confirmed and approved, you're ready to move on to the next phase: Measure.

CHAPTER 2: MEASURE

Before you can improve a process, you have to measure it. Here's how.

One of my favorite quotes comes from Thomas S. Monson, President, The Church of Jesus Christ of Latter-day Saints: “When performance is measured, performance improves. When performance is measured and reported, the rate of improvement accelerates.” The fact is that if you want to really improve a process you need understand it deeply, and you will only get that understanding through measurement. That's Phase 2 of the DMAIC framework.

Once you’ve completed the Define phase and have developed a Project Charter to guide your process improvement, your next task is to measure the current process and to establish a system for ongoing reporting.

Current State

Identifying weaknesses in a process requires that you take an objective and honest look at the current state of the process, no matter how painful it may be to do so. Only in this way can you determine what’s broken (or at least what's suboptimal) and begin the process of fixing it.

It may be tempting to go easy on yourself by only measuring the strengths of the process, by not digging too deeply, or by sugarcoating the results. Don't do it. Suboptimal processes are a sickness to your business and to cure that sickness you have to take your medicine.

Your initial measurements not only will help you identify where to start with your improvement efforts, but they will also become your comparison baseline for future, post-improvement measurements to help you track your progress.

Failure Modes & Effects Analysis

One of the tools we use to assess the initial state of each process and determine where to begin making improvements is Failure Modes & Effects Analysis, or FMEA..

FMEA is a tabular scoring tool that scores and ranks the failure points of a process according to various criteria, which results in a total score, known as a Risk Priority Number, or RPN.

To create an FMEA, create a spreadsheet with the following column headers:

1. Process step
2. Potential failure
3. Potential failure effect
4. SEV (Severity of failure)
5. Potential cause of failure
6. OCC (Occurrence frequency of failure)
7. Current monitor/control
8. DET (Failure detection ability of process/staff)
9. RPN (Risk Priority Number - total risk of this failure = SEV*OCC*DET)

An example of an FMEA is below:

Process Step	Potential Failure	Potential Failure Effect	SEV	Potential Cause of Failure	OCC	Current Monitor/ Control	DET	RPN
Cabinet installation	Cabinet installation taking too long	Delays to deliveries to jobsite	6	people	7	Foreman/team lead	8	**336**
			6	process/machine	5	none	10	**300**
			6	products/materials	8	purchasing team	6	**288**
			6	procedure/method	8	Production Management	9	**432**

An RPN can range from 1 (the best) to 1,000 (the worst), for each failure mode, or issue. This score provides guidance for prioritizing a process' failure modes for further analysis. In the example above, the Procedure/Method failure mode would be the top priority for further investigation, as it has the highest RPN (432).

Baseline Metrics

A major objective of the Measure phase is to produce baseline metrics for your process. How is the process performing now and what measure will you use to compare current performance to post-improvement performance?

For example, you could measure things like current cycle times, labor hours, Process Cycle Efficiency, defects and more. Each of these measurements can be performed on a completed production unit basis (a module, a panel, 100 subassemblies, etc.) to provide an overall baseline.

In addition, you can, and should, also apply these measurements to each sub-process—framing, wall assembly, MEP rough install, drywall hanging, finishing, sanding, painting, and so on. These sub-process measurements will help you identify the weaknesses of each process and establish baselines, in terms of time, cost, quality and safety.

Data Collection Systems

How do you get started with data collection? One way is to use manual data collection systems such as paper travelers, logs, or quality control sheets, in combination with a spreadsheet recording system. A lot of factories do this.

If you opt for a manual system, it's important that employees have a data collection template. The template should prompt them to collect data at appropriate times and record any information about the

data collection event, including the person collecting the data, the process involved and the environmental conditions.

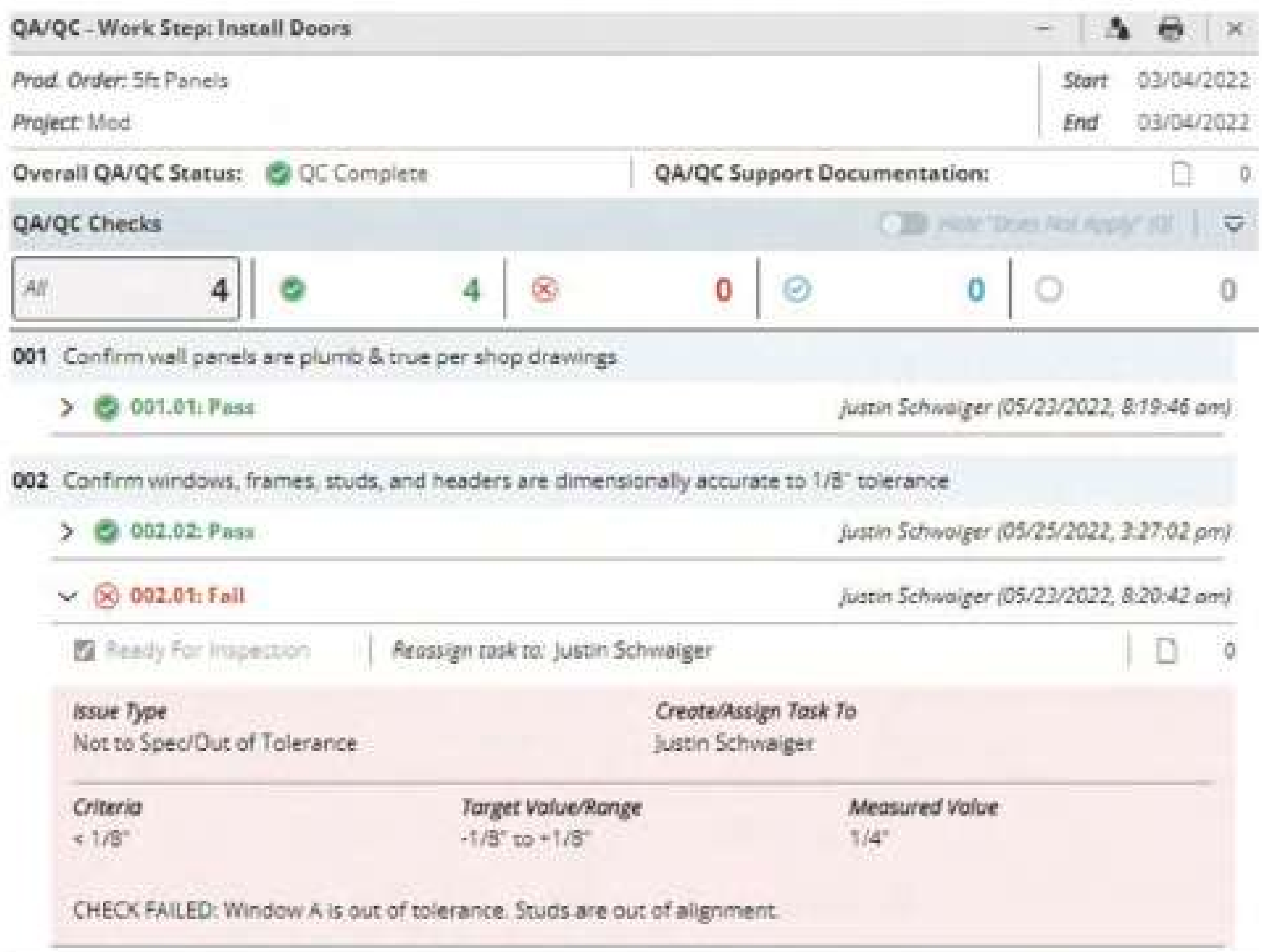
However, manual systems aren't ideal. While they're better than nothing in the near term, they are labor-intensive and subject to omissions, inaccuracies and variation. You should make it your goal to migrate to a digital solution as soon as possible.

CHAPTER 2: MEASURE

Using a digital or software-based system such as Moducore, Manufacton, or Offsight, will allow you to collect, analyze and visualize data automatically and in real time. Though these tools require a non-trivial investment to purchase/subscribe to and set them up, they will dramatically increase the accuracy, comprehension, resolution and usefulness of your data. These systems will also save you massive time in data collection, manipulation and analysis.

The illustration below is an example of a digital Quality Assurance/Quality Control form for door installation.

Digital forms like this one provide a fast, paperless and real-time way to collect detailed data on processes such as QA/QC inspections.



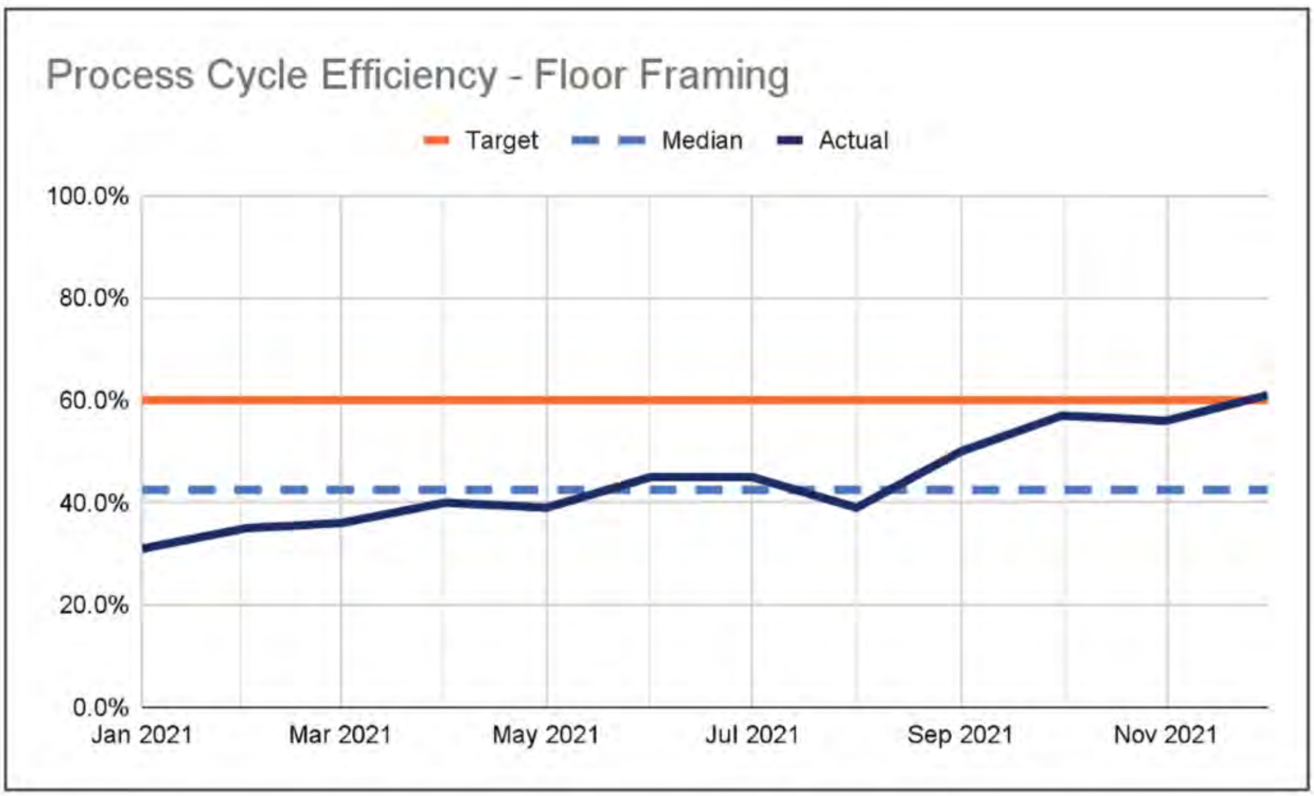
Digital data collection form

At the quantities being produced in an offsite construction factory, you should try to measure data for the entire population of output — every module or assembly you manufacture — as opposed to measuring data for random samples only. Population-level data is much more accurate than sample-level data and digital data measurement systems make collecting and reporting it easy and accurate.

Reporting

Once the baseline metric or metrics have been established, performance should be reported to all process workers and leaders on a frequent, ongoing basis, preferably graphically and in real time.

Below is an example of a basic run chart, showing Process Cycle Efficiency for a floor framing operation. It includes actual, target and median performance over time.



Run chart, showing Process Cycle Efficiency for a floor framing operation

A very effective method of reporting is to print out blank charts at the beginning of a reporting period and to have workers fill in the data on their areas of responsibility by hand at the end of each shift. For example, they could write in their daily numbers on production, safety, errors and more. This guarantees full visibility and understanding of the data and provides an opportunity for real-time feedback, both celebratory and constructive.

Often, providing workers with this type of real-time, clearly-relevant data, along with incentives for KPI target achievement, will prompt a noticeable improvement in results in directly controllable metrics such as safety or attendance. Knowing where things are in a process, and how they are getting better, gives workers real motivation to improve further.

For more complex or opaque metrics, such as Defects Per Module or Process Cycle Efficiency, the data will need to be analyzed further to discover the root causes of issues and identify effective solutions. That's where the Analyze phase comes in.

You've collected your data. What, exactly, is it telling you?

If you've implemented the Measure phase, you should now be in the habit of collecting relevant data about all of your processes on an ongoing basis. The data you're collecting should provide you with at least a basic clue as to which outputs are satisfactory, and which are unsatisfactory. For example, your data may tell you that your defects per assembly are too high, that a certain workstation is taking too long to complete its work, or that your Process Cycle Efficiency is only 13%.

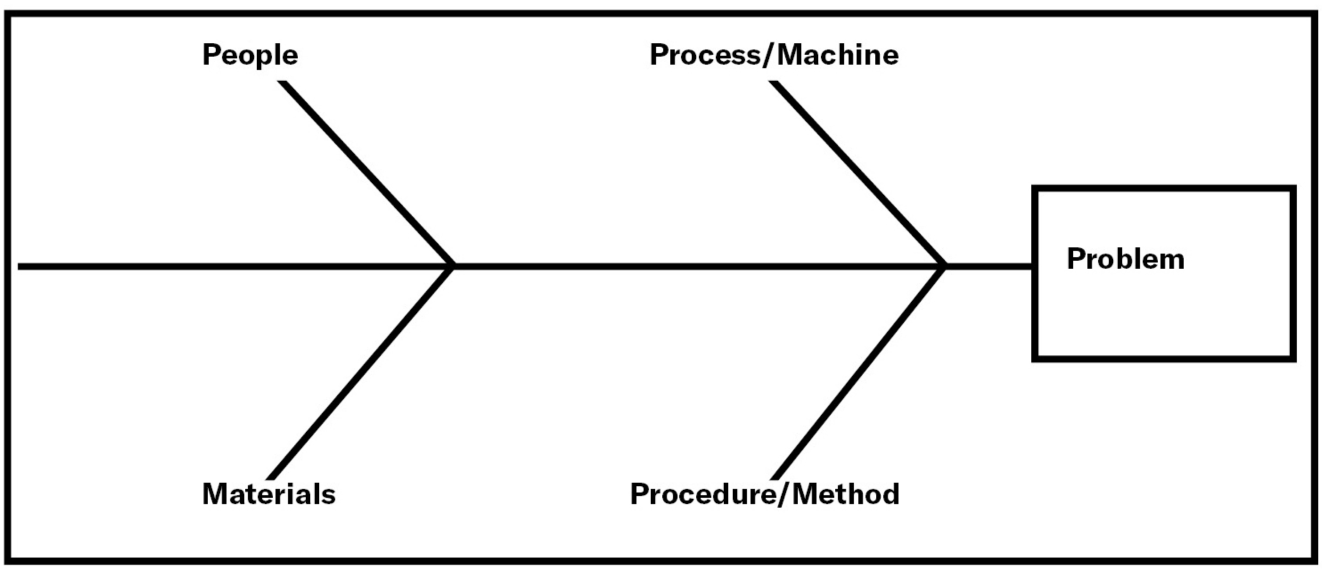
Now that you have that data in hand—and, ideally, a system for ongoing data collection—it's time to begin analyzing it to identify, quantify and prioritize the issues that need to be addressed.

Root Cause Analysis

The Analyze phase is all about uncovering the causes of your process issues, so you can fix them. The job here is to figure out why those outcomes are unsatisfactory.

One of the fundamental activities of the Analyze phase is what's known as Root Cause Analysis (RCA). This is where you and your team of experts (the line workers) deeply consider and discuss the possible causes of these issues. When discussing a problem, you and your team need to progressively dig deeper until you arrive at the root cause.

One of the most common and powerful tools for Root Cause Analysis is a simple graphic known as a fishbone diagram.



A simplified fishbone diagram

To conduct a Root Cause Analysis using a fishbone diagram, gather your team (the front-line workers who work in the area of the process that has the challenge) and sketch out a diagram like the one above.

The bones that connect to the spine of the diagram are:

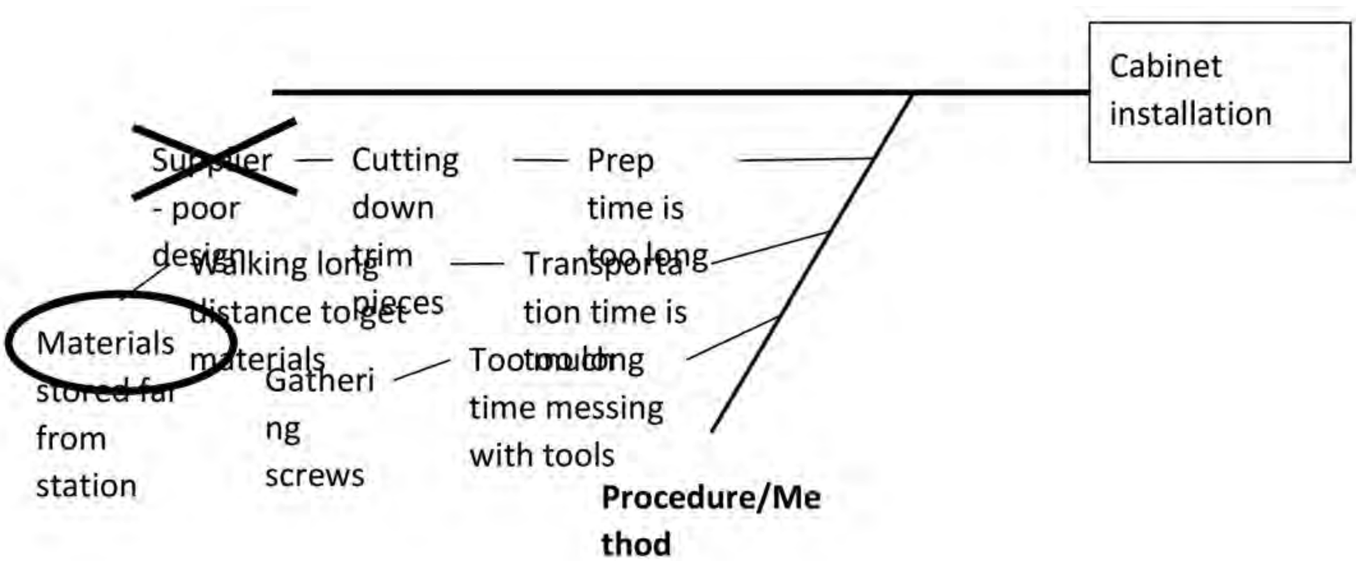
- People—Anyone who carries out, or interacts with, the process in question, including line workers and managers.
- Process/Machine —The way in which inputs become outputs, including the tools, equipment and machinery needed.

- Procedure/Method—How you define your procedures for getting the work done. These definitions could include written documents, unwritten rules, or standard operating procedures (SOPs).
- Products/Materials—The inputs needed by the process, including raw materials, usables and accessories.

For each category in the diagram, ask the team how something in that category might be responsible for the problem or defect. Capture their ideas either on sticky notes or directly on the diagram. For each idea, ask "why?" at least five times, to get to the root cause of the problem. Then repeat the process for each additional category.

If, for example, cabinet installation is taking too long, this process might lead the team to identify possible culprits as materials that are stored too far from where they're used. Or, they might conclude that the workstation layout requires too much movement on the part of the worker to reach the tools needed at each phase of the process.

Once you've captured the team's ideas in each category, review the ideas, reorganize if necessary and discuss them as a team. Remove any that are proven invalid through discussion. Then decide as a team which root causes seem most likely or highest priority, and circle those as possibilities for further investigation.



Section detail of a completed fishbone diagram

In the example above, for instance, the team realized that one potential root cause for their low Process Cycle Efficiency in cabinet installation was the distance at which their cabinet materials are stored relative to the workstation where the cabinets are installed. This root cause can now be further investigated.

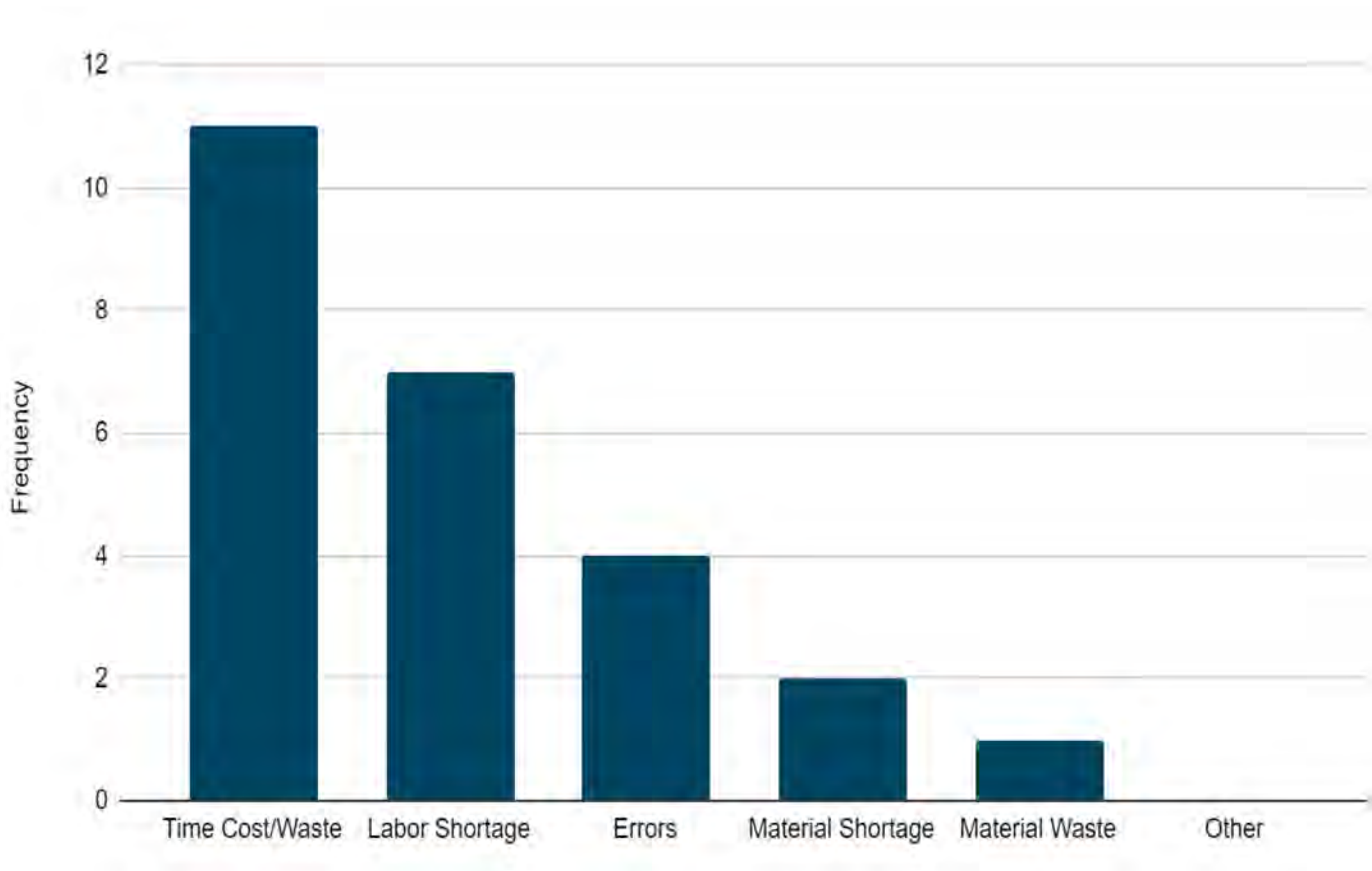
Pareto Charts

Named for the Italian economist Vilfredo Pareto, the Pareto Principle (AKA the "80/20 Rule,") reflects the fact that the majority of outputs usually stem from a minority of inputs. You can find examples of this in a variety of settings. Roughly speaking, about 80% of most companies sales will come from 20% of its salespeople and 80% of software problems will be caused by 20% of the bugs. Pareto even observed that 80% of the peas in his garden came from 20% of his pea plants.

How do you make use of this principle? If you have data tying problematic outputs, such as slow cabinet installation, to various inputs or root causes, such as sub-optimal workspace and storage layouts, this tool can help you prioritize the causes and determine where to begin with your corrective measures.

To create a Pareto Chart, simply chart the problem causes, or inputs, in order of highest to lowest frequency of occurrence. This will immediately show which causes should be your highest priority to address.

Below is an example of a Pareto Chart, showing actual categories of root causes of issues in real modular factories. As you can see, Time Waste and Labor Shortage constitute the majority of the causes of challenges in these factories, so addressing these causes first will yield the greatest return.



A Pareto chart. As with most problems, a few causes are the main drivers.

Start Simple

In addition to the basic tools I've described here, much more advanced statistical analysis can be conducted on your data to give you even more insight into the nature, degree and causation of the various potential causes of your issues. But even a basic analysis of the data you're gathering, as described above and with full participation of your process team, can take you a long way toward understanding what's causing a process to underperform.

Once you've completed your analysis and identified your most likely causes of problems, you can begin designing and implementing solutions. That's the Improve phase.

It's time to take action

In the Improve phase we work with our team members to ideate on potential solutions, select the most promising ones, and then test them to see how well they address the problem, or problems, we have identified. Once we've validated their effectiveness, we will implement the solutions.

This is the climax of the cycle, where all the work done in the first three phases culminates in solution implementation.

The Solutions Selection Matrix

The first part of the Improve phase is selecting solutions for testing. A very common and simple analytical tool for accomplishing this is what's called a Solutions Selection Matrix (SSM). The SSM allows your team to develop and evaluate multiple ideas for solutions to the process issues identified in the Analyze phase.

The Council for Six Sigma recommends creating the Matrix with a spreadsheet. The example below shows how the matrix might be completed for a problem that the team has identified as low Process Cycle Efficiency in the cabinet installation station.

Problem Statement	Validated Root Cause	Potential Solutions	Practical Method	Effectiveness	Feasibility	Cost/Benefit	Overall	Take Action?
Cabinet installation process efficiency is below 10%	Materials, tools, and accessories are stored far from the work location, causing excessive movement and transport waste	Keep tools & accessories near the module opening	Set up a mobile tool cart to hold all necessary tools & accessories	4	4	5	**80**	Yes
		Keep tools & accessories on the workers' persons	Require all workers to carry a stockedtoolbelt while working	2	3	3	**18**	No
		Keep materials near the location of use	Establish a storage rack adjacent to the cabinet install station(s)	5	3	3	**45**	Yes
		Delegate the transport waste to a lower-cost employee	Designate "runners" to fetch materials, tools, and accessories as needed	1	2	2	**4**	No

A Solutions Selection Matrix for a low process cycle efficiency problem.

1. Enter the problem statement in the first column. This should be the final problem statement that was arrived at during the Measure phase, if the team decided that the statement should be altered after gathering data. Otherwise, this can be the problem statement from the Define phase.
2. Entering a priority-validated root cause from the Analyze phase, which has been identified in this example as an inefficient storage layout. If the team is going to attempt to solve more than one root cause during the Improve phase, it should create an SSM for each root cause

3. Column three is for potential solution ideas. Here, teams should not question or attempt to analyze solutions, but should record any solution suggested that seems at all viable. The only solutions that might be ignored are those that are clearly out of scope or impossible, according to the process owner, e.g., Production Manager, etc. The example shows four possible solutions.
4. Here we note, at a very high level, the practical ways that each solution could be implemented. In this example, the process improvement team might propose that tools and accessories be kept near the module opening for easy access. A method by which that solution might occur is a mobile tool cart.
5. Rating solutions. After a list of possible solutions and practical methods is created, the team rates each possibility on effectiveness, feasibility and cost/benefit. Each category is given a rating of between 1 and 5.
    a. Effectiveness is the measure of how well a solution will eliminate a root cause for a problem, with 1 being not effective and 5 being highly effective.
    b. Feasibility is the measure of effort required to implement the improvement, with 1 being not feasible because of the effort or resources required and 5 being highly feasible.
    c. Cost/benefit is an estimated measure of how the costs of a project compare to the savings expected. This rating is not a formal cost/benefit analysis, but is a high-level estimation. If savings are expected to outweigh the costs associated with a project, the team ranks the solution as high. Otherwise, the team ranks the solution as low.
6. The scores for effectiveness, feasibility and cost/benefit are multiplied to calculate an overall score. The overall score can be used to prioritize solutions and select the most attractive solution.
7. Based on the resulting overall scores, as well as available resources in time, personnel and funding, the team selects the solution, or solutions, they will test out. As you can see, in this example, the first and third solutions look like they're the most promising ones to test.

Cost/Benefit Analysis

Although the Solutions Selection Matrix does a good job of identifying possible solutions to implement, company executives may want more information about the costs and benefits expected.

This is where the Cost/Benefit Analysis (CBA) comes in. It allows you to quantitatively compare the costs of the solution with the monetary benefits expected from it.

Costs include expenses such as software development or purchase, equipment purchase, building development or renovation, additional labor needed, training expenses, additional supplies and any losses associated with disruption as the solution is being implemented.

Quantifiable benefits might include an increase in profit margin or revenue (thanks to an increase in throughput) and cost savings or avoidance (such as lower labor costs or fewer callbacks). They might also include harder to quantify, but real, benefits such as better staff morale and improved customer retention.

Payback Analysis

One straightforward method of illustrating cost/benefit balance is Payback Analysis. To calculate Payback, you'll need the upfront cost of implementing the solution, as well as the annual estimated operating costs and financial benefits of the solution.

Here's the formula for this analysis:

Cost of implementing solution / (Annual financial benefits – Annual costs)

Let's assume that a project will have a $60,000 implementation cost and will require a $25,000 per year software subscription. The team expects $75,000 in financial benefits each year. The calculation is:

$60,000 / ($75,000 - $25,000) = $60,000/$50,000 = 1.2

It will take approximately 1.2 years for the project to pay for itself.

Net Present Value Analysis

If the annual costs and/or benefits of the solution are expected to vary year-to-year, you can calculate a more precise cost/benefit balance using a Net Present Value (NPV) analysis. A positive NPV indicates a favorable cost/benefit ratio.

An NPV analysis is a bit more complicated than a simple Payback Analysis. I don't have the space to describe it in detail here, but if you want more information, feel free to contact me.

Either a Payback or NPV analysis should give you a good quantitative idea as to whether or not, and to what extent, your proposed solution will make financial sense.

Pilot a Solution

For large or expensive changes, implementing solutions on a limited (pilot) basis will allow you to minimize the risk of evaluating the likely effectiveness of the solutions.
Benefits of a pilot include the following:

- Limited use of resources, which reduces waste if the solution turns out to be ineffective at resolving the problem
- Confirmation that expected results occur
- Allows troubleshooting of a new solution on a smaller scale to minimize disruption during full transition
- The opportunity for employees outside of the optimization team to provide feedback on the solution and implementation to make the final rollout more successful

Pilots can occur for a limited time, or on a limited scale (e.g., a specific module/assembly, station, team, etc.), depending on the nature and size of the problem and proposed solution. Start small, get feedback, improve the solution. Then, expand the pilot slowly until it's clear – demonstrated by measured results – that the solution is a good one.

Create an Action Plan

Once you've confirmed that the solution is effective, you can begin implementing it on a large scale. Throughout this process, you should work from an action plan, to ensure no tasks or priorities fall through the cracks.

Make sure you have retained and collected all the data, analysis and charts from the previous phases. This information will be critical in effectively implementing the final solution.

One of the most important pieces of documentation to be created/updated is a Standard Operating Procedures (SOPs) document. Without strong SOPs detailing the new/improved procedures, the solution implementation will not stick long-term and your process will likely regress to its former, broken state.

You will also need good documentation for staff training. Begin by training subject matter experts and/or process owners. These delegates can then train the rest of the process workers and impacted parties on the new SOPs. This training should then be integrated into the standing training policies and practices for the company, so all new workers and stakeholders of the process learn the improved procedures.

Conclusion

The Improve phase of DMAIC is when all of your careful preparation, planning, research, data collection and analysis pay off. You finally get to see the problem solved and the process fixed, hopefully permanently. But in order to ensure it is, indeed, permanent, we need to put in place systems to keep it going.

The new/improved process must be transitioned to the standard, permanent working environment, under the control of the process owner and systems need to be set up to maintain the new process and its benefits long-term. That’s the scope of the final Control phase.

CHAPTER 5: CONTROL

You've successfully improved key processes in your offsite factory. Here's how to ensure that you keep those improvements.

Now that you've implemented, tested and validated your solutions, and confirmed that they have addressed the issues in your process, you're ready for the fifth and final phase of the DMAIC framework: Control.

Let's say, as detailed in the previous chapter, that during the Improve phase you have raised your cabinet installation process efficiency from 10% to 50%. That's a real win, as the desired results have finally been attained.

It may seem like the job is done, but don't fall into the trap of believing that. If you want to keep the gains you've worked so hard for, you need to complete the Control phase. After all, this phase exists for a good reason.

The Control phase is where you "lock in" the process improvements you've made so that they don't unravel. The old, flawed processes are likely deeply ingrained as organizational habits and without strong controls in place the new processes you put into place in Phase 4 will likely devolve back to their unoptimized former state.

Revisit FMEA

As you start the Control phase, you should revisit the FMEA developed in the Measure phase, and recalculate the RPNs for the improved process. For example, as a result of your implemented solution(s), the RPN for your cabinet installation efficiency issue may have gone from 432 to 256. This will allow you to see that positive change has indeed taken place, providing important positive reinforcement and encouragement for the team.

Create a Control Plan

To ensure continued success of the improved process, you should create a written process control plan for the process owner. The purpose of this plan is to help the process owner and other process workers track and respond to key performance indicators (KPIs). This will ensure that the process remains improved.

The control plan should be a concise, easy-to-read document, either printed or digital, that shows what to monitor, how to monitor it, what the performance standards are and what to do when the process outputs do not meet the standards. See below for an example:

Whenever possible, corrective measures should be performed by the process workers themselves, rather than requiring a maintenance technician, or outside specialist, to perform. For example, the spot check referenced above is performed by the cabinet installer, rather than by a QC technician or foreman. This minimizes downtime and increases worker engagement and ownership of the continuous improvement process.

Optimally, you should try to find ways to automate the collection of ongoing measurements of the process. This can be done by means of software, often combined with hardware such as QR scanners, cameras, etc. This allows you to continuously gather data and easily and quickly convert them to real-time process control charts (see below).

Company	ABC Modular
Process	Cabinet installation
Control Plan Created on	9/22/2022
Control Plan Created by	John Doe
Process Phase	Preparation of cabinets
CTQ/Metric	Avg. PREP time per cabinet
Limit specification	LSL: 0 sec; USL: 30 sec
Unit of measurement	Seconds
Method of measurement	Stopwatch
Sample size	1 kitchen
Frequency	Every week
Employee	Cabinet installer
Record data in	QC log & daily production report
Corrective action	Identify source of delay. Report issue to foreman for follow-up.

A sample control plan.

Establish Visual Management

In addition to the control plan, teams can establish various visual systems and tools to make it easy to monitor the process going forward. Such tools include 5S workspace organization (which I detailed in [Five Days to a More Productive Factory Floor]() in the May 2022 issue off Offsite Builder magazine), signs, posted matrices and instructions, auditing boards that let teams keep track of individual or group performance over time, color coding and safety signals.

Standard operating procedures can be distilled into visual representations or graphics for quick reference during the process. Target results can be captured in photos or other graphics and posted in the work area. For example, illustrations of certain complex construction details, wiring or plumbing schematics, etc. could be posted at those stations for reference/confirmation by installation and QC workers.

Control Charts

One of the most common forms of visual process management is the control chart.

This type of chart can take various forms, but the most common type, illustrated above, includes data points, usually plotted over time, as well as lines representing the target (black), 1 (green) and 2

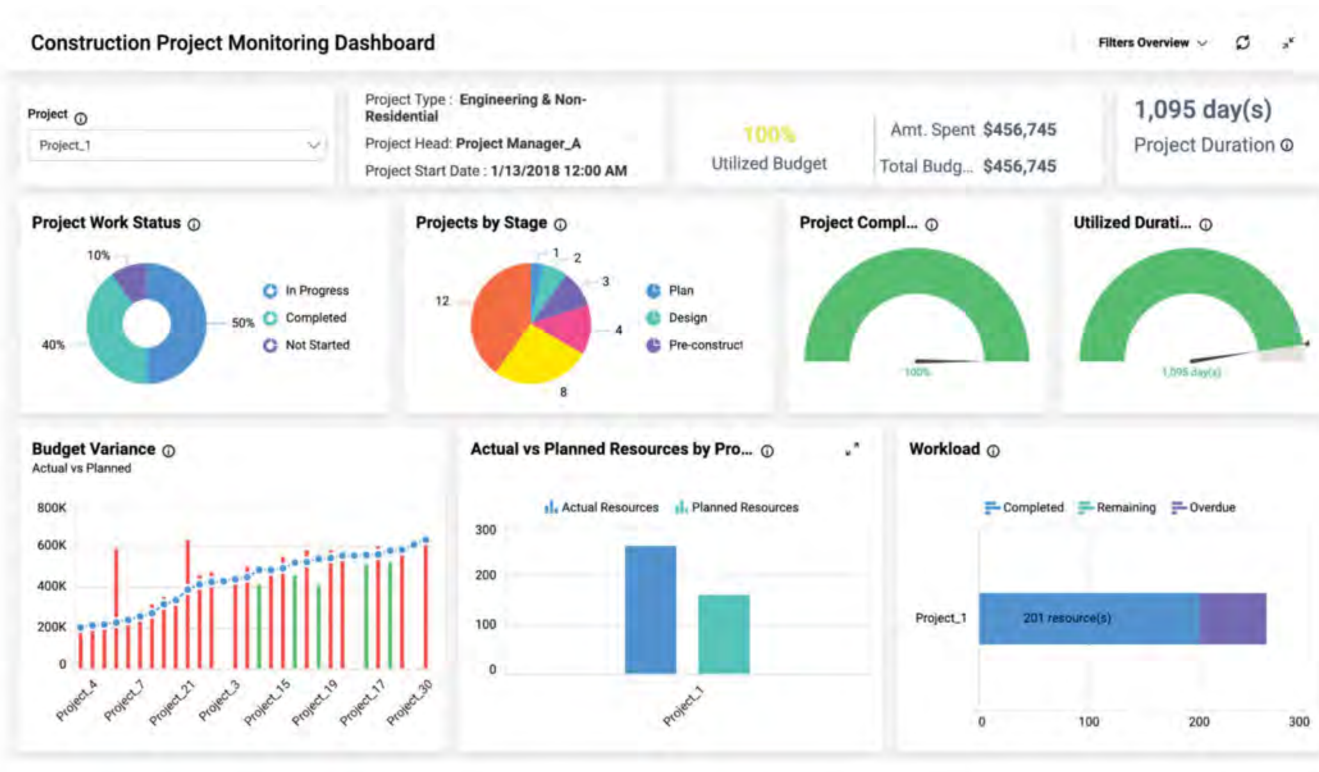
(yellow) standard deviations from the target, and the upper and lower control limits (red). In the example chart above – showing window rough opening gap sizes – the target result is 0.75 in, with an upper control limit of 1.00 in and a lower control limit 0.50 in.

Control charts like this show when, and to what extent, a process is out of control (i.e., outside the red lines), so corrective measures can be taken. You can use a control chart to display any numerical process data, such as numbers of defects, test results, panel sizes, framing member lengths, fastener totals, installation times, inventory levels, etc.

Again, ideally, control charts are composed of data points collected automatically via software, or other automated means and displayed in real time, on a monitor on the factory floor, for example. If that is not possible, someone can be assigned to periodically collect the data and update and display the chart manually. However, this method is much less effective than an automated system at catching and correcting process issues as they arise.

Dashboards

It's likely that your process has (or will have, if it doesn't yet) multiple Key Performance Indicators, or KPIs, that you need to track on an ongoing basis. Visually monitoring multiple KPIs is often done with a KPI "dashboard." This display combines real-time graphical representations of the most critical KPIs for your teams to easily and quickly monitor performance. The example below is generic, but your dashboard could include specific KPIs like modules in progress, project completion levels, labor productivity, production cycle times, Process Cycle Efficiencies by subprocess, profitability, throughput, etc.



A Construction Project Monitoring Dashboard. Source: Bold BI

Implementing Technology

Once upon a time, I sold software to the offsite construction industry, and I often told my customers that implementing technology before optimizing your process only serves to automate your waste. For example, implementing digital tracking software will not fix a wasteful process; it will only accelerate most of the waste and make it easier to see how wasteful the process is.

However, once the process has been improved to the point of at least being capable of consistently meeting customer requirements, the time may be right to implement certain judicious pieces of technology to help you maintain control of the improved process.

Of course, the process will hopefully continue to improve forever (that's how continuous improvement works), but software can be very helpful in automating the processes of collecting and reporting data, facilitating process control and further improvements. For example, offsite ERP software systems such as Moducore, Manufacton, Offsight, etc. can automate the process of tracking data such as work progress, cycle times, labor productivity and much more.

Celebrate, Reflect and Repeat

Now that the improved process is "locked in" with strong controls to maintain the improvements, don't forget to take time to celebrate and reflect on the outcome of the project. Recognizing the work of the team members will provide motivation for continuing to make further improvements. Recognition can be monetary, such as gift cards, cash bonuses, etc., but can also take the form of non-monetary rewards, such as public compliments, plaques, etc.

During the celebration and reflection meeting, while everyone is basking in the success of the project, is a good time to start coming up with ideas for future process improvement projects. You could reference information such as the RPNs and root cause Pareto charts on the FMEA, as well as collect new ideas from process owners and workers.

Taking advantage of opportunities like this to build on success to then immediately repeat the DMAIC cycle will help you to build a culture of continuous improvement.

And that culture is the secret to a truly optimized offsite construction organization.

ABOUT THE AUTHOR

Daniel Small is founder of ***Da Vinci Consulting*** in the Denver metropolitan area. He helps offsite (modular & prefab) construction companies dramatically increase their productivity, quality, customer satisfaction, & profit using his proprietary Lean Engineerovation™ framework

Mr. Small is an experienced executive advisor with over 20 years of background driving profitable growth through process optimization, innovation, and strategy in the construction industry. Over the course of his career, he has become adept at overcoming complex challenges faced by offsite construction companies and creating opportunities by improving existing processes and developing new solutions.

He holds engineering and MBA degrees and is certified as a Lean Six Sigma Black Belt. With additional training and experience in Jobs-To-Be-Done Innovation and Systems Thinking, he has a deep passion for helping his modular and prefab clients get the most from their manufacturing processes and create explosive, profitable growth. He is also an accomplished and impactful public speaker and trainer, having created and delivered thousands of hours of trainings, speeches, presentations, and classes.

Comfortable and effective in both the boardroom and the factory, Mr. Small confidently solves a wide variety of commercial and technical problems for his clients. Having worked with companies ranging from startups to Global 100 multinationals, he is recognized for aligning cross-functional teams at the intersection of business and technology, producing top- and bottom-line results. His work has resulted in millions of dollars in efficiency gains, new solution development, market share gains, and profitable revenue increases for his clients.
For assistance with improving your offsite manufacturing process,
contact him at ***DSmall@DaVinciInno.com***

DaVinci
CONSULTING

ABOUT OFFSITE BUILDER MAGAZINE

Offsite Builder, published by iMedia Group LLC, is the only monthly magazine that covers all aspects of the $10 billion prefabricated construction market. Our editorial focuses includes modular, panelized, SIPs and CLT construction. Our audience consists of builders and developers who have the foresight to branch out beyond the centuries-old method of building homes one stick at a time. Articles offer insight an advice on the technical, design and business issues affecting companies in this industry.

To browse our articles or sign up for a free subscription, please go to ***www.offsitebuilder.com***