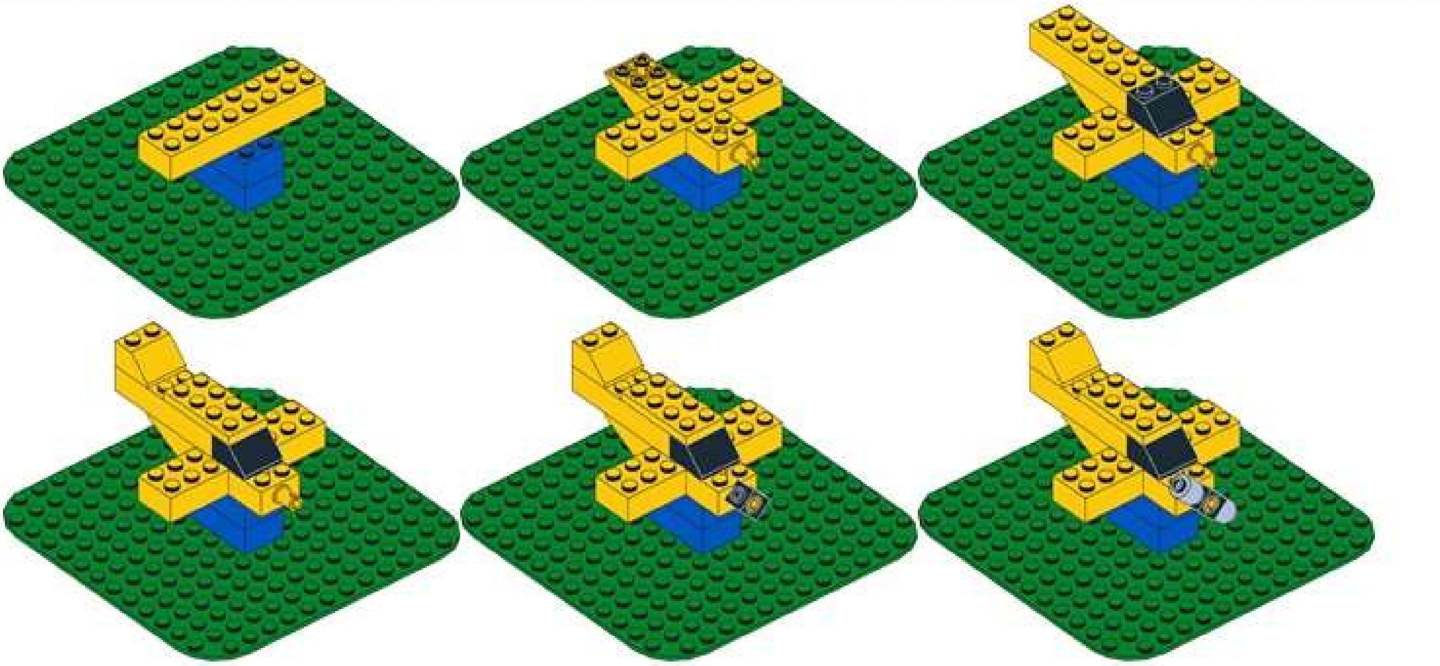
Collected Blog Posts of

AllAboutLean.com

2021

Christoph Roser



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AllAboutLean.com Publishing
Offenbach, Deutschland
2022

AllAboutLean.com Publishing, Christoph Roser, Hafeninsel 14, 63067 Offenbach, Deutschland, printed by Amazon Media EU S.à r.l., 5 Rue Plaetis, L-2338, Luxembourg

ISBN of the different versions

- 978-3-96382-043-4 Paperback in color
- 978-3-96382-044-1 Kindle eBook
- 978-3-96382-045-8 Free PDF for download at AllAboutLean.com

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at http://dnb.dnb.de.

Other Books by Christoph Roser

"Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, 439 pages, Productivity Press, 2016. ISBN 978-1-49875-630-3

All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production, AllAboutLean Publishing 2021, ISBN 978-3-96382-028-1 (Also available in German as **Alles über Verbrauchssteuerung. Planung, Umsetzung und Pflege von Kanban, CONWIP und anderen Pull Systemen in der Schlanken Produktion**. ISBN 978-3-96382-035-9.)

Fertigungstechnik für Führungskräfte. 2. überarbeitete und erweiterte Auflage, 293 pages, AllAboutLean Publishing, 2019. ISBN 978-3-96382-004-5 (Manufacturing fundamentals textbook for my lectures, in German)

Collected Blog Posts of AllAboutLean.com 2013, AllAboutLean Publishing, 2020. ISBN 978-3-96382-007-6

Collected Blog Posts of AllAboutLean.com 2014, AllAboutLean Publishing, 2020. ISBN 978-3-96382-010-6

Collected Blog Posts of AllAboutLean.com 2015, AllAboutLean Publishing, 2020. ISBN 978-3-96382-013-7

Collected Blog Posts of AllAboutLean.com 2016, AllAboutLean Publishing, 2020. ISBN 978-3-96382-016-8

Collected Blog Posts of AllAboutLean.com 2017, AllAboutLean Publishing, 2020. ISBN 978-3-96382-019-9

Collected Blog Posts of AllAboutLean.com 2018, AllAboutLean Publishing, 2020. ISBN 978-3-96382-022-9

Collected Blog Posts of AllAboutLean.com 2019, AllAboutLean Publishing, 2020. ISBN 978-3-96382-025-0

Collected Blog Posts of AllAboutLean.com 2020, AllAboutLean Publishing, 2021. ISBN 978-3-96382-030-4

Collected Blog Posts of AllAboutLean.com 2021, AllAboutLean Publishing, 2022. ISBN 978-3-96382-030-4

Preface to the 2013–2019 Collection of Blog Posts

Having successfully written my award-winning blog, AllAboutLean.com, for over six years now, I decided to make my blog posts available as collections. There will be one book of collected blog posts per year, from 2013 to 2019. This way you can store these blog posts conveniently on your computer should my website ever go offline. This also allows you a more professional citation to an article in a book, rather than just a blog, if you wish to use my works for academic publications.

This work is merely a collection of blog posts in chronological sequence, and hence does not make a consistent storyline but rather fragmented reading. I am also working on books that teach lean manufacturing. These will also be based on my blog, but they will be heavily edited and reworked to make a consistent storyline. The one I am currently writing focuses on pull production, and hopefully it will be available soon.

The blog posts in this collection are converted into a book as closely as I can manage. However, there are a few changes. For one, on my blog, image credits are available by clicking on the images. This does not work in printed form, hence all images in this collection have a caption and a proper credit at the end of this book. Besides my own images, there are many images by others, often available under a free license. I would like to thank these image authors for their generosity of making these images available without cost. Detailed credits for these other authors are also at the end of this book.

Additionally, a few images had to be removed due to copyright reasons. These are, for example, images from Amazon.com. My blog also includes videos and animations. However, the print medium is generally not well suited to videos and animations, and I do not even have the rights to all videos. Hence, I replaced these videos with a link to the video, and edited the animated images. On digital versions of this book (Kindle eBook, pdf, etc.), these links also should be clickable. No such luck with the print version, unfortunately.

Since my goal is to spread the idea of lean rather than getting rich, I make my blog available for free online. Subsequently, I also make this book available as a free PDF download on my website. However, if you buy it on Amazon, they do charge for their eBooks. If you want a paper version … well … printing and shipping does cost money, so that won’t be free either.

I would like to thank everybody who has supported me with my blog, including Christy for proofreading my texts (not an easy task with my messy grammar!), Madhuri for helping me with converting my blog posts to Word documents, and of course all my readers who commented and gave me feedback. Keep on reading!

As an academic, I am measured (somewhat) on the quantity of my publications (not the quality, mind you!), and my Karlsruhe University of Applied Science tracks the publications of its professors. In other words, one of my key performance indicators (KPI) is the number of publications I author. Hence, I will submit these collected blog posts as publications. On top of that, I will submit every blog post in this book as a book section too. Hence, I will have over three hundred publications including seven books, with me as an author, in one year! It will be interesting to see the reaction of the publication KPI system on this onslaught 😐. I just want to find out what happens if I submit over three hundred publications in one year 😐. I don’t know if I will get an award, or if I will get yelled at, but it surely will be fun. I will keep you posted.

Preface to the 2020 Collection of Blog Posts

2020 was again very productive, and I wrote another 53 blog posts. With the help of some WordPress programming, I also simplified the creation of this collected blog post volume, but it is still a lot of work to get all the images right and to give proper credits to the authors of other images. But the Corona pandemic gave me plenty of time. I also was able to work on my other book *All About Pull Production*, an extensive volume on pull production. At the time of writing, the proofreading process is nearly completed, and this comprehensive volume on pull production should be available soon. Hence, I took the liberty of listing it already in the *other publications* section.

As promised in my previous preface, I submitted 334 blog posts as book sections to my university publication database in 2020, as well as the seven books that contained them (plus some other conference and journal articles). With 373 publications in 2020 I was easily the most published author at my university 😎.

It took quite some time, but eventually someone noticed my creative output… and immediately concluded that this can’t be right and took them out of the statistics. Luckily, I was able to convince them that all was proper, and these are indeed publications (although admittedly it is a bit of a stretch to call them academic publications–but then, they aren’t shabby either!). Hence, my statistics is back up where it should be.

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1 Reducing Lead Time 4 – Development

Christoph Roser, January 5, 2021 Original at https://www.allaboutlean.com/lead-time-development/

Figure 1: Engineers at Drawing Boards (Image Bundesarchiv under the CC-BY-SA 3.0 Germany license)

Reducing lead time is often important for the success of a company. This last out of four posts looks a bit more in detail at the reduction in lead time during product development. This is especially important for make-to-order production, but also for the introduction of new products into the market. Let's have a look.

1.1 Introduction

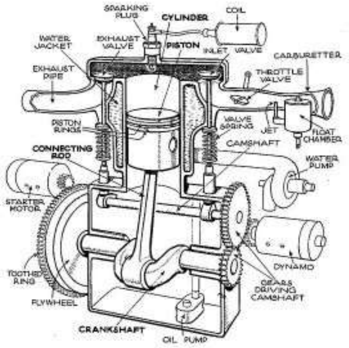


Figure 2: Engine drawing (Image Andy Dingley (scanner) in public domain)

Especially for make-to-order, but also for newly introduced make-to-stock products, there are aspects outside of manufacturing that influence the lead time or the time to market, respectively. Most often this is the development of the product, but it can also include logistics, quality control, or other departments.

Let's look at product development. Here, too, **the reduction of inventory (jobs/projects), fluctuations, and utilization and the improvement of the throughput can improve your lead time.** Since product development is always individual products "to order," the lot size is automatically one. Hence, a reduction in lot size is not possible here. On the other hand, with product development we have the possibility to overlap different phases of development, commonly known as **concurrent engineering** or **simultaneous engineering**. Let's have a look at the factors for development in more detail.

1.2 Reduce Jobs/Projects

Figure 3: Overworked worker (Image Roser)

In manufacturing, reducing the inventory reduces the lead time proportionally as determined by Little's Law. The equivalent in product development is reducing the number of jobs or projects. However, especially for a larger number of projects, **the reduction in lead time is over-proportional to the reduction in the number of projects**. Developers usually need to coordinate with other developers for development. Mechanical engineers, electrical engineers, and programmers are often involved in the same project. Depending on your product, you may also need chemists, biologists, mathematicians, and others to participate in the development.

These need to coordinate, which takes time. The more projects they have, the more time goes for coordination. I have seen departments where developers were in charge of ten projects. After all the coordination meetings there was almost no time left for actual development. The developers subsequently focused on one or two projects, and ditched the rest (although they communicated it more diplomatically to their management). Since eight out of ten projects were not worked on at all, the lead time went through the roof.

There is some academic research on what a good number of projects is for one person. It seems that **two to three projects** can be handled simultaneously without ill effects. A single project may be faster for this project, but with a lower utilization of the developer. In development projects, you often have to wait for other input. If you have only a single project, you often actually have to wait for such an input before you can continue. Having two to three projects allows the developer to use this time on other projects.

1.3 Reduce Fluctuations

Figure 4: Busy and Idle Worker (Image ONYXprj with permission)

Similar to manufacturing, fluctuations are also bad in development. Also similar to manufacturing, they are not easy to reduce. Yet, a reduction in fluctuation will reduce the swings for developers from being overworked to underutilized … although in the latter case, they will invent some work so as not to look idle to management.

1.4 Reduce Utilization

Figure 5: Engineering hands and blueprint (Image giggsy25 with permission)

Reducing utilization was an important factor in manufacturing. It is still important in development, although to a lesser degree. For one thing, how do you actually measure the utilization of a developer? Time at work? Forget it. Number of documents produced? Oh, please! Number of meetings attended? No way! I don't know of any even approximately valid method to measure the utilization of developers. Nevertheless, you should not run your development department at full speed all the time. Delays will pile up, and so does the lead time.

Humans can and will work at different speeds as needed. If the situation is urgent, workers can (and often but not always will) put in an extra effort. If the situation is relaxed, so is the working style. But be aware that if the situation is ALWAYS urgent, then "urgent" will soon be the new "relaxed"! So, please don't put your developers into a pressure steam cooker, hoping to get more out of them. It won't work, but your lead time will turn sour.

1.5 Improve Throughput

Figure 6: Working with Laptop and Hourglass (Image motortion with permission)

As in manufacturing, improving the throughput does reduce the lead time. Also similarly, the primary goal of such an activity is usually the reduction in cost and the increase in capacity, with the reduction in lead time being a smaller side effect.

Nevertheless, it is a worthy goal. There are many ways you can improve the throughput. Make sure your developers have the right tools (computers, software, databases, etc.) to do their work. There are many modern software tools that promise to help with development, although you would have to decide if you believe these promises.

The bigger lever, however, often is the reduction of waste. Reduce the non-value added time. One major but often overlooked factor are interruptions. Getting a phone call cuts you out of your current thoughts, and it will take time to get back to the task at hand. A three-minute phone call can easily waste fifteen minutes of time. Some employees can turn off their phones in the morning to focus on work, and handle requests in the afternoon. Other departments forbid any meetings before 11:00AM to give a continuous block of working time. I personally always turn off my email notifications. If my head is wrapped up in a problem, and my monitor starts to blink an email symbol, then I lose my focus. Instead, I answer my emails after I wrap up my thoughts.

Figure 7: Your last meeting? (Image Farina3000 with permission)

Another factor in eliminating waste is meetings … although this is a double-edged sword. I am sure you have had plenty of meetings where you felt like they were a waste of time. But on the other hand, you also surely had meetings that were very important and conveyed crucial information on the project. And the majority of meetings were probably a mix of both important and unimportant information. The trouble is in figuring out how many meetings you need, who should attend, and how they should be conducted to have a good ratio of useful to useless time. Too few meetings – or more accurately a lack of exchange of information – is not a good thing either.

My gut feeling tells me that there is often a tendency for too many and too-long meetings. This is because, for the manager who sets up the meeting, meetings are one of their most important management tools. A second factor is that often promotion is (subconsciously) based on visibility, and many employees believe (sometimes rightfully so) that talking in a meeting increases the chances for promotion.

There are many tricks for conducting efficient meetings, from having the meeting not sitting but standing, to a strict time schedule limiting the time on the different topics, etc. Explaining them all would exceed the scope of this article, but there is plenty of literature available.

1.6 Concurrent Engineering

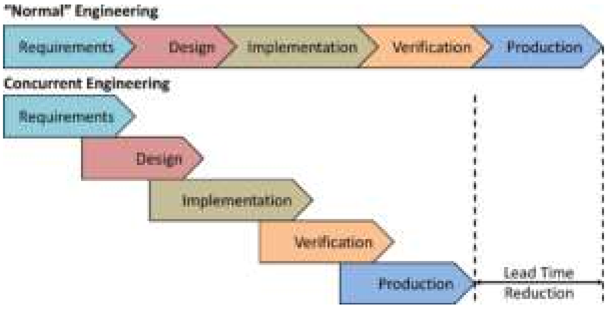


Figure 8: Concurrent Engineering (Image Roser)

Development also has options to reduce the lead time that production does not have, namely concurrent engineering (also known as simultaneous engineering). In manufacturing, the part can be only in one process at a time. In development, multiple people can work on the same project. In concurrent engineering, the different stages of the development project overlap. You start with the next phase before the previous phase has ended. You start the design before the requirements are set in stone, the implementation before the design is finished, the verification before the implementation is completed, and so on. This saves time, but of course at the cost of extra work due to changes in a previous process requiring a re-do of some parts of the next process. It is more effort, but often the reduced time is worth the cost. Details and guidelines for concurrent engineering can be found from many sources, so I won't go into detail here too.

1.7 Summary

This concludes my short series of posts on how to reduce the lead time. I hope it was helpful to you. Now, **go out, reduce your lead time, and organize your industry!**

2 Respect for People – Introduction

Christoph Roser, January 12, 2021 Original at https://www.allaboutlean.com/respect-for-people-introduction/

Figure 9: Business meeting (Image fizkes with permission)

One important aspect in lean manufacturing is "**Respect for People,**" or more correctly, "**Respect for Humanity.**" But while it is mentioned frequently in presentations and books on lean manufacturing, what it actually means is often glossed over. And it is not an easy topic to write about. There is no "5 Steps to Respect for People." Sorry. I have been thinking about writing a blog post on respect for quite some time, but it is difficult to write something substantial rather than just some anecdotes. It runs the risk of quickly drifting off into general management and leadership behavior. Nevertheless, I managed to write a series of three blog posts on it. Well, anyway, here we go…

2.1 Linguistics

Figure 10: Tongue Mouth (Image Clker in public domain)

In English, it is often called "**Respect for People.**" The original Japanese term used at Toyota, 人間性尊重 (*ningenseisoncho*), however, translates more correctly to "**Respect for Humanity"** or "**Respect for Human Nature.**" The word 人間性尊重 used by Toyota is slightly different from the conventional use in Japanese business of 人間尊重 (n*ingensoncho*). The additional character 性 in the middle is not only a person, but the nature of a person. Hence, the best translation is "**Respect for Humanity.**" In English it is much less commonly also called "**Respect for Mankind,**" or even less commonly, "**Respect for Stakeholders.**"

2.2 The Basic Idea Is Common in Many Cultures

Figure 11: Monks in Angkor Wat (Image Ekrem Canli under the CC-BY-SA 4.0 license)

The idea of respecting others is not new. Most cultures include such rules. In Christianity, it is best known as "**Do unto others as you would have them do unto you.**" This is very similar to the Confucian quote "**What you do not wish for yourself, do not do to others.**" In ancient India, it was "**One should never do something to others that one would regard as an injury to one's own self.**" In ancient Greece, it was "**Avoid doing what you would blame others for doing.**" Buddhism said, "**Hurt not**

others in ways that you yourself would find hurtful." This idea of treating others like you want to be treated yourself is so common that it has its own name: The Golden Rule.

2.3 What It Does NOT Mean!

Figure 12: Three out of four are happy… (Image AndreyPopov with permission)

First, let me get one thing out of the way. **Respect for people does not mean that you have to make everybody happy**. This is impossible. If you try to make everybody happy, then you a) will not succeed, and b) will be unhappy too. But don't go out trying to make people unhappy either!

Similarly, **respect for people does not mean that you have to be nice to everybody** either. It helps to be nice and courteous, but there may be times when you need to be not-so-nice. Honest but critical feedback may be more helpful than white lies or no feedback at all.

2.4 What to Respect?

The idea is to show respect. With the popular English term "Respect for People," the target audience is clear. We should respect other **people**. This is also the main focus at Toyota. The first Kanji in 人間性尊重 (*ningenseisoncho*) is 人 for a person. However, while "People" are clearly the focus, I believe "Respect for Humanity" should have a wider view. It should also include a general respect for the environment, or a respect for other companies (no matter if they are a supplier, a customer, or competition). Although, since all these are relevant to people, in the end, it goes back to "Respect for People."

Figure 13: Group of industrial workers. (Image Kurhan with permission)

2.5 Respect for Humanity Is More Than Being Nice

Figure 14: Tough love (too much?) (Image John Kennicutt in public domain)

While "Respect for Humanity" builds on these widely accepted cultural principles of respecting others, it also expands them. To me, "Respect for Humanity" also includes a lot of aspects of "**Tough Love.**" The goal is not being kind, but helping people to become the best they can be. A football coach is not paid to be nice. He is not paid to be loved. He is paid to help his players become the best they can be.

Military boot camp does not cuddle its recruits, but wants to make them better soldiers. A manager is there to help his people grow. Generally, **the aim is to help people become the best they can be.**

HOLD ON! Don't go yelling at your people like Gunnery Sergeant Hartman (NSFW), while pretending to love them! (Unless, of course, you are a US drill instructor. But even then, I think this is overdone.)

Figure 15: Not acceptable! (Image Elnur with permission)

While a military recruit may expect to be yelled at, an industry employee probably does not. In my view, yelling in manufacturing should be an act of last resort. It indicates that something else in the human interaction has failed beforehand. Taiichi Ohno was well known for yelling at this managers, and many of them could no longer sleep at night due to Ohno's terror. Ohno claimed that he did this to make them better managers, and that he never yelled at common workers. Even though I respect Ohno a lot, I think the yelling part may have been too much. But then, I never got yelled at by Ohno ☹.

Figure 16: Athlete Exercise (Image unknown author in public domain)

In case you are wondering, yes, it is tough to find a good balance. But respect for people aims to release the full potential of the people. To help them become better and reach their peak ability, this sometimes means pushing someone to the boundaries of their ability, or even challenging them beyond it to help them grow. People won't reach their peak if you go easy on them.

In my next post I will talk more about some aspects on respect for people, and start to tackle the very difficult question of how to actually show respect to others. Talking about it is cheap and easy. Doing it is much harder. Until then, **go out, respect humanity by actions and not by words, and organize your industry!**

3 Respect for People – Why and How

Christoph Roser, January 19, 2021 Original at
https://www.allaboutlean.com/respect-for-people-why-and-how/

Figure 17: Two People in Shop Floor Meeting (Image pressmaster with permission)

In my previous post on "**Respect for People**" or "**Respect for Humanity,**" I gave you a bit of an introduction to this very challenging topic. In this second post of the series I will look at why you should have respect for others, and especially how you can show respect. However, especially the "*how to …*" part will be difficult.

3.1 Why Respect?

Figure 18: Shop Floor Discussion (Image pressmaster with permission)

Respect for people is often seen as altruistic. However, in industry it does have indeed benefits if you have respect for others. It is difficult to respect people who don't respect you. Hence, having respect helps you to get respect in return. This does not mean that everybody respects you, but over time you will learn to cooperate more with others on the basis of mutual respect, and reduce interaction with others who don't respect you.

Respect also overlaps with trust. Mutual respect often includes mutual trust. And who would you rather do business with? A company that you can trust, or another company that may be 10% cheaper but you have to watch them every move so as not to get cheated? Hence, respect often makes good business sense. It is difficult to have a sustainable business model based on cheating, although some companies manage that too. (Surely you know a company you hate and wonder why they are still around).

Respect for humanity also includes not wasting the time of your people. That also makes clear business sense, as it better uses the valuable time of your people. This time is valuable to the people (as it is their time) as well as you (as you are paying for the time).

Training also makes your people more skilled and hence more valuable. The better they can do their work, or even learn new skills, the more they can contribute to your company.

3.2 So, How to Show Respect?

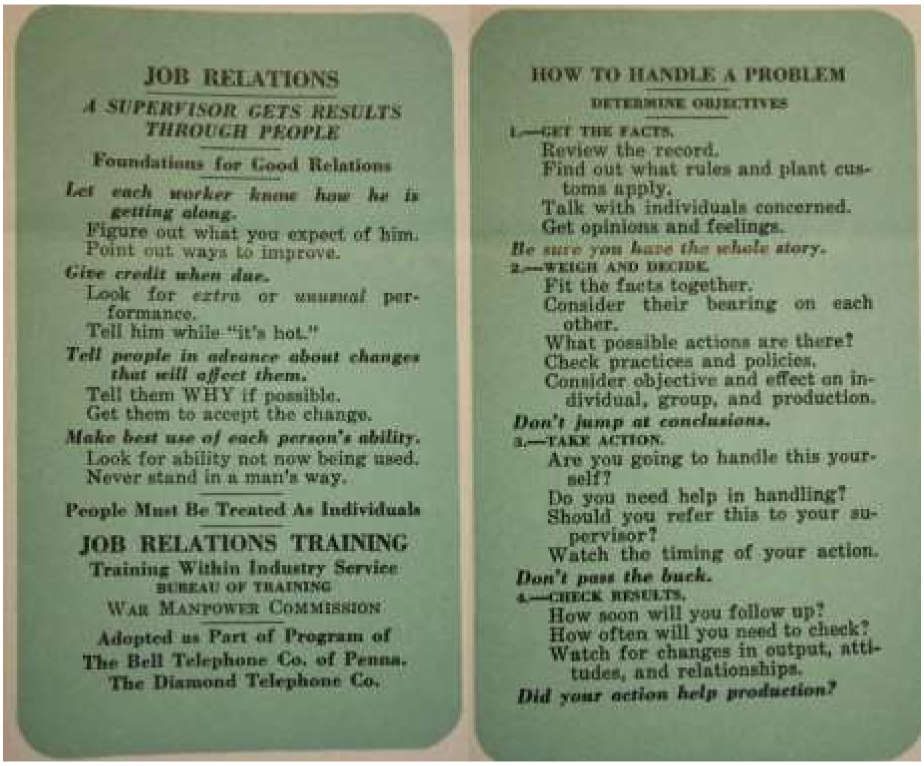
Figure 19: People Thinking 2 (Image Aaron Amat with permission)

The million-dollar question is now: How do you show respect for humanity? This is tough. This is the reason why I put off writing this blog post for so long, since it is difficult to give a concise answer. There is unfortunately no “5 Steps to Respect for Humanity.” Even if there was, I would doubt its validity. There are also no lean programs or consulting projects on “Respect for Humanity.”

A few things are easy. Improve safety. Invest in training. Develop your people. These things can be done even if a manager has a total lack of social skills.

But a lot of the other stuff is very fluffy. Since respect is always between two people, the best way depends on both sides. Some managers may be too aggressive and should tone it down. Others are not aggressive enough and should become more so. On the other hand, being more aggressive toward someone who is easily triggered may turn out badly, whereas another person actually may need a (verbal) kick to improve.

There are, however, guidelines for some aspects. One of my favorites is from Training within Industry (TWI), in particular the Job Relations (JR). Even though it is seventy years old now, the guidelines are still good. Below is the summary of Job Relations on how to get along with other people. Coincidentally, Toyota uses very similar steps in problem solving, possibly with a larger focus on the shop floor (gemba). More details in my post on Job Relations.



JOB RELATIONS

A SUPERVISOR GETS RESULTS THROUGH PEOPLE

Foundations for Good Relations

Let each worker know how he is getting along.
  Figure out what you expect of him.
  Point out ways to improve.
Give credit when due.
  Look for *extra* or *unusual* performance.
  Tell him while “it's hot.”
Tell people in advance about changes that will affect them.
  Tell them WHY if possible.
  Get them to accept the change.
Make best use of each person's ability.
  Look for ability not now being used.
  Never stand in a man's way.

People Must Be Treated As Individuals

JOB RELATIONS TRAINING
Training Within Industry Service
BUREAU OF TRAINING
WAR MANPOWER COMMISSION

Adopted as Part of Program of
The Bell Telephone Co. of Penna.
The Diamond Telephone Co.

HOW TO HANDLE A PROBLEM

DETERMINE OBJECTIVES

1.—GET THE FACTS.
  Review the record.
  Find out what rules and plant customs apply.
  Talk with individuals concerned.
  Get opinions and feelings.
Be sure you have the whole story.
2.—WEIGH AND DECIDE.
  Fit the facts together.
  Consider their bearing on each other.
  What possible actions are there?
  Check practices and policies.
  Consider objective and effect on individual, group, and production.
Don't jump at conclusions.
3.—TAKE ACTION.
  Are you going to handle this yourself?
  Do you need help in handling?
  Should you refer this to your supervisor?
  Watch the timing of your action.
Don't pass the buck.
4.—CHECK RESULTS.
  How soon will you follow up?
  How often will you need to check?
  Watch for changes in output, attitudes, and relationships.
Did your action help production?

Figure 20: Training within Industry Job Relations card (Image War Manpower Commission in public domain)

One important aspect of respect at Toyota is **time**. It is considered disrespectful to let the worker wait. Assume the worker sets up an automatic process for twenty seconds, and then has to wait another thirty seconds while the process runs. This waiting time is considered disrespectful! You are wasting the time of the worker, and hence have no respect (okay… less respect) for the abilities of the worker.

Figure 21: Safety gear (Image Compliance and Safety LLC under the CC-BY-SA 3.0 license)

Another important aspect of respect is **safety**. You should be able to provide a safe working environment for your people. Putting in the effort to protect the health of your people is definitely needed for respect.

Another important aspect is **training**. Having proper training can help people become better at what they do. Toyota puts a lot of effort into training, probably much more than many other companies.

There is also a host of general literature on leadership and how to deal with other people. One of the classics is How to Win Friends & Influence People by Dale Carnegie, but there are many more. Most of this literature focuses on interpersonal skills or management skills. This overlaps quite a lot but is not identical to respect for humanity.

One very important aspect that often falls short is listening. **Listen to your people**. Just being heard is a sign of respect, even if you cannot solve your people's problems. Even better is **active listening**, where you occasionally ask some questions and stay engaged. Listen to people regardless of their hierarchy or importance. Don't even think about automating this digitally ("They all can send me an email anytime, and I read it when I have time …").

Try to **avoid blaming others**. I know, blaming others is a favorite pastime in many companies, but it wastes a lot of energy and it does not generate respect. While I was at Toyota, I was never blamed for anything. and rarely was anybody else. When I worked for other companies in Europe, not a week went by without someone trying to blame me (or anybody else but them) for something.

And this should be obvious: **no lying or cheating**. Respect is a lot about trust, and you can neither trust nor respect someone who cheats.

In my next post I will go into more detail on why respect for people is so difficult. I will also show you one tool that I think can really help. And since I hate cliffhangers just to keep you suspended, this tool is feedback. But now you must come back and read the next article too! In the meantime, **go out, respect humanity by actions and not by words, and organize your industry!**

4 Respect for People – It's Difficult…

Christoph Roser, January 26, 2021 Original at https://www.allaboutlean.com/respect-for-people-its-difficult/

Figure 22: Manager and worker (Image michaeljung with permission)

In this last post on "**Respect for People**" or "**Respect for Humanity,**" I will look at all the difficulties in having respect for others. There is often the cultural aspect. There is the problem that everybody is different. One great (but not always easy tool) is **Feedback**! I will also talk a bit more about Toyota.

4.1 Cultural Differences

Figure 23: Multi-Ethnic Meeting (Image jovanmandic with permission)

Respect for People becomes even more difficult if you try to show respect for humanity across different cultures. In Northern Europe, it is often a sign of respect for a higher-ranked person to lower his status. Royalty often uses public transport just like everybody else. Here's King Olaf V of Norway on the subway in 1973. The conductor wanted to offer him a free ride, but the king insisted on paying for the trip. In many Asian cultures, this is unacceptable and would totally confuse the subordinates. For comparison, here is a picture of how the Thai king and his queen ride the subway, which by itself is exceedingly rare (they prefer helicopters, I think). And somehow, I don't think they paid for a ticket. Although, the current Thai king is a bit … odd … even to other Asians. (Only links to the images, since I don't have copyright, sorry).

Another example is Germany. We Germans are known for being very direct, which often comes across as rude. A Korean working for a German company in Germany tried to adapt… and came across as very rude to his German colleagues, since he did not know the German social norms of how direct/rude you can be with whom and when. Hence, showing respect is even more difficult if it is in a different culture.

This is also a topic that you can go into in great depth. One particular book that I liked was The Culture Map by Erin Meyer. It helped me to understand a lot more on the differences between cultures.

4.2 So, How to Show Respect for Humanity?

Figure 24: Portraits of people thinking (Image olly2 with permission)

So, now you know ho to show respect for humanity. Be nice, but not too much. Be aggressive, but not too much. Do this, but not too much. Don’t do that… but not always. Turn left unless you should have turned right.

Yes, I am aware that this is not too helpful. Sorry, it is a very difficult topic! The problem is that everybody is different. The problem is that it depends a lot on the person you are and the person you are dealing with. Like everybody else, I get along with some (hopefully most) people, but there are some who I don’t get along with. I of course blame the other side for that 😉. While you sometimes can avoid people you don’t like, sometimes you can’t, especially in the workplace. Hence, you have to learn to show respect and get along with most people.

Fortunately, there is one solution:

4.3 Feedback

Figure 25: Get feedback! (Image unknown author in public domain)

To become better at dealing with others, you need feedback. Honest feedback! It is easy to fall into the trap and think that it is all the other person’s fault, or that the other person won’t be angry because he understands how you meant it. In sum, it is hard to really see yourself if you can only see yourself from the inside. But it has to be honest feedback, and that’s where the difficulties start.

If you are a person in power, your subordinates may be hesitant to give you honest feedback. There are plenty of companies around where a disagreement with the boss leads to the end of a career. If anything, feedback from below must be anonymous. A mentor or coach can also give you feedback. Good feedback makes you feel good, but critical (but still constructive) feedback will help you to become better. Yet, all to often critical feedback is not wanted. You should want it! It helps you to grow.

4.4 What about Toyota?

TOYOTA

Figure 26: Toyota Logo (Image Toyota for editorial use)

Toyota is well known for the whole idea of respect for humanity, and they do a lot of things well. There are some things that Toyota does well. Suppliers rank it as a good customer, often much better than other car makers. To give just one other example, during the Pandemic Toyota received AUD 18 million in aid in Australia since their sales went down. Shortly thereafter, their sales unexpectedly recovered again. Toyota then approached the Australian tax office to pay back the assistance. Not many companies would give back 18 million just to be a "*responsible corporate citizen*". (Source, with thanks to Matt Mafrici for the info)

However, it would be foolish to assume that Toyota has achieved godliness in this area. Like all companies, Toyota is run by people, and, somehow, we are not that good in dealing with other people. If you are a full-time employee, Toyota will take care of you – while also demanding a lot on working time. The working times in Japan are pretty brutal (see my post on The Dark Side of Japan), and Toyota is no exception. It was well known for encouraging feedback from all levels, but this is slipping, and the culture at Toyota is changing.

As well, if you are not a full-time employee and only a temporary worker, then the nicety and the respect seems to be missing. Temp workers are treated much worse and are hired and fired as needed. In Japan, you will get a permanent position after five years, so all temporary workers are fired after five years at the latest. Female staff is often hired from subcontractors that are close to Toyota. After five years, they are fired and hired by an almost identical subcontractor for the next five years. There is little security and no chance for promotion.

So, Toyota does a lot of things right, and there are many positive examples that you can find online (some of them even from me). But, just like many other companies, Toyota also does many things wrong.

Overall, it is easy to talk about respect for humanity, but it is much more difficult to do it (as it is to write about it). We all know lots of examples where someone showed a lack of respect. This is easy to see. **However, few of us have examples where we ourself did not show proper respect to others. It is very hard to judge yourself. And, since we don't know any example of ourself disrespecting others, we assume that we always respect others. Well… everybody assumes that. Try to think of situations where you yourself may have shown a lack of respect, and think about how you could show more respect.** Nevertheless, I hoped these blog posts on respect for humanity helped you to understand what it means, and maybe even gave you some inspiration on improving yourself. Now, **go out, respect humanity by actions and not by words, and organize your industry!**

5 Manufacturing Drives Prosperity

Christoph Roser, February 2, 2021 Original at https://www.allaboutlean.com/manufacturing-drives-prosperity/

Figure 27: Futuristic Robot and Human (Image World Image with permission)

Manufacturing is one of the drivers of modern prosperity. Most manufactured goods become cheaper and cheaper over time, adjusted for inflation. Services, on the other hand, usually become more expensive over time. In this blog post I dive a bit deeper into these changes, using the USA consumer price index as an example.

5.1 A Bit on Inflation

Figure 28: Burning Money (Image siam.pukkato with permission)

Over time, the things you purchase become more expensive. That is called inflation. A moderate inflation of a few percentage points is often seen as good. For example, the goal of the USA is around 2% inflation per year. Wages are expected to rise along with inflation to make up for the loss in purchasing power. The **average** wage in the US is indeed increasing faster than inflation, but this is in large part due to a few wealthy people becoming even wealthier. However, the lower-income wages rise much slower than they should, creating lots of social problems.

For some time, Japan had the opposite, a *deflation*, and this is seen as problematic. Unfortunately, many countries nowadays suffer from insufficient inflation.

Figure 29: Bringing money to the bank, Weimar, 1923 (Image paul prescott with permission)

On the other hand, hyperinflation is terrible, as it destroys people's savings. Germany in 1923 had an inflation rate of 29,525% – **per month!** More recently, Venezuela had 80,000% per year in 2018, and Zimbabwe even more. The world record goes to Hungary, which in 1946 had an inflation rate of 13,000,000,000,000,000% – **per month!**

5.2 Consumer Price Index

Figure 30: A (healthy) shopping basket (Image paul prescott with permission)

Measuring inflation, however, is a bit tricky, and it leaves lots of room for number fudging. Inflation is measured by following the prices of different quantities of different goods in a typical scenario of expenses for an average consumer. This is often called a basket of goods. This includes purchased goods, services, and other expenses of everyday life. With taxes, however, it includes only sales taxes and taxes that occur during purchase. Other taxes are typically not included, since this would make the government look bad, and we don't want that (and I am sure the government can give you a much better-sounding reason for doing this).

On the plus side, the price history for a wide range of goods is available for many countries. For the USA you can find these at the Bureau of Labor Statistics. In Germany it would be the Statistisches Bundesamt.

5.3 Price Changes of Selected Items

Hence, I had a detailed look at the data from the Bureau of Labor Statistics. The graph below shows the change of prices for different items since 1998, where 1998 is 100%. The graph is inflation adjusted, hence the average stays at 100%. The average price in dollars increased by 56%, but the graph is adjusted to eliminate the average price increase. If you are curious, my Excel raw data can be found here, including many more data points and many more years than what I have in my graph.

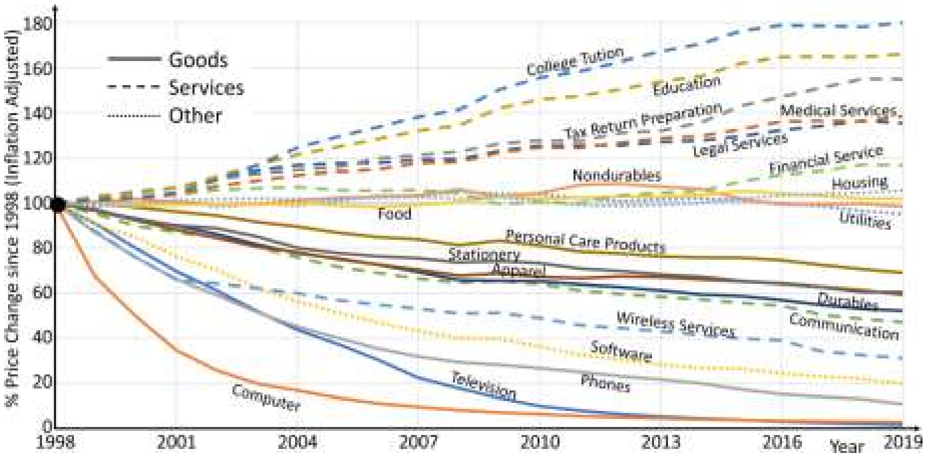


Figure 31: Inflation Adjusted Price Change since 1998 in the USA for selected items (Image Roser)

5.4 Change in Manufactured Goods

Figure 32: Cheaper every year (Image BMW Werk Leipzig under the CC-BY-SA 2.0 Germany license)

Since I am interested in the change of manufactured goods compared to non-manufactured goods, all physical goods in the graph have a solid line. All services have a dashed line, and the rest (utilities, housing, software) are a dotted line. **Almost all physical goods have become significantly cheaper**, some of them extremely so. TVs and computers are now dirt cheap, costing only around 3% of the 1998 price adjusted for inflation. Telephones are now only 14% of the 1998 price, also inflation adjusted. In general, durable goods (automobiles, appliances, books, furniture, etc.) cost only half of what they would have in 1998, again adjusted for inflation. The other large group of non-durables (also known as consumables), including its large subgroup of food items, kept roughly the same adjusted price compared to 1998.

Only few physical goods became more expensive, like tobacco and college textbooks. Tobacco now has higher taxes to improve overall health by smoking less. College textbooks is an organized scam where students are often forced to buy overpriced and expensive textbooks for the benefit of some professors, publishers, and universities. Side note: I use one of my own books for my own lectures, but this is priced at cost at the beginning of the semester for students. Nine euro for a 300-page book is not bad, I think. Still, some students complain that it is not free, but they become quiet after hearing that many US students pay $2,000 and more per semester for textbooks.

5.5 Change in Services and Other

Figure 33: A bit more please this year… (Image sebastiangauert with permission)

It looks very different for services, which I have as dashed lines in the diagram above. **Almost all services became significantly more expensive**. Tuition almost doubled in price, even before inflation is added. Medical services and legal services became significantly more expensive. Pretty much the only service that became cheaper was communication, including wireless communication, and this was probably mostly due to cheaper computers. Other than that, there are few services that became cheaper (private transport and recreation was a tad cheaper).

Housing and utilities did not change much with inflation, but software also became cheaper, probably also influenced by cheaper computers.

5.6 The Big Picture

Figure 34: Milling Example (Image ZM2010-LWL-BBW-Soest under the CC-BY 3.0 license)

In sum, manufactured goods are getting cheaper over time, while services are becoming more expensive. The data here is for the USA, but the trend is similar for most of the world. A few items may be different (healthcare and education in the US is particularly outrageously priced), but the big picture remains the same. Some items have a disparity in power between the seller and the buyer. It is hard to negotiate a price when you are on the operation table, and US healthcare particularly takes advantage of this. Prices are much lower in the rest of the world. I can buy an international travel insurance for one year for €700, valid worldwide excluding the USA and Canada. If I include the USA, the price more than doubles to €1650, because of the insane healthcare prices in the USA.

5.7 Why the Difference?

Figure 35: A man drawing blueprints (Image Tiko Aramyan with permission)

The simple reason is that manufacturing becomes more and more automated. We replace human labor with machines, and also use different tools (including lean) to use both machines and labors efficiently. With mass production, we can make products insanely cheap. In one of my previous blog posts I was looking for the cheapest ballpoint pen, and nowadays you can make a ballpoint pen for USD 0.035. A decent pen can be found from USD 0.045. This is, at most, two minutes of human work per pen, including all development and machine building. All the rest is the work of machines and computers.

This trend is likely to continue in the future. In fact, even services may eventually be affected. With increasingly smarter computers, more and more service tasks could be automated. Already students are hesitant to pay big tuition for mere online courses (due to the COVID-19 pandemic). Many banks have noticed that they no longer need fancy brick-and-mortar buildings. And many consumers have noticed that they don't need a fancy bank in the first place, resulting in a rise in cheaper *fintech* companies. Fintech stands for "financial technology," and aims to use computer technology to provide banking and other services much cheaper than what would be possible conventionally. I myself am looking forward to this revolution.

While this post is not a typical post on hardcore lean tools and philosophies, I do hope that you enjoyed reading it, and that it gave you a bit more understanding of the big picture. Now, **go out, reduce the cost and subsequently the prices of your products some more, and organize your industry!**

6 How to Use a Minimum in a Supermarket

Christoph Roser, February 9, 2021 Original at https://www.allaboutlean.com/supermarket-minimum-use/

Figure 36: Warning: Toilet paper stock out imminent! (Image Roser)

The kanban formula (or estimation) helps you determine the number of kanban. All of these should fit in the supermarket, hence the maximum in the supermarket represents all kanban. Many supermarkets also have a minimum inventory level. Unfortunately, there is little information on how to set the minimum. Time to take a deeper look on how to set and use the minimum level in the supermarket. In this first post I will look at how to use a minimum level in a supermarket. The next post will look at how to determine a good minimum level.

6.1 Introduction

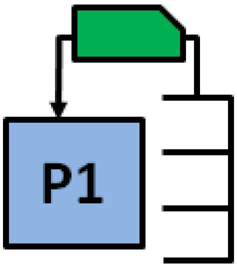


Figure 37: Simple Kanban Loop (Image Roser)

A supermarket is the inventory at the end of a kanban loop. Whenever a part leaves, a signal is given to replenish this material. This signal is the kanban. Hence, the maximum inventory in the supermarket is the inventory represented by all kanban.

It is often recommended to also add a minimum level to the supermarket. This is usually helpful. The term *minimum*, however, is unfortunate and a bit confusing. The real “minimum” in a supermarket is zero. If you need parts, you should use any material that is in the supermarket until you run out.

What we mean here by minimum is more of a warning level. **Reaching the “minimum” level should give you a warning that you run out of stock soon.** Even though the name is a bit confusing, to stay consistent with pretty much the rest of the world, I will also call this warning level a minimum.

Hence, the minimum is a warning that you will be out of stock soon. This will give you time to react and prevent an actual stock out. This will give you time to do firefighting, even though I don’t like firefighting much. Also, please note that **the minimum is part of the total inventory limit** represented by all kanban for this part type, **not in addition to the total.**

6.2 An Analogy

Figure 38: A typical fuel gauge (Image Roser)

To illustrate this, let me give you an analogy that you are all familiar with: the gas tank in your car (or similar for your battery if you have an electric car). Usually this is displayed as a fuel gauge somewhere on your dashboard. This fuel gauge includes a minimum warning, sometimes called the reserve. If your fuel level falls below the minimum, a warning light will come on and there may be a warning sound. This gives you time to refuel before you are stranded.

However, if the warning light goes off when you have only three kilometers' worth of fuel left, then it is probably way too late. Hence, your minimum is too low. On the other hand, if the warning goes off if there is still half a tank of fuel, then it will be more annoying than helpful. In this case, your minimum is too high. Overall, the minimum level should be set so that you can comfortably reach a gas station without going too much out of your way. Finally, if your warning limit is set at 25% but it blinks five times a day, then your fuel tank is too small! The same goes for supermarkets.

Figure 39: Too many signals! (Image Roser)

Some people get really excited with adding a minimum and want to do more. Sometimes they add also a yellow area to indicate a pre-warning and a green area to indicate everything is fine. Frankly, I would advise against that. It may be a case of too much labeling, or too much 5S. Again, take your fuel gauge as an example. Do you really need a warning that there is "only 75%" of fuel left? Do you really need a yellow and a green area? If you have too many green, yellow, and red colors, as shown below, it confuses the image and makes people ignore warnings. In any case, don't expect shop floor people to pay attention.

6.3 What to Do If You Reach the Minimum?

If you reach the minimum, you have too few kanban with material of this part type in the supermarket. There are many possible reasons for that. It could be that you cannot produce due to **lack of material**. In this case, the issue should have been escalated already, but now is a good time to escalate again with even more urgency.

Another possibility is that the **kanban are merely delayed due to other kanban of other parts being in front of them**. This is much easier to fix. Simply fast-track the needed kanban to the front of the queue for production. Make sure to allow enough time for logistics to transport the material. Depending on the urgency, you may also escalate with logistics to accelerate the material delivery for these urgent kanban. If you have a prioritized queue for production anyway, put the urgent kanban in the queue for prioritized parts. In the example pictured, the blue balls have reached their minimum. As part of the escalation, two of the corresponding kanban are moved to the front of the queue for production. However, it can also be argued that moving one kanban would have been sufficient.

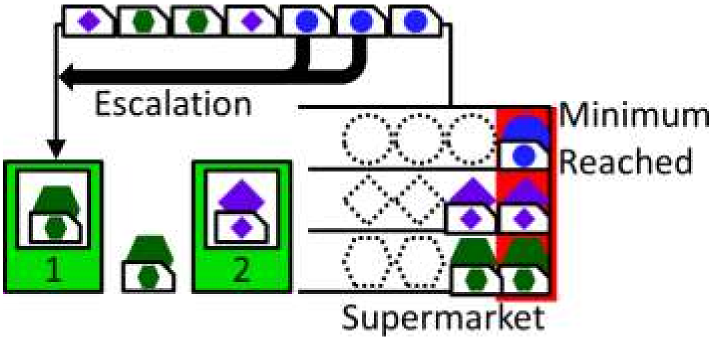


Figure 40: Example Minimum Escalate (Image Roser)

In the best case, you will find that many of **the needed kanban are already in production** and will arrive in the supermarket shortly anyway. Here, you probably don't have to do anything. The problem is already solved, and material will arrive before you run out. In the illustration here, the blue balls also have reached their minimum. However, there are already multiple blue balls in production, and no action is necessary.

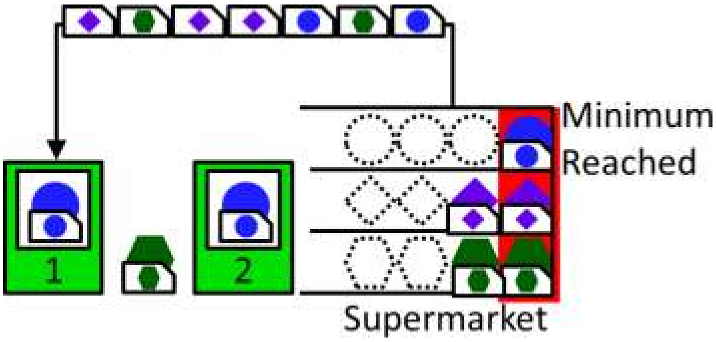


Figure 41: Example Minimum Not Escalate (Image Roser)

There is a complication for **kanban systems with a very long lead time**. In such kanban systems, most kanban will be replenished at any given time. Depending on your minimum level, moving a kanban to the front of the queue for production may not be enough. It may be necessary to escalate by prioritizing products already in production. It may be necessary to move parts in production to the front of their respective queues and prioritize their production. This is also shown in the example below. Moving parts already in production will allow lower minimum limits. For systems with very long replenishment times, this may even necessary to avoid overly large minimums, which would result in too many minimum warnings. However, if you can, avoid moving material already in production. Depending on your system, this can increase chaos and can cause subsequent problems. It is also requires much more effort than merely moving a kanban card.

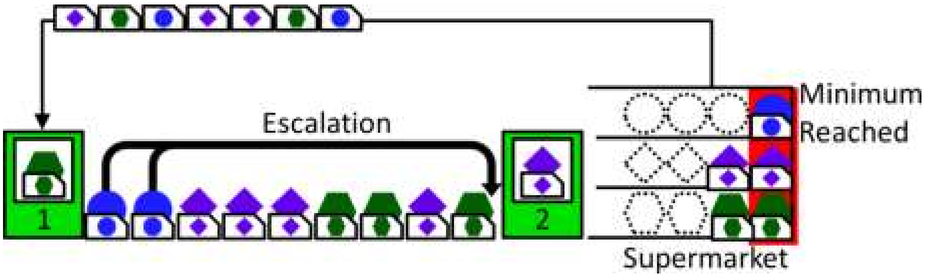


Figure 42: Example Minimum Long RT Escalate (Image Roser)

In my next post I will talk a bit more on what your minimum levels should be. I will also give a few more tips on when you should have a minimum, and how to fine tune the minimum. Until then, stay tuned and **go out and organize your industry!**

7 What Is a Good Minimum for the Supermarket?

Christoph Roser, February 16, 2021 Original at *https://www.allaboutlean.com/supermarket-minimum-level/*

Figure 43: Prevent a stock out! (Image Roser)

A minimum level in a supermarket gives you a warning that a stock out is imminent. Hopefully it also gives you enough time to prevent such a stock out, even though this may result in firefighting. In my last post I talked on how to use a minimum level. This post will look at how to determine a good minimum level.

7.1 What Influences the Minimum for My Supermarket?

Figure 44: Almost empty… (Image Roser)

Similar to the minimum of the fuel gauge, a minimum in a supermarket should give you enough time to react. At the same time, it should not annoy you with too many unnecessary warnings. To determine the minimum, you have to consider what kind of escalations you are willing to do to prevent an imminent stock out. It is almost always possible to **move the kanban for the critical parts ahead in the queue for production**, or more generally ahead in the information flow. Another option is **shifting material in production around to accelerate the critical parts**. However, shifting material around may be too much hassle and may cause even more chaos.

Depending on your action plan, the minimum could be different. The diagram below shows common elements contributing to the replenishment time. If you reach the minimum, there should be lots of kanban in the loop. If many of them are waiting, then you can fast-track the waiting times and get the needed parts to the front of the line in the queue for production.

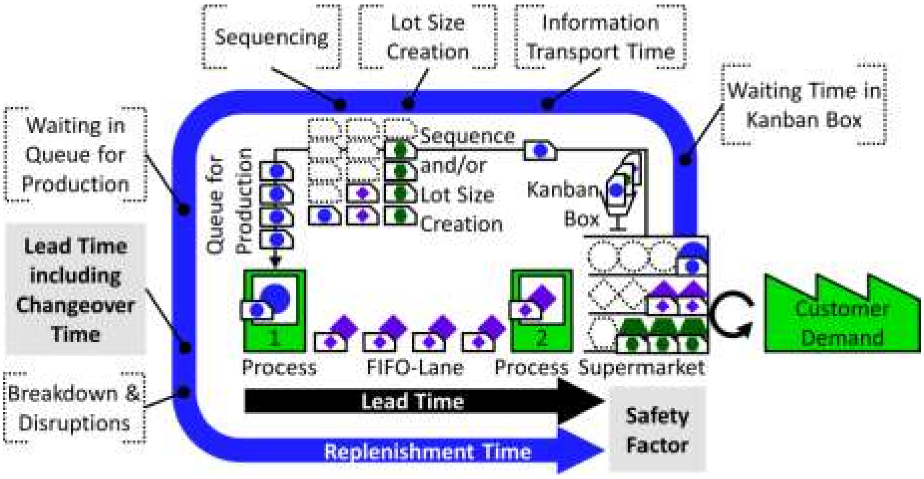


Figure 45: Minimum Lead Time (Image Roser)

7.2 How to Get a Good Minimum Minimum Lead Time (Image Roser)

Figure 46: Speed up the information flow (Image NotionPic with permission)

Hence, the minimum level usually does not depend on the information flow in the replenishment time. It usually depends on the lead time, in combination with the emergency measures you are willing to take to prevent a stock out. What customer demand for this part type do you want to cover during the lead time, and how much can you shorten the lead time? It is almost always possible to accelerate the information flow. **If you do not plan to re-sequence material during production your minimum inventory should cover the customer demand during the average lead time.** This should include some safety for breakdowns, longer lead times, temporarily higher customer demand, or simply the time it takes to notice that you have reached the minimum and to take action. It should also include elements of the information flow that you cannot eliminate (e.g. a required lot size or a absolutely required production sequence).

Figure 47: Can you change the sequence? (Image The Light Writer 33 with permission)

If you plan to re-sequence the material during production, your minimum inventory could cover the customer demand during the minimum lead time, consisting of the processing times and transport times. This should also include some safety for breakdowns, delays, temporarily higher demand, or simply the time it takes to notice that you have reached the minimum and to take action.

Hence, it boils down on how much you think you can accelerate the replenishment time by skipping kanban and/or material queues. You need to cover the customer demand during this time to ensure a stable material availability. Keep in mind that in many cases you can find material in production already that will be finished.

7.3 When to Use a Minimum?

Figure 48: Limbo dance on Beach (Image omgimages with permission)

You should use a minimum level in the supermarket whenever it can help you prevent stock outs. I believe it is beneficial in many kanban systems, especially larger ones where the operators do not have a full picture of what is going on. If it is a small kanban loop where the operators have a good grasp of the situation, they may automatically react if they are running low. In a larger and difficult-to-understand pull systems, they may not. In any case, the minimum level is optional. It is quite possible to establish kanban systems without minimum levels. If you later find out that you need it, you may add the minimum later. A lot of kanban systems I have seen did not have a minimum, and those that had one did not always use it.

Implementing the minimum can be as simple as a colored area in the supermarket. If the inventory falls below this level, you have reached the minimum. It could also be a light signal or similar, or part of a digital system. The harder part is training the operators to understand the minimum and react if they reach the minimum.

7.4 Fine-Tuning the Minimum

Figure 49: Fine Tuning a Piano (Image Gerain0812 with permission)

Reaching the minimum causes firefighting to prevent a stock out. Hence, reaching the minimum should be an exception to avoid chaotic firefighting. Especially for a newly implemented minimum level, keep track of how often you reach it, and how often it actually resulted in escalations. **If you reach the minimum too often, you may have too few kanban**. A higher inventory limit (i.e., more kanban) would make it less likely to reach the minimum. **If you never reach the minimum, you may have too many kanban** … although this may be the lesser evil.

You may find out that you still run out of stock frequently despite emergency escalations and while still having raw material available. If you lack raw materials, then it is a supplier issue. **If it is an internal problem and you can't react fast enough, then your minimum is too low**. You do not have enough time to counteract the problem. In this case you may increase the minimum. Alternatively you may change the escalation procedure and maybe start re-sequencing work already in production. On the other hand, if your reaction leaves you with ample time frequently, then your minimum may be too large. Overall, like many lean methods the fine tuning is based on observing the system and adjusting as needed.

Altogether, a minimum level in a supermarket can help you to notice upcoming stock outs early enough to implement countermeasures. Usually this involves accelerating the information and material flow by prioritizing the parts that are about to run out. However, it won't help you if you run out of everything. Getting a minimum warning too often will also increase chaos on the shop floor. Make sure to set the number of kanban and the minimum so that you reach the minimum only infrequently.

Now, go out, set a good minimum for your supermarket (if you think it will help), make sure that there is actually a response if the minimum is reached, and **organize your industry!**

8 A Brief History of Maintenance

Christoph Roser, February 23, 2021 Original at https://www.allaboutlean.com/maintenance-history/

Figure 50: Red Oil Can (Image unknown author in public domain)

At the suggestion of multiple readers, I would like to take a deeper look into maintenance, especially total productive maintenance (TPM). Maintaining your machines and tools is important for your business. In many places, maintenance seems to be more reactive: if it breaks, fix it. Often, a better approach would be proactive maintenance: maintain it so it doesn't break in the first place. In this first post in this series of articles on maintenance, I would like to look a bit into the history of maintenance. Subsequent posts will look deeper into why we need to maintain our stuff and how to do it. The overarching theme is guided by total productive maintenance, but I won't hesitate to give my critical opinion where necessary.

8.1 Pre-Industrial Corrective Maintenance

Figure 51: Montgolfier Balloon (Image Claude-Louis Desrais in public domain)

For most of our industrial history, maintenance was simple. When it broke, you fixed it. Maintenance was purely reactive. This is called **corrective maintenance** or, for more drastic failures, sometimes **emergency maintenance**. For most pre-industrial management, this was fine. If something broke, then the customer just had to wait longer for its product. Very few businesses had anything even remotely similar to what we see as maintenance nowadays. One of the few exceptions was the Montgolfier paper mills, which started to employ regular maintenance, including cleaning of the tools, around 1800. They used thirty-five days per year for maintenance. The family is more famous, however, for inventing the hot air balloon.

8.2 Preventive Maintenance

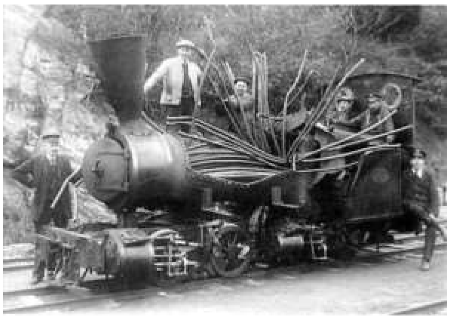


Figure 52: Boiler Explosion (Image unknown author in public domain)

With the Industrial Revolution, maintenance became more prominent. The problem was that boilers of steam engines tended to explode, maiming or killing the workers nearby. This led to technical checks and verifications to ensure that the boiler was in a safe working condition. The German TÜV was also established after a large boiler explosion in 1865. The goal was to prevent loss of life through maintenance. But as long as they didn't kill anybody, machines were usually fixed only after they broke.

Figure 53: Henry Ford and Model T (Image Ford Motor Co. in public domain)

As manufacturing became more and more connected, supply chains more complicated, and product varieties increased, breakdowns of machines led to many (and expensive) follow-up problems. The idea to fix machines before(!) they broke appeared, and **preventive maintenance (PM)** (or **planned maintenance**) was born. Henry Ford used it extensively in his factories and also recommended it for his car. For example, the Ford Model T manual from 1919 advises

> *Frequently inspect the running gear. See that no unnecessary play exists in either front or rear wheels and that all bolts and nuts are tight. Make a practice of taking care of every repair or adjustment as soon as its necessity is discovered. This attention requires but little time and may avoid delay or possible accident on the road.*

The challenge here is that there are numerous possible failures. It may be impossible, or at least financially insensible, to prevent them all. It would be better to prevent only the problems that are likely to happen, but then you would need to know which problems are likely to happen. The question of what to maintain, how to maintain, how often to maintain, which spare parts to stock, and so on still challenges maintenance to this day.

8.3 Maintenance Becomes Buzzwordy

Figure 54: WW II Aircraft Maintenance (Image Bond Photograph Library in public domain)

War is the driver of many inventions, and maintenance of aircraft and other gear during World War II became more prominent. In the years after World War II, a whole flurry of terms related to maintenance appeared. **Corrective Maintenance** appeared in 1957, **maintenance prevention** (not to be confused with preventive maintenance) appeared in 1959, and **productive maintenance** appeared in 1961. In the US airline industry, **reliability centered maintenance (RCM)** was also developed, but is less known nowadays. The overarching term **proactive maintenance** is also sometimes used. There are some minor differences between the meanings of these terms, but to me they all feel the same, and the difference may be more of a way to sell consulting to clients rather than differences in actual maintenance.

Figure 55: Seiichi Nakajima (Image JMAC under the CC-BY-SA 4.0 license)

The idea of productive maintenance reached Japan after World War II. At this time, a lot of industrial ideas from the US fell on fertile ground in Japan, like Training within Industry, or Deming's quality circles, and were improved upon. Productive maintenance, too, turned into **total productive maintenance (TPM)** in 1969. The key driver behind this development was Seichi Nakajima, who learned about productive maintenance in the USA and in Europe. He developed TPM together with the Japan Institute for Plant Maintenance (JIPM). The motto is "Protect your machine and take care of it with your own hands." The same acronym is also sometimes written as **total preventive maintenance**, but this seems to be not a different set of tools but merely a confusion of the many different terms.

Figure 56: Japan Ticket Machine Maintenance (Image Nesnad under the CC-BY-SA 4.0 license)

At the same time, maintenance for most companies was still mostly reactive and not very organized. Only between 1960 and 1980 did maintenance become more prominent and structured. Around this time, norms for maintenance were established, together with the sale of certificates.

8.4 Predictive Maintenance

Figure 57: Predictive Maintenance (Image leowolfert with permission)

Finally, with industry 4.0, **predictive maintenance** (**PdM 4.0**) emerged, trying to… well … predict the problem before it happens. The idea is to collect lots of data (buzzword: big data) and have algorithms and AI's look for patterns to predict upcoming problems and permit maintenance to fix the problem before it happens. As such, it is also a proactive maintenance, but with the idea to reduce excessive maintenance though a better understanding of the system.

Total productive maintenance (TPM) is currently the most popular one, although I have a feeling that there will be even more buzzwords in the future. Overall, there are a lot of buzzwords trying to address the problem of maintenance from different angles.

In my next post I look at the different reasons why you should maintain your equipment. There is more to this than just “uptime.” More posts on maintenance, especially total productive maintenance (TPM) will follow. Now, **go out, keep your gear in good running order, and organize your industry!**

8.5 Selected Sources

Peter Poór, David Ženíšek, Josef Basl, “Historical Overview of Maintenance Management Strategies: Development from Breakdown Maintenance to Predictive Maintenance in Accordance with Four Industrial Revolutions”, Proceedings of the International Conference on Industrial Engineering and Operations Management Pilsen, Czech Republic, July 23-26, 2019

9 What Are the Goals of Maintenance?

Christoph Roser, March 2, 2021 Original at https://www.allaboutlean.com/maintenance-goals/

Figure 58: Car Repair (Image Gobierno de la Ciudad de Buenos Aires under the CC-BY 2.0 license)

In my last post I looked at the history of maintenance. This post goes into more detail on the reasons why you should do maintenance. There are many more than merely to improve uptime. Let's have a look at the different goals of maintenance. For illustration I will use the example of a car, since you are probably at least somewhat familiar with the maintenance of your car.

9.1 Reduce Frequency of Unplanned Downtime

Figure 59: Car Breakdown (Image Anthony O'Neil under the CC BY-SA 2.0 license)

Maintenance in general helps the performance of your value stream. The first thing most people think of is to **increase uptime**, which is probably also the most frequent goal in maintenance. Sometimes this is also defined as to **increase utilization**. More precisely, however, would be to say that you want to **reduce frequency of unplanned downtime**, also known as **reducing breakdowns** both in frequency and duration.

Maintenance itself will take time at the machines. However, *it makes a huge difference if you can plan the downtime, instead of the downtime planning you!* Let's take the example of your car. Regular maintenance may take your car out of action for a day or so. It is a bit of a hassle, but you can plan for a day when you may not need the car, or you can pre-arrange a rental car. However, if you skip maintenance, eventually your car will break down. This may be more expensive and may also take more time to fix. But even if has the same cost and takes the same time, the hassle would be much more. You may have just loaded yourself and your family in the car to head off to vacation, and halfway there you have a breakdown. Now everybody has to wait, you have to get your car towed (by whom? to where?), and at least a day of holiday is wasted for everybody. Not fun!

9.2 Reduce Duration Unplanned Downtime

Figure 60: Rally Paris Dakar (Image jean_cayo in public domain)

In the event of an unplanned downtime, the goal is to get the machine back up and running quickly. The goal is to **reduce the duration of unplanned downtime**. Paper mills often have a maintenance team that has little to do and may be surfing the net… until there is a problem and they have to run. Downtime of a paper mill is very expensive. Your car may not be a good example for reducing unplanned downtime… unless you are into racing, in which case a maintenance car may be on standby to help you when your car has issues.

9.3 Prevent Harm to People

Figure 61: Car Crash (Image Thue in public domain)

A second goal is to **prevent harm to people**. This is slightly overlapping with the reduction of unplanned downtime, but with a focus on the prevention of injury and death. This may be harm to yourself, your people, your customers, or other bystanders. Let's take again the example of your car. If your brakes fail, it would be an unplanned downtime. The bigger issue, however, is the risk of an accident. This could lead to injury and death of your passengers and (oh no!) to yourself. Even if the safety features of your car protected the occupants, another person may get seriously hurt. If you run over a pedestrian, you will probably be fine. The pedestrian won't. And, remember, we are all pedestrians sometimes. Historically, organized maintenance started due to exploding boilers of steam engines.

9.4 Maintain Product Quality

Figure 62: Unhappy Driver (Image Nadi_Aks with permission)

Another goal that sometimes gets overlooked is to **maintain product quality**. Depending on your machine, maintenance can influence product quality. In the worst case, you may have to repair or scrap products. Even if the product is still acceptable, it may be not as good as it could have been. I had one example where a packaging machine added more items to a package due to an ill-maintained counting/measuring unit. Of course the customer had no issues with getting 10% more products, but the company lost money.

Assume the driver-side window can no longer be opened. The car still drives, you can get around, but at every toll booth or at every entry or exit of a paid parking garage, you have to get out to get the parking ticket or pay the tolls. Very soon this will annoy the heck out of you. But it will be worse if the window is stuck in the open position. From temperature to thieving to rain, your driving experience will take a downturn.

9.5 Maintain Production Speed

Figure 63: Manual Gear Stick (Image Winkelbohrer under the CC-BY-SA 2.0 license)

Similarly, a ill-maintained machine may no longer work at the maximum possible speed. Maintenance can help to **maintain your production speed**. This results in better output and lower production cost.

Using the example of a car, assume the car has a worn out manual gear. Shifting is possible, but a nuisance. The car drives, but the driving experience is unpleasant. Due to problems with shifting gears, the drive may be slower than a similar car with a well-working gearbox.

9.6 Reduce Cost

Figure 64: Red Toy Car On Dollar Banknotes (Image Andrii_Z with permission)

Maintenance also helps to **reduce cost**. However, this is a double-edged sword. On the one hand, there is the cost of not enough maintenance. This includes all the points above and below, like unplanned downtime, harm to others, flawed quality, slow production speed. On the other hand, it is easy to go overboard with maintenance, and maintain too much and too often. There are reports of machines where the performance went down due to too-frequent maintenance requiring time consuming re-adjustments of the production parameters.

Hence the goal is to find a trade-off between too much maintenance and too little. The problem is, nobody really knows where that is. The data supporting these decisions often simply does not exist. There is also a time lag between reducing or increasing maintenance, and a result in the system performance. It is a common trick of managers to reduce maintenance, save cost, get praised, and leave for another position before the system blows up three years later.

This is also easy to see with your car. The maker of your car probably recommends a maintenance schedule. Is this necessary? It sometimes feels like the recommendation is overly cautious. But then, I don't know the effect of reducing maintenance. So far I've had my car serviced at the recommended intervals, although the nagging feeling remains if this is needed. In any case, to protect myself from legal liability (see next point), I suggest following the maintenance guidelines by the maker.

9.7 Reduce Legal Liability

Figure 65: Judge with Gavel (Image StudioRomantic with permission)

This also brings us to the last point, maintenance can help you to **reduce legal liability**. If somebody got hurt (physically, financially, emotionally) due to a flaw with your product, it may sometimes help to prove that your system was well maintained.

Cars in many countries have mandatory safety inspections, which is also a sort of maintenance. If you skip those, you will be in legal trouble even if nobody got hurt. If you hurt somebody else, the court won't take it kindly if your mandatory inspection is out of date. Not all maintenance has the benefit of protection from legal liability, but it is sometimes also a consideration. Sometimes it may even be necessary to get an accreditation.

9.8 More Benefits of Maintenance

There are many more potential benefits of maintenance, although not all of them may apply to every situation. Maintenance can **extend the lifespan of your equipment**. It can help with **ergonomics and efficiency**. Sometimes maintenance is **legally required** for the equipment to be used (e.g. aircraft or cars). Maintenance can help you to **get lower insurance rates**, and it may even **extend your warranty**. It can also have a **positive impact on the environment. Customers also like it if the manufacturer keeps his machines in order.** (Many thanks to Rob van Stekelenborg for the additional suggestions in the comment) Now, go out, keep your machines in good running order, and **organize your industry!**

10 An Overview of the Eight Pillars of Total Productive Maintenance

Christoph Roser, March 9, 2021 Original at https://www.allaboutlean.com/tpm-pillars-overview/

Figure 66: National Capitol Columns (Image AgnosticPreachersKid under the CC-BY-SA 3.0 license)

Total Productive Maintenance (TPM) is the best known framework for organizing maintenance. In this post I would like to dig deeper into its ideas and how it works. The principles of TPM are often arranged as "eight pillars," although there are different views of what these eight pillars are. Let me give you an overview of these. In this post I will also look at the general problem of maintenance. In subsequent posts I will be going deeper into the individual pillars.

I will try to not only give a brief explanation how all the pillars work, but also give my opinion on which pillars I find useful and which one I don't. There are some excellent elements in this framework that everybody should use on the shop floor, but there are also additional pillars that to me serve little purpose. In any case, I look forward to hearing your opinion in the comments.

10.1 The General Problem with Maintenance

Figure 67: Car Repair (Image Gobierno de la Ciudad de Buenos Aires under the CC-BY 2.0 license)

Maintenance is sometimes neglected in manufacturing. The first problem is that **the relation between maintenance and the effect of maintenance is ill understood**. If you change the oil of your car, does it really improve the performance or prevent breakdowns? Sure, if you never change the oil, then eventually it will be bad for the vehicle. But what maintenance interval is sensible? Should you exchange every 15,000 kilometer, or every 40,000 kilometer? Or even less? The cost is often easy to determine based on labor and parts. For your car this would be the oil, the oil filter, etc., as well as the labor for exchanging the oil.

Figure 68: Oil Change Car (Image Dvortygirl under the CC-BY-SA 3.0 license)

But the benefit is much harder to figure out. Let's take your car as an example. How often will your car have problems? What kind of problems? Is it just a higher fuel consumption, or will the entire engine have to be scrapped due to a lack of oil. Does the breakdown happen when you just by chance drive to the mechanic anyway, which would be less of a hassle, or does the breakdown happen when you are on your way to an interview for your dream job, which would be extremely detrimental?

Given sufficient data points, you can eventually describe these relations statistically. Some industries have better data, like automotive or aviation, simply because they collect plenty of data and accidents may be extremely expensive. But getting sufficient data points takes time, and a small company may never have enough data to understand a machine before the machine is replaced by a new one. Hence, a cost-benefit analysis is difficult to to for maintenance.

Figure 69: Car Breakdown (Image Anthony O'Neil under the CC BY-SA 2.0 license)

The second problem is the **delay between maintenance (or lack thereof) and the improved uptime (or lack thereof).** This can easily be years. For example, if you buy a used car, you probably should look at the service history. Not only does this delay make the relation more difficult to understand, but in industry the person paying for the maintenance and the person benefiting from it may be different. It is a dirty trick by one manager to look good by saving money on maintenance but leaving the problem of deteriorating equipment to his successor three years later. At the same time, you can't blame him either, since the relation is also difficult to understand. It does not help that maintenance consultants almost always favor more maintenance, even though they are (often) right. Overall, determining the right amount of maintenance is usually a rough and error-prone guesswork at best.

10.2 Overview of the Pillars

Figure 70: Luxor Aerial View (Image Ovedc under the CC-BY-SA 4.0 license)

Now, let's have a look at the eight pillars of TPM. Frameworks are often arranged as houses with pillars, foundations, and so on. There is the house of lean, with three columns and the three pillars of SCRUM. There are some graphs with the four pillars of Six Sigma, and so on. Pillars are used to give these ideas weight, although sometimes it feels more like a sales tactic to me.

TPM also has pillars, and an unusually high number of them too. In the English literature, there are usually eight pillars of TPM. Originally there were only seven, but the the Japan Institute of Plant Maintenance (JIPM) expanded them to eight. Additionally, 5S is also often listed as the foundation of TPM. Let me give you an overview of the most common version of the pillars:

1. Focused Improvement (meaning Continuous Improvement)
2. Autonomous Maintenance
3. Planned Maintenance
4. Early Equipment Management (somewhat similar to Design for Maintenance)
5. Quality Maintenance (which in lean would be called Jidoka)
6. Education and Training (which in lean would be part of standardization)
7. Administrative & Office Maintenance

8. Safety, Health, and Environment

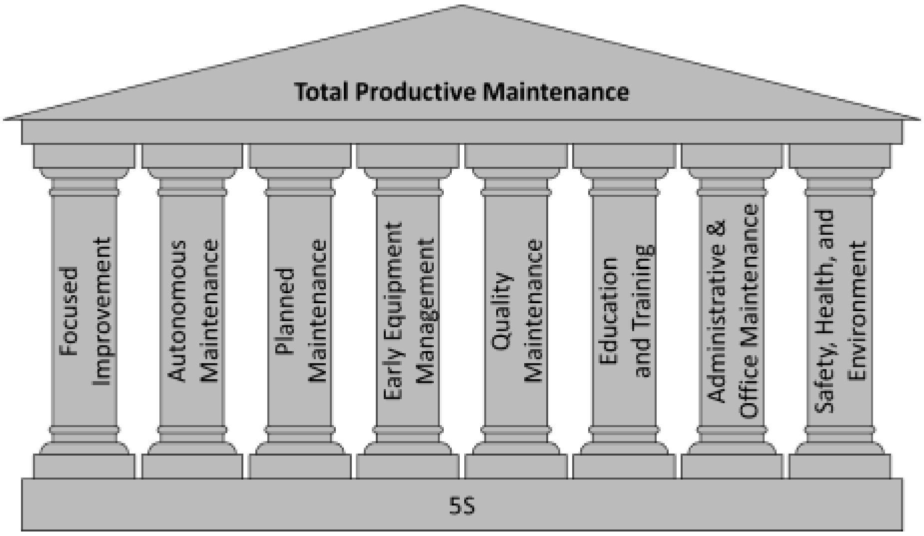


Figure 71: A common version of the Eight Pillars of Total Productive Maintenance (Image Roser)

In Japanese, these pillars would be as follows:

1. Focused Improvement is Kobetsu-Kaizen (個別 改善 for individual; separate; personal; case-by-case and betterment; improvement).
2. Autonomous Maintenance is Jishu Hozen (自主 保全 for independence; autonomy; self-reliance and preservation; integrity; conservation; maintenance).
3. Planned Maintenance is Keikaku Hozen (計画 保全 for plan; project; schedule; scheme; program; and preservation; integrity; conservation; maintenance).
4. Early Equipment Management is Shoki Kanri (初期 管理 for early; initial stage and control; management).
5. Quality Maintenance is Hinshitzu Hozen (品質 保全 for quality and management).
6. Education and Training is Kyōiku Kunren (教育 訓練 for education; schooling; training; instruction; teaching; upbringing and training; drill; practice; discipline).
7. Administrative & Office Maintenance is *Kanri kansetsu bumon katsudō* (管理 間接部門活動 for control and internal division; back-office section; indirect department).
8. Safety, Health, and Environment is *Anzen* and *Kankyō Kanri* (安全 for safety; security, 環境 管理 for environment and control; management).

10.3 Variants of the Pillars

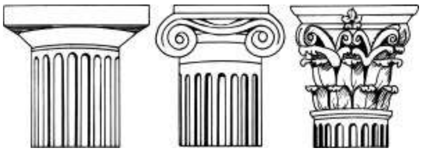


Figure 72: Doric, Ionic, Corinthian Capitals (Image Matěj Orlický and Pearson Scott Foresman in public domain)

However, there are also other versions of the eight pillars. They often differ not only in sequence, but also in the names and the content. For example, what in English is called *Focused Improvement*, is in German *Continuous Improvement* (which for me as a lean guy feels more normal). The *Early Equipment Management* focuses on design for maintenance, but this is sometimes replaced by *Ramp Up*, focusing more on ramp up than on machine design.

In other sources you can also find only seven pillars of TPM. Some of these dropped the *safety, health, and environment* aspect (and I am always unhappy if safety is overlooked), others dropped the *early equipment management*. There are even sources with only five pillars, dropping the *administrative* part, and putting *continuous improvement* and *safety* as foundations instead of pillars (where I like them much better). If you want more pillars, this is not a problem either. There is a variant of TPM with nine pillars also available, adding *logistics*. There are even completely different structures and pillars that claim to be TPM, with pillars like "*To reduce forced deterioration*" or "*To reduce natural deterioration.*"

Figure 73: Child Drawing of a House (Image Øyvind Holmstad under the CC-BY-SA 4.0 license)

There are many more versions of the pillars of TPM. If you're curious, just do a google image search for the "Pillars of TPM." The points I'm getting at are that **there is no fixed canon of pillars, and everybody likes drawing houses**. However, despite a lack of structure, and besides an overlap of some of these topics, **TPM contains lots of useful ideas worth exploring**. In my next posts I will go deeper into the different pillars of TPM. Now, **go out, think about how you can improve your maintenance, and organize your industry!**

PS: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

11 The Pillars of TPM – Focused Improvement

Christoph Roser, March 16, 2021 Original at https://www.allaboutlean.com/tpm-pillar-focused-improvement/

Figure 74: Palmyra Columns (Image High Contrast under the CC-BY 3.0 Germany license)

In this and subsequent posts I will have a deeper look at the different pillars of Total Productive Maintenance (TPM). This first post looks at the pillar of focused improvement, which is practically identical with continuous improvement. However, it can be argued if this should be its own pillar or if it should be part of the foundation of a house. I will tell you which parts I like and which ones I don't, based on my knowledge in lean. Hopefully this helps you to figure out which parts to use, which ones to not use, and which ones to modify to fit your shop floor. But feel free to disagree. I am looking forward to your comments, as I will surely learn something form them. Anyway, let's have a look at this pillar through my "lean glasses."

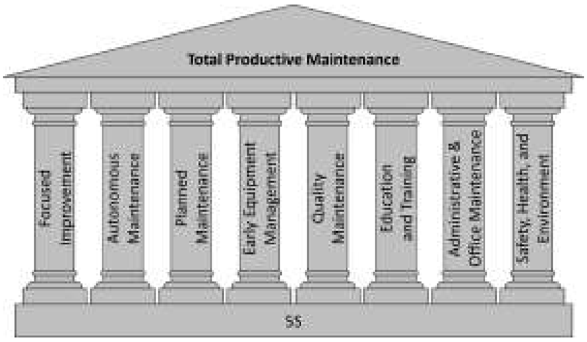


Figure 75: Eight Pillars of TPM (Image Roser)

For a quick reference, here again are the eight pillars of TPM. The bold one is the focus of this blog post.

1. **Focused Improvement** (meaning *continuous improvement*)
2. Autonomous Maintenance
3. Planned Maintenance
4. Early Equipment Management (meaning *Design for Maintenance*)
5. Quality Maintenance (which in lean would be called Jidoka)
6. Education and Training (which in lean would be part of standardization)
7. Administrative & Office Maintenance
8. Safety, Health, and Environment

11.1 Overview of Focused Improvement

Figure 76: Kaizen (Image Rawpixel.com with permission)

The first pillar I would like to discuss is **focused improvement**. In lean, this would be continuous improvement (i.e. *kaizen*), and much TPM literature also simply uses the Japanese term *kaizen.* In

Japanese it is even called *Kobetsu-Kaizen* (個別 改善 for individual; separate; personal; case-by-case and betterment; improvement). Kaizen is obviously also one of the core philosophies in lean.

The key to continuous improvement is to first pick the right problems, and then to make sure that they are actually solved. Both parts are not that easy. To pick the right problem, hoshin kanri can help to pick larger projects. Especially for smaller projects, an estimation of the cost and benefit may be helpful.

Figure 77: PDCA Circle (Image Roser)

For the actual implementation, PDCA is the right tool. As always, make sure not to forget the "check" and "act" part to verify if the "improvement" has actually improved something.

In TPM, however, many descriptions of "focused improvement" seem to fall a bit short of the idea of kaizen in lean. Naturally, since the topic is maintenance, it is more focused on improving maintenance, both regarding how to do it and how to improve the performance. This is fine. The bigger problem is that TPM often focuses solely on eliminating waste, although this misconception also happens in lean frequently enough too.

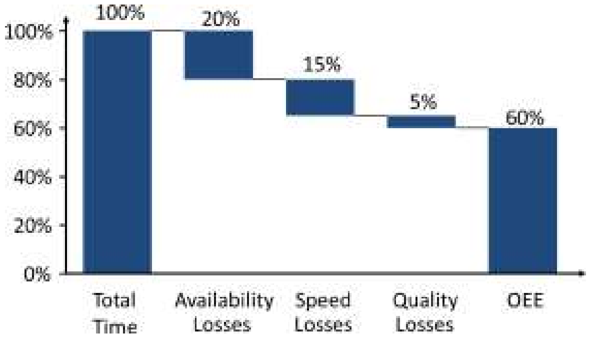


Figure 78: Example of an OEE waterfall chart (Image Roser)

In particular, TPM focuses on eliminating losses in machine performance. Like lean, TPM calculates an Overall Equipment Effectiveness (OEE). This is the same as in lean, although TPM often uses a slightly different and in my view inferior formula to calculate OEE. But as in lean, they group the losses by availability, speed, and quality losses. However, the final number is the same, and the OEE is a good tool if you want to understand and reduce machine downtime.

11.2 The Types of Waste in TPM–Focused Improvement

TPM also looks at other types of waste. In lean you may be familiar with the classical seven types of waste as shown below. TPM has expanded this to many more, and uses sixteen types of waste. These are sometimes but inconsistently grouped by availability, speed, and quality losses from the OEE.

Figure 79: Seven Trash Cans Labeled (Image Thomas Söllner with permission)

Here is one possible list of these sixteen losses. I found quite a few but different lists, but I won't go into details here. Often it is also arranged into the classical OEE subgroups of availability losses, performance losses (or speed losses), and quality losses.

1. Planned Machine Stop
2. Unplanned Machine Stop (Breakdown)
3. Setup and Adjustment Losses
4. Ramp-Up Losses
5. Minor Stops
6. Speed Losses
7. Defect and Rework Losses
8. Shutdown Losses
9. Management Losses
10. Motion
11. Line Organization
12. Logistics
13. Adjustments
14. Loss of Energy
15. Die Jig and Tool Losses
16. Yield Losses

For me, this is not a good list (but then I may be biased by being used to the seven types of waste in lean). I have three gripes about this list, and then some more about the pillar itself. First, it seems to be **overlapping**. For example, a lot of the entries, like set-ups or shutdown losses, could be considered planned stops. Another example for a possible overlap are the ramp-up losses, the set-up and adjustment losses, and the adjustment losses. There may be small differences, but for me these are the same.

Figure 80: Missing Piece (Image unknown author in public domain)

Second, I have the gut feeling that this list is **incomplete**. For example, where would you put a machine that is waiting on another machine? Is that line organization? Or is it logistics? What if it is not a line? If you have loss of energy, why don't you have loss of wasted material? Using consulting speak, the list is not MECE: it is not *mutually exclusive and completely exhaustive*. In my experience, the longer a list is, the more difficult it is to make it MECE. However, it is fine if this list of losses is not intended to be MECE but only serves as inspiration.

Finally, I find it **difficult to measure** these losses. In general it is important to measure your key performance indicators (KPI). How do you measure management losses? How do you measure line organization? It is difficult to improve what you can't measure.

11.3 Is This a Good Pillar?

Figure 81: Three Evils of Manufacturing (Image Giuseppe Canino and flydime under the CC-BY-SA 2.0 license)

But there is a bigger oversight besides the list with sixteen types of waste (muda). Reducing waste is important, but it is only one of three evils in manufacturing, and waste is the least important one in lean. The other two are unevenness (mura) and overburden (muri), where overburden is the most important type of waste. This is also relevant for maintenance, but TPM often **neglects unevenness and overburden**. But again, this unfortunately also happens in lean often enough. If you run your machine too fast or too hard (overburden), breakdowns become more likely. The same goes for the workers. If your system fluctuates (unevenness), it can also lead to maintenance problems. I admit overlooking, or at least neglecting, unevenness and overburden is common in lean, but I find these important aspects for improvement.

Finally, I believe continuous improvement is very important. However, I find it odd to make it a separate pillar. If I have a pillar for continuous improvement, does this mean that planned maintenance does not include continuous improvement? Surely not, and surely not what the creators of this house of TPM intended. If we stay with the analogy of the house, **continuous improvement should be not a separate pillar, but part of the foundation**, influencing all pillars that rest on it.

But again, I am a lean guy, and the TPM framework is not my natural environment. Maybe it makes more sense for people that are trained in TPM. And again, the idea of continuous improvement is very relevant! The goal of this series of blog posts is to give you ideas and suggestions on what parts of the TPM framework are useful for you, which ones are not, and how you could modify it to get the most out of it for your shop floor. In my next post I will continue with the next pillars. Now, **go out, improve your maintenance, and organize your industry!**

P.S.: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

12 The Pillars of TPM – Autonomous Maintenance

Christoph Roser, March 23, 2021 Original at https://www.allaboutlean.com/tpm-pillar-autonomous-maintenance/

Figure 82: Temple of Olympian Zeus (Image Joyofmuseums under the CC-BY-SA 4.0 license)

This small series on Total Productive Maintenance (TPM) looks at the pillars of the TPM framework. This particular post focuses on the topic of autonomous maintenance, which I think is a valid and useful pillar of TPM. It is one of the pillars of the framework where TPM really shines and adds a lot of value to industry. Sometimes it is even listed as the first pillar to underline its importance for maintenance. The ideas of autonomous maintenance can be applied in almost any shop floor, improving the overall system performance and reducing the cost.

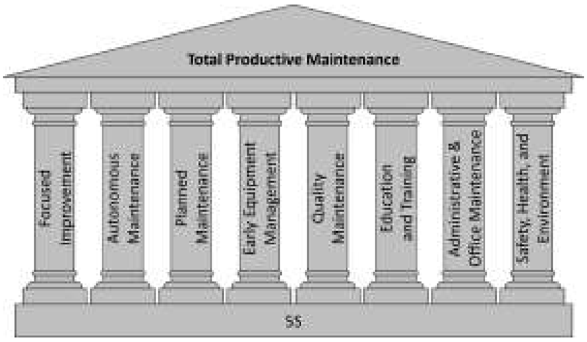


Figure 83: Eight Pillars of TPM (Image Roser)

For a quick reference, here again are the eight pillars of TPM. The bold one is the focus of this blog post.

1. Focused Improvement (meaning *Continuous Improvement*)
2. **Autonomous Maintenance**
3. Planned Maintenance
4. Early Equipment Management (meaning *Design for Maintenance*)
5. Quality Maintenance (which in lean would be called Jidoka)
6. Education and Training (which in lean would be part of standardization)
7. Administrative & Office Maintenance
8. Safety, Health, and Environment

12.1 Overview of Autonomous Maintenance

Figure 84: Factory Workers (Image Cherie A. Thurlby in public domain)

The next pillar **Autonomous Maintenance** is a very important pillar. In Japanese this is called *Jishu Hozen* (自主 保全 for independence; autonomy; self-reliance and preservation; integrity; conservation; maintenance). The "total" in Total Productive Maintenance refers to involving everybody in the maintenance efforts. The idea in a nutshell is that the operators of the machine take over part of the maintenance. This is very sensible and useful. Nobody will know the machine as well as the worker who spends eight hours per day with it. Implementing autonomous maintenance often includes a time slot for every shift focused on maintenance.

12.2 How to Do Autonomous Maintenance

Figure 85: Maintenance Work in Industry (Image Somsak Sarabua with permission)

There are a few important aspects of autonomous maintenance. First, **the worker is able to do simple maintenance tasks himself**. This may include cleaning, lubrication, fixing minor errors, tightening nuts and bolts, and other simple tasks. It may also include safety checks. For computer controlled machines, it can also include taking care of smaller error messages or simply pressing a button to acknowledge a digital warning. It helps that normally 70%–80% of the work done by maintenance personnel does not require advanced technical skills. (Source: Baudin, Michel. Working with Machines: The Nuts and Bolts of Lean Operations with Jidoka. 1st ed. New York, USA: Productivity Press, 2007. ISBN 978-1-56327-329-2. Pg. 305)

Figure 86: Factory Worker and Lathe (Image World Image with permission)

Second, **the worker will be the first to notice changes in the machine behavior**. He probably knows the machine better than anyone else, and is much more likely to notice an issue before it turns into a bigger problem. If he alerts maintenance about such an issue, it may be fixed before the machine breaks down. Examples could be unusual clanking sounds, the smell of something starting to heat up, or general unusual behavior of the system. They also have the responsibility to escalate if something seems odd.

Figure 87: Supervisor Checking A Clipboard (Image The Light Writer 33 with permission)

In autonomous maintenance, **the worker is able to do smaller inspection tasks**, like reading gauges, measuring pressures or tensions, and so on. This may also include some documentation. This also reduces the workload of the maintenance personnel and makes these inspections more efficient.

Figure 88: Oil Cans (Image Werner Habbel with permission)

It is usually in the worker’s best interest to have a well-functioning machine. Hence, the worker may take better care of the machine than a far-away and rarely visiting maintenance guy. He is also already at the machine, hence there is no extra walking involved. For simple breakdowns, the fix may also be much faster than if the worker has to issue a maintenance request and wait for maintenance. The worker may also notice upcoming problems much earlier, whereas the maintenance guy may notice it only after it breaks. Overall, a lot of **maintenance may be faster and cheaper** than if a person from maintenance has to come to take care of the machine. Highly trained maintenance personnel may be freed up to take better care of the more complicated tasks. Increasing efficiency of maintenance and shifting tasks from higher trained and potentially higher paid maintenance personnel to machine operators also **reduces labor cost**.

Giving the worker more control over his machine is a way to **empower the employee** and make him more involved. It gives the operator more "ownership" of the equipment. Not always, but often this helps with morale. Hence, there are usually lots of benefits in autonomous maintenance, often resulting in savings in maintenance cost as well as better machine performance and fewer breakdowns.

12.3 The Effort to Do Autonomous Maintenance

On the downside, the **workload for the operator increases**. It may be necessary to free up time for the worker to do maintenance. However, if done right, the additional workload of the operator will be less than the freed up time of the (sometimes more expensive) maintenance personnel. Nevertheless, since workload shifts from maintenance to production, expect some political wrangling of the involved stakeholders.

Figure 89: Students in Classroom (Image Rido81 with permission)

Additionally, you **need to train the operators** to do simple maintenance tasks. This can be done in a classroom, but hands-on training on site is usually better. Ideally, **the worker should have a standard** on how to do maintenance. This could be a list of which bolts to tighten and which places to lubricate when and how, what where and when to inspect, and so on. This may also include elements related to cleanliness (5S). Like any standard, someone also needs to occasionally check to make sure the standard is followed, and there should be a process on how to improve the standard. This training and the resulting standard should also include steps to alert maintenance personnel if the worker notices something out of the ordinary. The current state could also be part of the shop floor meeting or shift handover. There could also be documentation on the performed maintenance steps.

When implementing the new autonomous maintenance standard, it is good practice to do this for a well-functioning and clean machine. Hand over the responsibilities to the worker for a machine in perfect working conditions, not a barely functioning piece of junk. Depending on the situation, you may even do modifications to the machine to make autonomous maintenance easier or even possible in the first place. At the same time, don't expect miracles. If the machine has bigger problems, you still need a properly trained maintenance guy. The same applies to safety critical repairs. You don't want an amateur twiddling with your gas pipes or the high-voltage power lines. Make a clear distinction on what the worker can and is allowed to do, and what not.

Overall, **autonomous maintenance is a very important and valid tool for maintenance**. It can be used in almost any shop floor, to the benefit of the entire system. Now, **go out, teach your people how to take care of their equipment, and organize your industry!**

P.S.: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

13 The Pillars of TPM – Planned Maintenance

Christoph Roser, March 30, 2021 Original at https://www.allaboutlean.com/tpm-pillar-planned-maintenance/

Figure 90: Temple of Jupiter in Baalbek (Image Vyacheslav Argenberg under the CC-BY 4.0 license)

The next pillar in this series on Total Productive Maintenance (TPM) is planned maintenance. The idea is instead of fixing issues after the machine breaks, you do maintenance so it doesn't break in the first place. Like autonomous maintenance, this is one of the pillars where TPM really shines and adds value to manufacturing. Let's have a deeper look into planned maintenance.

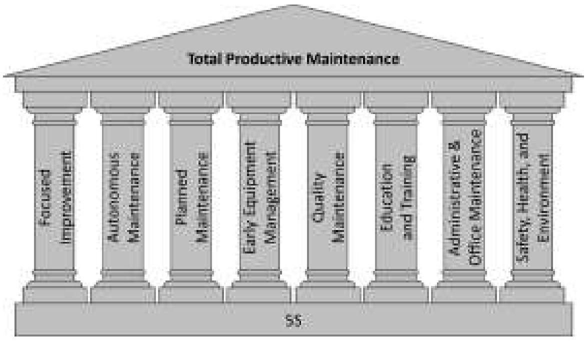


Figure 91: Eight Pillars of TPM (Image Roser)

For a quick reference, here again are the eight pillars of TPM. The bold one is the focus of this blog post.

1. Focused Improvement (meaning *Continuous Improvement*)
2. Autonomous Maintenance
3. **Planned Maintenance**
4. Early Equipment Management (meaning *Design for Maintenance*)
5. Quality Maintenance (which in lean would be called Jidoka)
6. Education and Training (which in lean would be part of standardization)
7. Administrative & Office Maintenance
8. Safety, Health, and Environment

13.1 Overview of Planned Maintenance

Figure 92: Car Repair (Image Gobierno de la Ciudad de Buenos Aires under the CC-BY 2.0 license)

Another very useful tool is **planned maintenance**. In Japanese this would be *Keikaku Hozen* (計画 保全 for plan; project; schedule; scheme; program; and preservation; integrity; conservation; maintenance). Sometimes it is also called **preventive maintenance** or, if it includes lots of data gathering, **predictive maintenance**.

The basic idea here is to do preventive maintenance (i.e., fix it before it breaks). In most cases this will be a regular scheduled maintenance, although there may also be unplanned preventive maintenance (i.e., *unplanned planned maintenance*?) if there is information on an upcoming problem. Hence it may have been better to name this pillar "preventive maintenance" rather than "planned maintenance."

Figure 93: Oil Change Car (Image Dvortygirl under the CC-BY-SA 3.0 license)

Let's take an example of your car. You have scheduled maintenance (i.e., your regular oil change). The advantage of the scheduled maintenance is that you can schedule it for a time when you don't need your car. You do it before or after (instead of while) you have to drive across the continent.

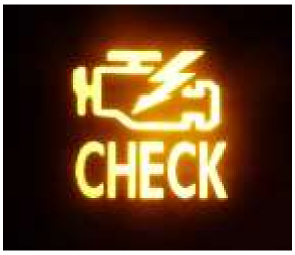


Figure 94: Check Engine Light (Image Wikiuser100000 under the CC-BY-SA 3.0 license)

Unplanned maintenance in your car would be a yellow warning light. This indicates that something is amiss and should be checked eventually. (Don't mix this up with red warning lights, which usually indicate serious problems and the car should be stopped as soon as safely possible. Consult your manual for proper procedures). Yet, you still may be able to schedule the maintenance to a time of your convenience, rather than RIGHT NOW.

The same applies to machines on your shop floor. With planned maintenance, you can schedule the downtime for maintenance (both scheduled and unscheduled preventive maintenance) to a time of your choosing. If it is an annual maintenance event, you of course pick the off-season. If it is a shorter period (weekly or monthly), you may pick an off-shift or a weekend.

In any case, you can plan the production capacity much better. Not only that, but you can also plan the maintenance capacity much better. You distribute your scheduled maintenance over time, so your maintenance personnel is neither overloaded nor underworked, while still having capacity for emergency repairs. You can even postpone a scheduled maintenance somewhat if your maintenance people are busy dealing with breakdowns.

13.2 Benefit of Planned Maintenance

Figure 95: Car Breakdown (Image Anthony O'Neil under the CC BY-SA 2.0 license)

Planned maintenance is usually the cheaper option over random unplanned breakdowns. A breakdown usually comes when you need the machine the most. Your car may break down when you just left with your family for a three-week road-trip vacation, or when you are on your way to a job interview for your dream job. These are really bad times for a car to break down. Rather than you planning the maintenance, the maintenance plans you. In a factory, it may also lead to workers idling, delayed deliveries, and other effects from the delay. The repair may also be much more expensive. If you neglect to change your oil in your car, sooner or later your engine is going to die on you. You could have had a lot of oil changes for the price of a new engine.

13.3 How Much Planned Maintenance

The question is now what type of maintenance you should plan when. This is difficult to answer. Since breakdowns are (hopefully) rare occurrences, it is difficult to get good data on the types and frequencies of breakdowns. It is also a lot of work to collect the data. For example, the airline industry has usually good data on their planes, since there are a) a lot of them and b) people really don't want planes to crash. Hence, a lot of effort is put into understanding and maintaining aircraft.

Figure 96: Various O Rings (Image arsslawa with permission)

It may be different in your company. The machines you are using were probably produced in much smaller quantities than aircraft, or your machine may even be unique. Still, even then you may get your hands on data for the components. Manufacturers often have information on the life cycle of ball bearings or valves. You may also start to collect data yourself. This can be, for example, statistics on previous breakdowns. One plant I worked in had a testing machine that pressure tested some pipes. They noticed that the O-ring sealing the connection between the machine and the part wore out every 15 000 parts, leading to false positives (i.e., defects that were not really defects). The solution was to change the O-ring every 12 000 parts to be on the safe side.

Figure 97: Supervisor Checking A Clipboard (Image The Light Writer 33 with permission)

You may also observe machine performance. Statistical process control is a tool from quality management, but it can easily be adapted to monitor the performance of your machine. If you see any worrying trends, counteract before the machine breaks.

Collecting this data is an effort and an expense. The more data you collect, the more effectively you can plan your maintenance, the better it is to find a trade off between too much and too little maintenance. But this is hard and there are no easy solutions. In many cases, especially in smaller companies, this comes down to gut feeling, which may or may not be accurate. Another problem is that if you do lots of planned maintenance, your machines will rarely break, so it looks like the maintenance may not have been necessary in the first place. Then there are also different stakeholders. The maintenance department may get yelled at if something breaks, hence they tend toward more maintenance (and hence to more maintenance people and hence more power for the head of maintenance). Maintenance consultants may also err on the side of too much maintenance, since it is what they are paid for. Plant managers, on the other hand, may or may not err toward too little maintenance, especially since there is a time lag between reducing maintenance expenses and the machine blowing up. By the time machine performance suffers from too little maintenance, the manager may already be on another position.

Again, a very valid and useful tool for industry! Now, **go out, maintain your machines so they don't break (or at least break less), and organize your industry!**

P.S.: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

14 The Pillars of TPM – Early Equipment Management

Christoph Roser, April 6, 2021 Original at https://www.allaboutlean.com/tpm-pillar-early-equipment-management/

Figure 98: Columns at Luxor (Image Olaf Tausch under the CC-BY 3.0 license)

The next pillar of Total Productive Maintenance (TPM) is Early Equipment management. This includes topics like design for maintenance. It is also a valid tool, although it is hard to estimate how much early equipment management is right for your company. Nevertheless, it may give you inspiration to improve your shop floor.

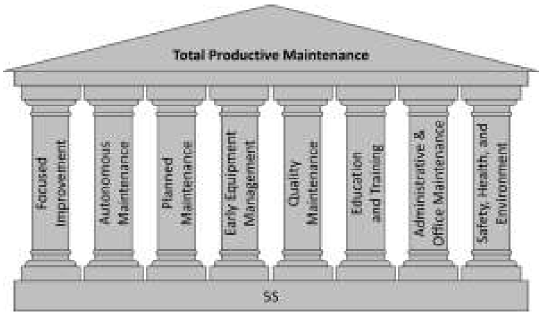


Figure 99: Eight Pillars of TPM (Image Roser)

For a quick reference, here again are the eight pillars of TPM. The bold one is the focus of this blog post.

1. Focused Improvement (meaning *Continuous Improvement*)
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7. Administrative & Office Maintenance
8. Safety, Health, and Environment

14.1 Overview of Early Equipment Management

Early equipment management is about what you can do before maintenance happens. In Japanese this is *Shoki Kanri* (初期 管理 for early; initial stage and control; management). Early equipment management seems to have different meanings in Total Productive Maintenance. Usually it is called early equipment management (or variants thereof), and focuses on the design of the machine to make maintenance easier. You could call it *design for maintenance*, although it also includes additional elements. Sometimes it is called start-up monitoring or ramp-up management, and the goal is to have a faster ramp-up after a maintenance. This is sort of a SMED for maintenance. Sometimes it is even dropped completely, and the TPM house has only seven pillars.

To me it is one of the wobblier pillars of TPM, and there are many different opinions on what this pillar actually is. This topic also often drifts off into product design, and general machine efficiency and performance topics, both of which are for me separate topics from maintenance. It may be that TPM is trying to span up an overarching umbrella for all manufacturing topics, and forces the whole efficiency and productivity topics into this pillar. To me this is the wrong approach, and there are other (and better) tools available for this. Hence, in the following I will focus on the actual maintenance aspect of the early equipment management pillar. In any case, it does contain sensible elements.

14.2 How to Do Early Equipment Management

Figure 100: Where's the battery… (Image Everyonephoto with permission)

Let's start with the machine design. You can put in effort to **design your machine for easy maintenance**. Here you try to reduce the duration and labor cost for maintenance. To give you an example, in most cars the battery is easily accessible and replacing the battery is usually not a big task. Since a car battery lasts from four to six years, it may have to be replaced multiple times during the lifespan of a car. However, some cars have their battery in odd and hard-to-access spots. Sometimes you have to remove a wheel to access the battery (which means you have to jack up the car too). In some extreme examples, you even have to take out the complete engine to get to the battery. A 15-minute swap of a battery turned into a 2+ hour highly complex and error-prone task. Clearly, one is easier than the other.

Figure 101: Here's your light bulb… (Image AleksandrKondratov with permission)

You can also **design your machine for inexpensive maintenance**. Here you try to reduce the expense on spare parts. Again, take your car as an example. When a headlight failed in older cars, you merely had to replace the light bulb, with material costs being a few dollars. Nowadays, you often have to replace the entire light module, costing you easily hundreds of dollars.

Figure 102: Oil Filter (Image Dvortygirl under the CC-BY-SA 3.0 license)

Another possibility is to **design your machine for infrequent maintenance**. You want to make your machine more reliable, so your maintenance intervals can be longer. With your car, you may buy a long-life oil filter, allowing you to drive longer between oil changes (use at your own risk). Similarly, for your machine this can reduce the frequency of planned maintenance.

Figure 103: Automatic Transmission (Image Silverxxx under the CC-BY-SA 3.0 license)

Closely related is to **design your machine for infrequent breakdowns**. It may cost more to design and build a higher-quality machine using higher-quality parts, but this results in fewer unplanned breakdowns. When talking with taxi drivers (who obviously drive a lot), they often tell me that a Mercedes transmission lasts for around 100 000 km (60 000 miles). A Toyota transmission lasts in excess of 400 000 km (250 000 miles), which is more than what even taxi drivers drive. Combined with the design for easy and infrequent maintenance the goal is to improve the OEE.

Figure 104: Notice how little the passenger cabin is damaged? (Image Thue in public domain)

Machine breakdowns are bad, but even worse is an injured operator. Hence, **design your machine for safety**. Here you will find lots of examples in your car. Some are very visible like seat belts or airbags. Others are less visible like designed crumple zones, safety cells, steering wheel retractors, and many more which you will notice only if you crash (and then your mind is probably not focusing on these). It is amazing what kinds of crashes people survive nowadays. Even more crashes are avoided through other safety features like anti-lock braking systems, emergency braking assist systems, electronic stability control (ESC), collision avoidance systems, and many more. A very important topic, although here we start to move away from maintenance and toward general sensible advice regardless of maintenance.

TPM may also include topics like **design for quality** or **design for cost**, or the related **life-cycle cost**. However, while important, these are for me too far removed from maintenance, and I would see them as part of the maintenance organization. Sometimes, **training** the employees in how to handle and maintain the machine is also included, but this is already part of the education and training pillar, hence to me it is redundant here too. In some sources, the **development lead time** and **concurrent engineering** are also included. This is sometimes called **early product maintenance**. However, this also is for me too far off topic, and is better covered with other methods.

More relevant is the topic of **ramp-up management**, where sometimes the entire pillar is called ramp-up management. The idea is to go from the end of the maintenance activities to full production as fast as possible. Often this is simply turning on the machine. However, in other cases it may require more readjustment and calibration, leading to slower production and possibly defective parts before the system is up and running again. This again is a valid topic for maintenance. Unfortunately, in my view there are some gaps. You may sometimes also have a ramp-down process. And, if we are aiming to reduce the overall duration, we can also have a look at the maintenance process itself. Luckily, there is already a well-known and useful tool that covers this topic: SMED, also known as quick changeover. While SMED is designed to **reduce ramp-down, idle, and ramp-up time for the set-up process**, it can be used pretty much identically for reducing the **reduce ramp-down, idle, and ramp-up time for the maintenance process**.

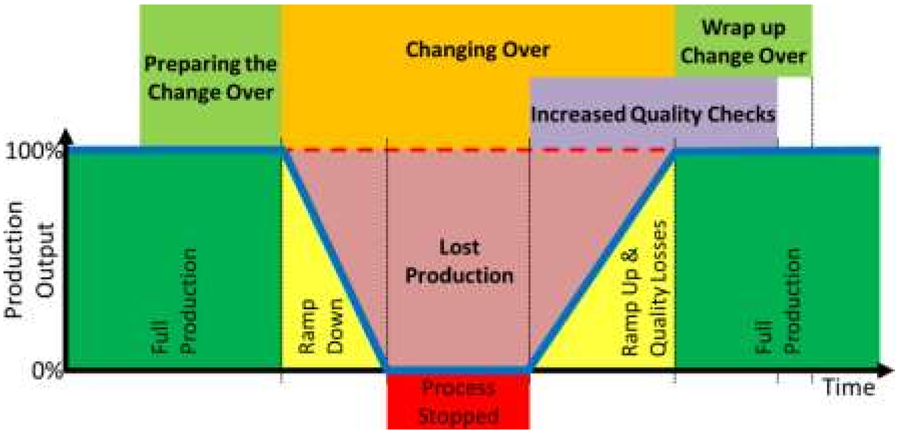


Figure 105: Changeovers and maintenance ramp downs and ups are very similar. (Image Roser)

14.3 How Much Early Equipment Management is Good?

Overall, there are lots of things you can do to reduce the maintenance effort and to improve the OEE. The tough question, however, is: Should you? All those possible actions above will have a cost, sometimes more, sometimes less, but usually something you can estimate. They will also have a benefit, which will be much MUCH harder to estimate. Going overboard and doing too much early equipment management may be wasting just as much money as doing too little. But nobody knows what exactly the right amount of early equipment management is.

An additional complication is that there is a significant delay between the cost of doing early equipment management and receiving the benefit of it. An additional complication is that the manager in charge of the machine purchasing & development budget is different from the manager in charge of the maintenance budget. The development manager may need to spend more money, while the maintenance manager reaps the benefit. This may not always happen. Eventually, someone has to make a decision with insufficient data (although this is normal for management). If you have to make a decision, take the best guess of the cost and benefit that you and your people can do. Now, **go out, design your machines so they run better, and organize your industry!**

P.S.: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

15 The Pillars of TPM – Quality, Training, Administration, and Safety

Christoph Roser, April 13, 2021 Original at https://www.allaboutlean.com/tpm-pillar-quality-training-administration-safety/

Figure 106: Roman Columns (Image Squirrel_photos in public domain)

This post continues the series on the pillars of Total Productive Maintenance (TPM). Here we look at the last four pillars: quality, training, administrative, and safety. However, I find those pillars weaker than the first four. While the topics are important, in my view they should not be separate pillars. I think these topics are either better placed elsewhere (administrative) or should be integral part of all the other pillars (quality, training, and safety). Hence, I believe this is a weaker part of the TPM framework, and I won't go into as much details as the previous pillars. In any case, let's have a look. But feel free to disagree! I am looking forward to your comments, as I will surely learn something from them.

For a quick reference, here again are the eight pillars of TPM. The bold ones are the focus of this blog post.

1. Focused Improvement (meaning *Continuous Improvement*)
2. Autonomous Maintenance
3. Planned Maintenance
4. Early Equipment Management (meaning *Design for Maintenance*)
5. **Quality Maintenance** (which in lean would be called Jidoka)
6. **Education and Training** (which in lean would be part of standardization)
7. **Administrative & Office Maintenance**
8. **Safety, Health, and Environment**

15.1 Quality Maintenance

Figure 107: Defective Brick (Image Sergey Chuyko with permission)

Let's have a look at Quality Maintenance. In Japanese this is called *Hinshitzu Hozen* (品質 保全 for quality and management). Quality is a very worthy goal in manufacturing. But is it an integral part of maintenance? The goal of **quality maintenance** in TPM is simple: zero defects. However, here I have two gripes right away. While zero defects sounds good, it may not always be the best solution. Getting to truly zero defects can be very expensive, and it may not even possible in all cases. You should push for quality if the impact of a defect is large. If a defect leads to a plane dropping out of the sky, you better make sure that there are no defects. However, in other cases a defect may not be anything of significance. If you buy a pack with 100 plastic forks, it doesn't really matter if one is broken. Hence, push quality only within the limits of reason. I wrote a whole post on this gripe: Lean Is Zero Defects? – I Don't Think So!

Figure 108: Five good parts, one defect… (Image svetamart & bajinda with permission)

My second gripe is: In my opinion, this topic is ill-placed under the framework of maintenance! There are much better frameworks out there, like Total Quality Management (TQM). Total Productive Maintenance is sometimes even confused with Total Quality Management, and even the abbreviations are similar (TPM vs. TQM). If you are in the lean framework, Jidoka or poka yoke would be a possible topic here, and machines should stop automatically if they detect an abnormality.

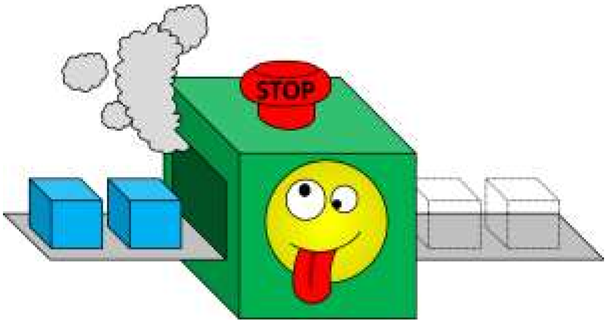


Figure 109: Broken Machine in Jidoka (Image Roser)

TPM and quality is at least loosely related, as bad maintenance can lead to more defects, and preventive maintenance can prevent defects by preventing breakdowns. However, my goal in maintenance would be to get the machine into good shape, and the good shape should be good enough so that no defects happen. Reducing defects even further is a quality topic. This may lead to changes in maintenance, but for me the quality guys are in the lead here. In any case, the details of the TPM quality maintenance pillar could be found almost identically in a TQM handbook. Hence, the methods uses for quality management in TPM are sound, prevent defects through jidoka or similar tools, use statistical process control to notice trends before defect happen, and if a defect happens use root cause analysis to figure out how to prevent it from happening again, and so on. In sum, the topic is important, but I would see it as part of quality, not maintenance.

15.2 Education and Training

Figure 110: Students in Classroom (Image Rido81 with permission)

This pillar is about education and training, or *Kyōiku Kunren* (教育 訓練 for education; schooling; training; instruction; teaching; upbringing and training; drill; practice; discipline) in Japanese. Good maintenance requires skills. Especially autonomous maintenance needs training of the operators. Yet I am a bit perplexed that it is a separate pillar. Rather I would have this integrated into other pillars. I can't do autonomous maintenance if I don't do training of the operators. It is too tightly inter-meshed for a separate pillar. If anything, I would have it as a foundation of the TPM house.

TPM incorporates good existing tools, like a skill matrix. It also aims to create a structure for the training, so as not to miss out any stakeholders in maintenance. In my view, however, I miss the mentioning of standards. Maybe I am too biased from lean, but a lot of training should be training in the use of a standard. Having a standard includes not only training of the operators, but also improving the standard.

15.3 Administrative & Office Maintenance

Figure 111: Japanese Office (Image Danny Choo under the CC-BY-SA 2.0 license)

The pillar of administrative and office maintenance is called *Kanri kansetsu bumon katsudō* (管理 間接部門活動 for control and internal division; back-office section; indirect department) in Japanese. The idea of the administrative and office maintenance pillar is also a bit fuzzy. Some sources see it as the administration supporting the maintenance efforts. Other sources see it as the reduction of waste in administrative areas. Both are valid topics, but again I think both are misplaced as a part of the maintenance efforts. To me it also does not justify to be a pillar. Besides, if we start about maintenance and efficiency in the office, why not have more pillars for logistics, healthcare, service, and so on. But again, this may be the effort to turn maintenance into an overarching framework for the entire industry.

15.4 Safety, Health, and Environment

Figure 112: Bandage on Hand (Image VadimGuzhva with permission)

The last pillar of TPM is safety, health, and environment. In Japanese safety and health are merged, and it is called *Anzen* and *Kankyō Kanri* (安全 for safety; security, 環境 管理 for environment and control; management). These topics are very important, but here too I think these are misplaced. If you have a separate pillar for safety, it makes you vulnerable to neglect it elsewhere until you actually get to that column. I find it risky to have a separate deployment of your safety efforts.

In any case, the goal is zero accidents, zero incidents, zero pollution, zero burnout, etc. The underlying ideas are also sensible, by alerting and teaching the workers on health and safety, by making machines safe to use (although this is again an overlap with the pillar early equipment management), having first-aid equipment and people that know how to use it, actively searching for safety and related issues so they can be fixed before someone gets hurt, and so on. But again, in my view this is not a separate column.

In any case, regardless where you have training, quality, or safety, you must have it somewhere. Now, **go out, train your people to improve quality and safety, and organize your industry!**

P.S.: Many thanks to Leandro Barreda and Gil Santos for nudging me to write about maintenance.

16 The Pillars of TPM – The Missing Pillar Reactive Maintenance?

Christoph Roser, April 20, 2021 Original at
https://www.allaboutlean.com/missing-tpm-pillar-reactive-maintenance/

Figure 113: Where is the other pillar? (Image Kotzian under the CC-BY 3.0 license)

In the last few posts I went in detail through the eight pillars of Total Productive Maintenance (TPM). However, looking at this framework of eight pillars, besides having a few pillars too many, I am sorely missing one very important pillar: Reactive Maintenance! How do you fix stuff after it breaks? If I create a structured approach for maintenance, reactive maintenance would be one of the key points, yet it is completely absent in the TPM framework. This is in my opinion one of the flaws of TPM. I am looking forward to receiving your responses or rebuttals. I am sure I will learn more about maintenance through your comments. In any case, let me explain my view.

I also will go a bit into when to do reactive and when to do preventive maintenance. In my next post I will go into greater detail on how to do reactive maintenance.

16.1 Preventive vs. Reactive Maintenance

Figure 114: Too late to fix the brakes… (Image Levy & fils, Kuhn in public domain)

Preventive maintenance tries to fix a problem before it becomes a problem. Reactive maintenance (often called corrective maintenance) fixes the problem only after the fact. The advantage of preventive maintenance is that the problem will be much smaller or nonexistent, whereas reactive maintenance usually has many expensive follow-up problems like delays, missed deadlines, cost of spare parts, or injured people. The advantage of reactive maintenance is that you have a much better understanding of the problem, whereas preventive maintenance is often based on guesswork with anecdotal evidence. In sum, with reactive maintenance you see exactly what your money does, but it can be much more costly than preventive maintenance where it is unclear which expense is actually beneficial.

Originally, reactive maintenance was part of TPM. But somewhere along the line, this got dropped. Most TPM frameworks don't mention corrective maintenance, and then often only in a historical context. I have yet to find an example of the eight (more or less) pillars of TPM that include reactive maintenance. When googling, there are over 600 000 results for preventive maintenance, but only 150 000 results for reactive or corrective maintenance.

Figure 115: Destroyed Tire Namibia (Image Jochen Roser with permission)

I think the underlying idea of TPM is that with enough preventive maintenance you no longer need reactive maintenance. However, I believe this is absurd. **Reactive maintenance is as important as preventive maintenance** (or even more so). I have yet to see a factory that had no breakdowns. In some factories reactive maintenance is even more common than the preventive maintenance. Even with an insane amount of maintenance, you will still have breakdowns, just fewer of them (hopefully). Even in this case, excessive preventive maintenance may be more expensive than the problems arising from a breakdown. Granted, most companies are still quite a bit away from too much preventive maintenance, but all companies I known still do reactive maintenance on a regular basis.

Figure 116: PDCA Circle (Image Roser)

Hence, for me reactive maintenance is an important part of maintenance, and would fully justify its own column in the house of TPM. I agree, it is not a sexy pillar. When selling maintenance services, the idea of *not having any breakdowns* sells much better than *what to do after a breakdown*. Plus, the service provider will have long been paid before the company finds out what kind of difference the preventive maintenance actually made. In terms of the PDCA, the Check and Act may happen only years later, if it is done at all.

But on the shop floor, what to do after a breakdown is often a big issue, and there is also often lots of potential to improve preventive maintenance. I find it important to provide guidance here too, even though it does not sell as well, and the factory is much quicker in finding out if it was worth it. Hence I am strongly in favor of including reactive maintenance as part of the pillars of TPM. In my next post I would like to go deeper into how to do reactive maintenance. But before that, a little bit about when to do predictive maintenance and when to do reactive maintenance.

16.2 How Much Preventive and How Much Reactive Maintenance?

Figure 117: Thinking Man (Image MicroOne with permission)

The more preventive maintenance you do, the less reactive maintenance you will need. The big question is: What is a sensible amount of preventive maintenance? Having one reactive maintenance is usually more expensive overall than one preventive maintenance. However, you need many more preventive maintenance events, and it is unclear how many reactive maintenance events were prevented through preventive maintenance. Like with your car, an oil change is cheaper than a new engine, but you need multiple oil changes, and it is unclear how many broken engines this prevents.

Figure 118: Girl with Abacus (Image ElenaYakimova with permission)

Hence, in theory where you just can assume numbers, it is possible to do a cost-benefit analysis. In reality, you are missing a lot of numbers, and even an estimate on the frequency of breakdowns is at best a wild guess. You have no other option but to guess and hope that it will work out.

In literature, it is often recommended that the goal should be 80% preventive maintenance and 20% reactive maintenance. I haven't found any scientific proof for this, but my gut feeling tells me that this number is probably not too far off. In reality, however, you will find that typical maintenance departments often do 30% to 50% reactive maintenance. It is also a gut feeling that many companies could benefit from more preventive maintenance, but it is really tough to make such a statement for an individual company.

Figure 119: Injury Fork Lift (Image HalfPoint with permission)

Although on one aspect I am certain: If preventive maintenance can prevent injuries, then you should do it! Authorities in charge of the road or rail networks often have a "budget" for every potential life saved. In advanced countries this is often around $1 million. The authorities are willing to spend $1 million to save one life. Hence, with respect to possible injuries, you should very much err on the side of safety.

Figure 120: Ball Bearing (Image Roser)

Preventive maintenance is often just guesswork, but **predictive maintenance** can help by collecting data and estimating when an item will break or if it will break soon. This is also related to industry 4.0.

For example, a sensor could measure the vibrations of a bearing. If the system detects an increase in vibration, it may be time to exchange the bearing before it fails (at an inconvenient time with higher follow-up cost). There are lots of possibilities, but unfortunately they are also not free, which makes the cost-benefit analysis between predictive and and reactive maintenance still difficult.

In any case, try to get a good balance between preventive and reactive maintenance. Only in weak companies is reactive maintenance the default. In my next post I will go deeper into how to do reactive maintenance. Now **go out, understand your system better in order to maintain it, and organize your industry!**

17 How to Do Reactive Maintenance

Christoph Roser, April 27, 2021 Original at https://www.allaboutlean.com/how-to-do-reactive-maintenance/

Figure 121: Fire Ladder Engine Flashing (Image fifg with permission)

In this post I will finally go into more details on reactive maintenance. I already explained in my last post that I am missing the reactive maintenance in the eight pillars of Total Productive Maintenance (TPM), as well as preventive maintenance being often the better approach. The goal of reactive maintenance is to resolve breakdowns quickly to minimize the delay. This often includes a spare-parts management to decide which spare parts to keep in stock and which ones to order. It also helps to get a better understanding of your system to know what you are more likely to need and what not. A good analogy is the fire department, where speed is also (or even more) critical. Let’s look at the details:

17.1 Speed of Reactive Maintenance

Figure 122: An urgent call… (Image Sylvain Pedneault under the CC-BY-SA 3.0 license)

Something broke and needs fixing. Now is not the time to complain or to blame, or to wonder how this could have been prevented. Now is the time to act. Hence, reactive maintenance sometimes has the nickname *run-to-failure maintenance*. If something breaks, time is critical. The broken equipment is probably stopping the material flow and causing customers and workers to wait. Therefore, a fast reaction is important.

Figure 123: All ready to go… (Image Reytan in public domain)

A good analogy is the fire department or the emergency services. When the alarm comes, they do not start to gather their tools and load them in the fire engine, only to find out that the tank is empty. Instead, as much as possible is prepared and ready to go. The same should apply to reactive maintenance. The tools should already be in the toolbox or tool cart, and spare parts should be available. The tools should also be in working order. Having to walk back because you need an extra O-ring is wasted time.

Hence, great care should be taken in **preparing and maintaining the toolkit**. Do you carry the toolbox or roll it? Are there stairs in between? Make sure to select suitable tools and spare parts, and refill consumables like duct tape or O-rings after use. Include a spare battery as needed, for example for the voltage tester. Fire departments go to great length to optimize their reaction speed, and the same should apply to maintenance. Hence, you may look to your fire department for inspiration. If you are familiar with SMED, you may also look there for inspiration.

Figure 124: Firefighter drill (Image DVIDSHUB under the CC-BY 2.0 license)

Also make sure to have **good standards on how to issue and respond to a breakdown**. Have your people properly trained so they know what to do. This does not only include technical training, but guideline rules on how to prioritize tasks (preventive tasks are often less urgent than reactive tasks, and some breakdowns are less urgent than others), who to send to which problem.

The workload of the team should be balanced, including reactive tasks, preventive tasks, and maybe even some idle time. For example, paper mills often have a maintenance team idling next to the large paper machine. They have lots of free time. But once there is a breakdown, they have to run. It may not be as extreme in your company as in a paper mill, but try not to overload the maintenance team with work. Ideally, maintenance has work that they can drop anytime to fix a breakdown, although in reality this may not always be possible.

Figure 125: Worker in Factory making a Phone Call (Image Standret with permission)

Finally, make sure that the escalation channels from the troubled machine to the maintenance are in good order. It is troublesome if the operator has an urgent call for maintenance, but nobody picks up the phone. You may also use other types of (digital) escalation systems.

17.2 Spare-Part Management

Figure 126: Rubber Spare Parts (Image DmyTo with permission)

Another important question is **spare-part management**. Here, the actions move a bit from reactive to preventive, as you are trying to predict which future spare parts you need. There are different key factors here: **How likely do you need the part, how expensive is a delay in getting the part, how fast can you get one from the supplier, and how much does it cost to keep the part?**

Figure 127: Large Parts (Image baicai lin under the CC-BY-SA 2.0 license)

- Spare parts that are **cheap to keep** because they are inexpensive, small, and have a long shelf life should be in stock on site. O-rings, screws, nuts, filters, and similar are commonly held in stock.
- For more expensive parts, it depends on the **speed of reordering**. Does the supplier send out spare parts overnight, or is it a custom-made spare part with a three-month lead time? The faster the delivery is, the more likely you can get away with not having it in stock but instead wait for the replacement.
- Another consideration is **how likely do you need the parts**. In general, parts that are commonly needed are often better to be kept in stock, whereas infrequently needed parts may be ordered as needed to keep the inventory costs down.
- The last consideration is **how expensive is it to wait** on a spare part. If the delay in getting a spare part causes only minor subsequent troubles, then you may wait. For example, if one of your forklift breaks, it is only a small problem if you have twenty similar forklifts more. However, if the final automotive assembly line breaks down, then this will cost around $1 million per day.

Figure 128: Auto Parts Store (Image Visitor7 under the CC-BY-SA 3.0 license)

These are the main criteria for deciding which spare parts to have on stock, and which ones not. The cost of keeping the part and the speed of reordering are often known. The expense in waiting for a part can at least roughly be estimated. The real difficulties are in determining the likelihood of needing the parts, making spare-part management difficult. But it has to be done. Computer systems can help you here in deciding what to stock and what not. Pull systems like kanban can be used to automatically replenish consumed parts. But be prepared to have a large and costly inventory that sees little turnover compared to manufacturing inventory. It may be better than delays during a breakdown, but nobody knows what inventory is exactly right. Also make sure to keep track of your spare parts, replace expired parts, and keep them organized.

17.3 Understand Your System

Figure 129: Boring Inspection (Image SeventyFour with permission)

Similar to predictive maintenance, **gather data** over time to better understand your system, what parts you need, and where to focus on predictive and where to focus on reactive maintenance. Adjust your predictive and reactive maintenance standards and your spare-part inventory as your understanding of the system increases.

This concludes my overview of the different tools in maintenance, loosely based on the eight pillars of total productive maintenance (TPM). However, I am not yet done. In my next post I will have a critical look at total productive maintenance. Now, **go out, fix your stuff when it breaks (or even before), and organize your industry!**

18 An Alternative Structure for Total Productive Maintenance

Christoph Roser, May 4, 2021 Original at https://www.allaboutlean.com/tpm-critical-view/

Figure 130: Oiling Machine (Image jaczi with permission)

Maintenance is good. Maintenance is useful. But like all other tools, the wrong type of maintenance can cause more problems than it wants to solve. Hence, in this post I would like to point out some of the flaws of Total Productive Maintenance (TPM). Don't get me wrong. TPM is useful and has its strengths, but it also has its weaknesses. You need to know both to use TPM properly. I am looking forward to your input in the comments, as I am sure I will learn something.

18.1 A Brief Critique on the Structure of the Pillars of TPM

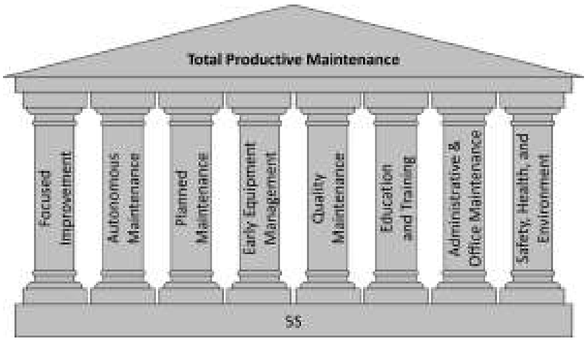


Figure 131: Eight Pillars of TPM (Image Roser)

Total Productive Maintenance is often based on eight pillars, although some use seven and others use nine, and they are not always the same. Regardless, these pillars contain a lot of good ideas. However, the structure of these pillars is a bit wobbly. Most pillars describe how to do maintenance. However, with the administrative & office maintenance, they stray from the "how to" to the "where." This would open up another box of topics, which could contain many more areas like logistics, services, healthcare, and so on. Hence, to me it fells like it is either excessive or incomplete.

Figure 132: Cleaning Tools in Bucket (Image Nick Youngson / Alpha Stock Images under the CC-BY-SA 3.0 license)

I would also take 5S out of the foundation, as it is not such a critical method for me. (Useful? Sure! But foundation material? Probably not). Instead, the pillars of focused improvement (or continuous improvement), education and training, and safety, health, and environment are much more overarching, and I would move them into the foundation.

Figure 133: 727 crash in Costa Rica in 1988. No deaths (Image soshoup with permission)

I am also missing the topic of **reactive maintenance**. What do you do when the machine breaks down? It is supposedly to be part of the Planned maintenance pillar, but often it is not even mentioned, and usually glossed over. I assume the idea is that with preventive maintenance (or planned maintenance, as it is called in the pillars), breakdowns will not happen. However, I believe this is a fallacy. Preventive maintenance can reduce the likelihood of breakdowns, but it is impossible to eliminate all breakdowns. Probably among the best-maintained machines in the world are commercial aircraft, and even so a plane crashes every now and then due to technical problems. This is despite large sums that are put into maintenance of aircraft. However, in most companies the breakdown of equipment does not result in three hundred dead people, and – depending on your company – it may be cheaper to have an occasional breakdown rather than put vast sums into maintenance. Hence, even though it is only after a breakdown, reactive maintenance should also be an important topic in most companies. Besides, even if you miss all other forms of maintenance, reactive maintenance is the default form of maintenance.

TPM often sees itself as the overarching topic in manufacturing, and from the TPM point of view everything else is second to TPM. A similar example would be Total Quality Management (TQM), which often sees everything else as second to TQM. As I am a lean guy, I of course see everything else as second to lean. Well… I am trying not to, but sometimes it slips in. Depending on your view, you can see TPM as a (group of) tool(s) or as the whole toolbox. If you see TPM only as one set of tools, then topics like focused improvement (kaizen), education (standardization), and possibly also quality maintenance would be not part of TPM but part of the bigger toolbox.

Figure 134: TPM TQM Lean Scrabble Tiles (Image Roser)

Don't get me wrong. All of these are important topics. Just make sure you don't do redundant activities. If you already have a good approach toward continuous improvement, do not create a second one just for TPM, but have TPM as part of your overall improvement approach. If you already have a strong quality program, don't establish a second one with TPM, but have the quality part of TPM as part of your overarching quality efforts. It all depends on which topic is "big" at your company. A quality guy sees quality as the most important aspect of a company. A maintenance guy sees maintenance as the most important aspect. A lean guy like me… is obviously correct and lean is the most important topic in the world </sarcasm>. In any case, make sure neither to overlook these topics nor do them redundantly.

18.2 A Better Version of the Pillars?

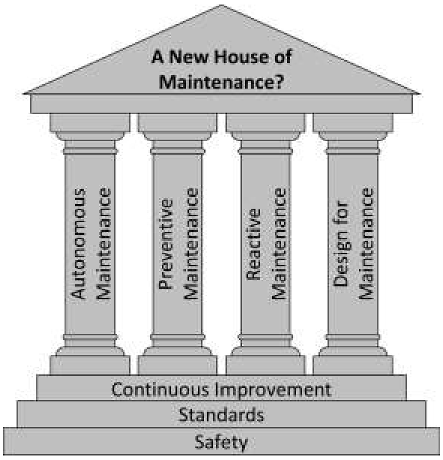


Figure 135: Updated Pillars of Maintenance (Image Roser)

Just for fun, I created a different house of maintenance. It is loosely based on total productive maintenance, but with quite a bit of reconstruction. Safety (or the pillar for safety, health, and environment) went into the foundation. Similarly, focused improvement was renamed to continuous improvement and also moved into the foundation. Education and training was renamed to standards as the third layer in the foundation. The pillar early maintenance was renamed to design for maintenance, although it is for me a smaller pillar. The pillars of quality maintenance, and administrative maintenance were dropped altogether, since I think that they belong into *other houses* (e.g., the house of total quality management quality) if you so will. Finally, I added the missing pillar on reactive maintenance.

This is not a variant of the pillars of Total Productive Maintenance, but something different. I am also not a big fan of drawing houses, but maybe it helps you to see which parts I consider important and which ones less so. This house is also not perfect and has for example overlap between preventive/reactive maintenance and autonomous maintenance. Yet, I like it better than the old one. Again, just for fun.

18.3 A Warning on Maintenance in General

Figure 136: Sprayer Maintenance (Image United Soybean Board under the CC-BY 2.0 license)

Maintenance is usually very useful and necessary. But like any tool, it can be used incorrectly. Focusing too much on maintenance runs the risk of neglecting other areas. A more holistic view of the entire system gives a better overall performance, of which maintenance is only one of many aspects. In most companies the risk is more of neglecting maintenance rather than overdoing it. However, there are also examples of doing too much maintenance.

For (a slightly older example) example, a detailed analysis by C. H. Waddington found that preventive maintenance itself created unscheduled downtime in their aircraft during World War II (hence this is sometimes known as the *Waddington Effect*). The preventive maintenance increased the breakdowns rather than reducing them, with the chances for a downtime being highest shortly after the maintenance.

Figure 137: Worried Worker (Image zorandim with permission)

Subsequent studies by Ignizio supported this and also found that planned maintenance can increase downtime significantly. He also found that maintenance intervals may be too frequent, and 30% of the preventive maintenance was too frequent, increasing cost. Between 30% to 40% of preventive maintenance effort was spent on machines that had few failures to begin with, hence there was no benefit from the maintenance effort. Only 13% of the maintenance efforts actually created value for the company, whereas 19% were a waste of resources. Overall, it is difficult to determine where to do preventive maintenance, how to do it (a lot of the negative effects were from sloppy standards and time pressure on the maintenance personnel), how often to do it, and so on. Yet, not doing it may be worse. This post concludes a lengthy eleven-post series on maintenance. Now, **go out, do maintenance, but not too much, but not too little either, and organize your industry!**

18.4 Source

Ignizio, James P. Optimizing Factory Performance: Cost-Effective Ways to Achieve Significant and Sustainable Improvement. 1st ed. New York: Mcgraw-Hill Professional, 2009. ISBN 0-07-163285-9.
C. H. Waddington OR in World War 2: Operational Research Against the U-Boat, 1946.

19 Pull: A Way Forward for Supply Chains – Guest Post by John Shook

Christoph Roser, May 11, 2021 Original at https://www.allaboutlean.com/pull-a-way-forward-john-shook/

Figure 138: John Shook (Image John Shook with permission)

The release of Christoph Roser's new book All About Pull Production inspires John Shook to discuss the origins and true meaning of "pull" and why it is incorrect to blame JIT for the shortcomings of global supply chains.

Guest post by John Shook based on his foreword in my book, and also a Cross-Post with Planet Lean*. Many thanks, John!*

One thing Covid-19 has unequivocally proved is that global supply chains in every industry are broken. When the pandemic began, we saw this in the empty shelves of supermarkets around the world. Today, we see this in the painfully slow vaccine rollout experienced by many countries as a result of supply issues. The fact that global supply chains are broken is not new (although current conditions seem to be even more dire than usual), but the fact that now everyone *knows* they are broken is. Also not new is the fact that the method that could dramatically improve the situation is getting blamed for the failure: the pull system devised by Toyota more than half a century ago, known as Just-In-Time. So it is timely indeed that Christoph Roser has launched his new book, *All About Pull Production*.

What is a pull system? Here's a few words of context.

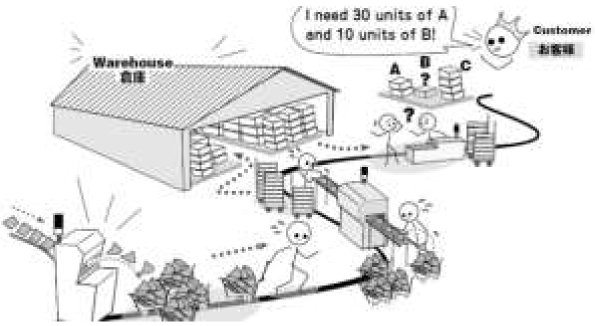


Figure 139: John Shook on the true meaning and significance of pull production (Image John Shook with permission)

Roser's book dives deeply into the ins and outs of "pull", a method of matching supply with demand that is widely referenced but poorly understood. The commonly accepted academic definition of pull has been offered by Wally Hopp and Mark Spearman, who claim in their influential 2004 paper (Manufacturing and Service Operations Vol. 6, No. 2, Spring 2004, pp. 133–148) that the defining characteristic of a pull system is the presence of inventory control limits: "A pull production system is one that explicitly limits the amount of work in process that can be in the system."

That is an attractively simple definition; however, it is incorrect. Toyota developed "pull" and supply chain design through real-world practice at a time when it had no access to automotive suppliers and therefore *needed* to innovate. Inventory was not the main problem they were trying to solve (nor is it today). The critical supply chain (or, as lean thinkers prefer to call it, a value stream) problem to solve is that each point in the chain needs to know at any given moment exactly what to make and what to move. This does indeed entail the problem of inventory and inventory leads to many other associated problems (including carrying costs, among others). For this reason, pundits, academicians and even practitioners tend to focus on the piles of stuff we call inventory without looking further to understand the deeper causes. The piles are there. They continue to grow. They block our view.

A pull system, such as Toyota's broader system of Just-In-Time, approaches the problem of supply chain design not merely from the perspective of inventory control. How can we organize all the work, all the material, and all of the *time* entailed in a long supply chain so that it operates as effectively and efficiently as possible? How can we have each step producing precisely what the next step needs when it needs it, in the amount needed? Is a top-down planning process the best way, informing each step in a large supply system what to make and when? Such an approach might work, if everything went according to said plan. But, alas, in the real world, everything going according to plan is an increasingly rare occurrence. Things go wrong. Machines stop running. Trucks break down. Humans make mistakes. And, anyway, in today's world, customers make last-minute decisions. People change their minds. So, how can we organize all this complexity when the beginning of the supply chain is half a world and half a year away from the customer?

These are the problems that pull systems tackle from an unconventional set of assumptions. Minimum inventory is desirable, to be sure, but (sorry Hopp and Spearman) setting inventory limits is not the defining characteristic of a pull system. The amount of inventory needed is the result of actions taken and decisions geared to address multiple problems – mainly, how to ensure that what is needed gets to where it is needed when it is needed, neither too late *nor* too soon.

Here is the definition of pull system from the Lean Lexicon: "A method of production control in which downstream activities signal their needs to upstream activities. Pull production strives to eliminate overproduction and is one of the three major components of a complete just-in-time production system". And note that, while minimal or even "zero inventory" might be "ideal", in the real world inventories can be used strategically – utilized in six distinctly different ways (see here) – to make the overall system work with aim for greater "total system effectiveness and efficiency", not "local or point efficiency".

Toyota discovered early on (as has, more recently, Tesla) that the auto industry presented a multitude of deeply complex problems beyond the obvious ones of designing, building, and marketing the product. There are employees to hire and train, parts and materials to source, products to sell and service, regulatory concerns to contend with. And there is the thorny issue of managing the thousands of parts and materials that go into a car. As straightforward as it may sound, corralling and herding the endless stream of materials can be as difficult as transforming them into the product!

Toyota auto company founder Kiichiro Toyoda came up with the concept – and even the curious name – of "Just-In-Time" in the 1930s on a reconnaissance mission to the UK. He missed a train connection, providing him a lesson he would never forget in the value of promptness and inspiring the insight that one should never fail to arrive where one needs to be *just in time*. As his company back home was figuring out how to actually build the automobiles that he designed, the factory was facing the problem of constantly running out of parts and materials. As a startup, the fledgling company didn't have the capital to purchase large stockpiles (which the fledgling suppliers struggled to produce in quantity anyway). The answer was to bring in parts and materials daily, just in time, to be fabricated or assembled.

A decade later, Kiichiro's machine shop manager Taiichi Ohno began experimenting with simple pull systems on the plant floor. He found that workers at downstream processes were frequently out of the materials they needed to do their work, while upstream processes were busy producing the wrong thing. He decided to tackle the problem of "overproduction" (producing too much *or,* and this second point is overlooked by many, *too soon*) by reversing the direction of the flow of information – via Kanban cards or simply the empty bins themselves – that instructed each operation what to produce and move (Ohno didn't *invent* pull; he developed the definitive, sustainably successful, pull system). (A note to lean geeks: Value Stream Maps, aka Material & Information Flow Analysis, track the *control* or *instruction information* – not all the information that travels about in any work system. This is an especially critical distinction to make when "mapping" – to analyze and improve – a system in which the product of the system is a transformed form of information.)

In the end, two simple rules prevailed: 1) never make or move too much or 2) too little. Simple indeed. But to actualize these simple rules in the real world requires turning things upside down: pull, don't push. Start by connecting individual processes. Make production flow, ideally one-piece-at-a-time wherever possible. Wherever it isn't possible to flow from value creating step to value creating step, connect disparate processes through some sort of mechanism (such as Kanban) to enable downstream processes to pull from upstream processes what they need when they need it. With those connections made, and single-piece flow established wherever possible, focus on shortening lead times between each step, resulting in a high-velocity and highly responsive value stream. Simple! And brilliant!

But simple doesn't mean easy and brilliant doesn't necessarily mean intuitive.

My first exposure to Toyota's pull system was in the first half of 1984 on the stamping shop floor of Toyota's Takaoka Assembly Plant. Toyota was preparing for the beginning of operations at NUMMI (New United Motor Manufacturing Inc.), the company's joint venture with General Motors in Fremont, California. My aha moment – "Oh, *that's* what JIT means!" – came after, not during, my plant training, which was when I was supposed to learn all about TPS.

Though I was still new to the process, I was already in the position of explaining TPS to visitors, mostly from General Motors. While I had learned enough to be able to walk through a basic explanation of Kanban and "pull vs push", I didn't really get it. Then one day, as I was being backed into a corner to explain, really, what pull was and why it was so important, I became frustrated with one particular production manager from GM as he was frustrated with me.

A practical mid-level manager with decades of experience, he pressured me: "I don't get it. So what? I hear what you're saying but I don't see the big deal. Why should I care about 'pull instead of push'? I don't see the advantage." I was as frustrated as he, annoyed that he couldn't understand the same explanations that had seemed to suffice for others. Our frustrations rose as we egged each other on. I recall my face reddening as I realized that I couldn't explain it well because I myself didn't *really* know what the big deal was. I understood the rudiments in terms of the actions on the plant floor. And I understood to some extent the big-picture argument for what pull was and how it was unconventional, in abstract terms. But I didn't know how to connect the dots and hadn't fully grasped what was so revolutionary about JIT and pull.

I think my frustration – first toward my guest and then gradually but steadily toward myself – was the spark that led to insight and my aha moment. I was suddenly, finally, struck by the power of all these quick cycle replenishment loops that were repeating seemingly endlessly throughout the entire supply chain. The small loop of material and information flow that we were observing was fractal. What we were witnessing at the end of a big press line as stamped steel was taken away every few minutes to a store located just a short walk away, which was then connected in a similar way to the process that followed (the body welding shop), was taking place all up and down the supply chain. The next day, we visited some outside suppliers connected with the assembly plant by Kanban. Those Kanban were cycling between the two factories as frequently as eight times per day. It is a *system* with feedback loops, self-correcting and, indeed, revolutionary. Systems within systems within a system.

Within a few months, NUMMI was up and running and the world outside Toyota was getting its first close look at a successful pull system in operation. Still, what observers can see on the surface – such as low inventory – is only the result. The work behind the scenes to execute a system that looks so simple is in fact *deceptively simple*. Toyota had established an entire department to innovate every aspect of the design and operation of its supply system. To this day, it is the rare company (especially outside the auto industry) that is willing to invest in developing the organizational capability required to successfully transform to a pull system. (Toyota views conversion from push to pull as a defining characteristic of the higher-level functioning of its system of Just-In-Time – which is in turn a major component of its Toyota Production System – but pull is just one piece of JIT, along with the concepts and practices of creating continuous flow with a defined Takt Time. A complete JIT supply system – the right item in the right place in the right amount at the right time with no shortages and no overproduction – requires many additional pieces beyond pull (which is after all simply a technique), including the location and scale of capacity installation, supplier-OEM relations, and, first and foremost, accurate and deep understanding of the needs of customers! (See Toyota’s official definition of JIT here.)

19.1 Misunderstandings, Fallacies, Confusion And Damage Done

It is unfortunate indeed that the most viable way forward to fix what ails supply chains is frequently blamed for their failure. Academicians (such as those referenced above) do not have a monopoly on spreading misunderstandings about supply chain dynamics. Periodically, even the most highly esteemed journals publish articles blaming supply problems on Just in Time or lean manufacturing. Shortages of goods, such as those that followed 9/11 (Jim Womack and Dan Jones responded at that time here) or the disruptions from the massive earthquake and tsunami that struck Japan in 2011 or the Covid-19 pandemic (remarkably predicted with this preemptive debunking from Womack in 2006), invariably lead to nonsense such as this headline article in the Wall Street Journal in late 2020: *Why Are There Still Not Enough Paper Towels?* In it, the author writes: “Blame lean manufacturing. A decades long effort to eke out more profit by keeping inventory low left many manufacturers unprepared when Covid-19 struck. And production is unlikely to ramp up significantly any time soon.” (LEI responded to this via a letter to the editor.)

Now, in early 2021, the latest global supply chain crisis – progressing to items perhaps more challenging than toilet paper – entails semiconductors and geopolitics. Policies that led to three decades of chasing lowest piece prices in China are being reversed. The pendulum swings again. Through it all, there is a better way.

19.2 A Way Forward

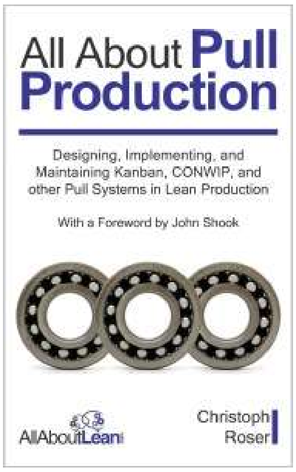


Figure 140: All About Pull Production Ebook Cover (Image Roser)

Enter Christoph Roser’s timely exposé *All About Pull*. With his latest book, Roser makes no pretense at giving us a sound bite for casual readers of 1,500-word simplifications. The content in these pages will require you practitioners to do some work.

Roser introduces many techniques and tools that will help you to reconfigure supply chain operations. But more importantly, by exploring numerous approaches and methods, he challenges readers to rethink their strategy, to reconsider what their supply system needs to accomplish and why. How can you get each item to be in the right place at the right time? How can the thousands of people and processes of an extended value stream do the right work at the right time?

The true nature of the lean enterprise is a holistic business system. In it, everything is connected. Therefore, the discipline of point optimization – the decades-long focus of supply chain research and a now-accepted dogma – typically creates waste everywhere in the system except the point being optimized. Until supply chain leaders train their vision on the entire value stream, cost savings will be illusory and eye-candy improvements unsustainable.

The power of lean is realized at the gemba through the way in which activities are connected and uncoupling those connections – be they on the shop floor or in the extended value stream – destroys the key dynamic of a lean system: the ability to learn and adapt. Break supply chain management into disconnected points of lowest-piece price locations or a set of black-box optimization algorithms and you will lose the ability to build a rational, practical, adaptable supply chain configured as a living learning system. Ultimately, this challenges managers to deeply understand how their value streams currently work and to design improved versions of them that are manageable and adaptable to rapidly changing real-world conditions.

System designs that ignore the human side of decision-making and hope to control supply chains through technology-only or technology-mainly solutions will not solve our problems. Centralized decisions (whether made by humans in command & control style or by machines using AI in black-box control style) are doomed for two reasons: 1) in today's world they cannot match the dynamic adaptability of a distributed decision-making system, and 2) any time we divorce decision-making and ownership from the humans who do the work, we take away from those humans their sense of ownership, their engagement, and increase the likelihood that errors and even sabotage will occur as a result of alienation. Conversely, pull via Kanban or any other means – along with the other elements of a Just-In-Time production system, and, indeed, all the tools and methods of a lean system – cascades ownership to wherever the work is taking place. Ohno spoke of "Kanban democracy", an elegant system with responsibility and authorization distributed dynamically based on need and transparent rules of engagement.

Supply system designers have no end of problems to solve and approaches to tackle them. The shift to pull is a technical challenge but it also requires a fundamental shift in the mindsets of not only supply chain professionals but also of chief executives. And it requires teamwork on a massive level. There is no denying the need for effective supply systems that meet the rapidly evolving complexities of the 21st Century. Learning the principles and practices of pull is a great place to start.

20 The Different Ways to Establish Pull Production

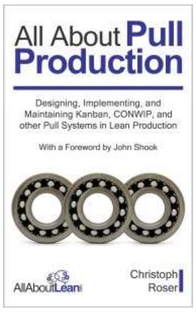
Christoph Roser, May 18, 2021 Original at *https://www.allaboutlean.com/different-pull-systems/*

Figure 141: Different Bearings (Image maxxyustas with permission)

Kanban is the best known way to establish pull production. But it is not the only way. There are many different methods to create a pull system. This blog post is loosely based on my new book All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production, which is a practical guide for anyone looking to implement pull systems. Let me give you an overview.

This is a Cross-Post with the (almost) identical article 7 tools to establish pull production *on Planet Lean.*

20.1 Introduction



All About **Pull Production**

Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production

With a Foreword by John Shook

AllAboutLean

Christoph Roser

Figure 142: All About Pull Production Ebook Cover (Image Roser)

There is much misconception on what a pull system actually is. Here is the definition from my book, which has three requirements.

- A pull system must have an **explicit target limit on your inventory** or workload.
- A pull system must **release a signal when an item or batch of items leaves the system**. For batches of material, the signal can be with either the first or the last item in a batch.
- This **signal must start replenishment** for make-to-stock items **or release the next job** for make-to-order items. The replenishment or release must be the same quantity or the same workload as the items that left the system.
- A system missing any of these three requirements above is a push system.

See also my post The (True) Difference Between Push and Pull (which is also one of my most popular blog posts). Now, let me introduce you to the many different ways to establish pull systems.

20.2 Almost Pull: FIFO

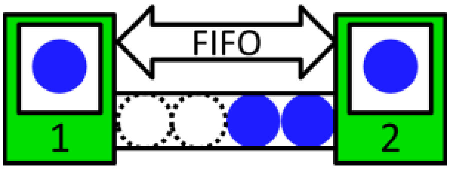


Figure 143: FIFO (Image Roser)

This one may surprise you, but First-In-First-Out (FIFO) is not only an excellent tool for material flow, but also a rudimentary pull system. There is a upper limit on the inventory. When a part leaves, a space opens up, which is the signal for the preceding process to fill up this space. Hence, FIFO on its own is a rudimentary pull system. The only thing missing is that while an empty slot signals the preceding process to produce, it does NOT signal **what** to produce.

Hence, if you use only FIFO, you will need additional information on what to produce. In reality, however, a FIFO is part of a larger production system, and the info on what to produce is provided, often even through a pull system.

20.3 Kanban

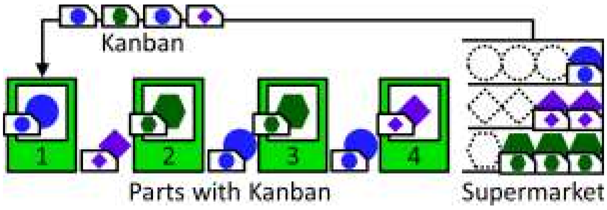


Figure 144: Kanban (Image Roser)

This is the best known way to establish pull production. The inventory is limited by the number of kanbans. If a part leaves the system, the kanban returns to the beginning of the loop and initiates reproduction. Effectively, the kanban is the signal. This is one of the easiest ways to implement pull, and there are even different variants of kanban systems.

Production kanban and **transport kanban** work very similarly, except the one reproduces and the other one re-delivers. If you have only two kanban for one part type, it is often called a **two-bin kanban** system. One box of parts is used, and another box is replenished. A triangle kanban has only one kanban per part type, which reduces ordering effort at the cost of a slightly higher inventory.

20.4 CONWIP

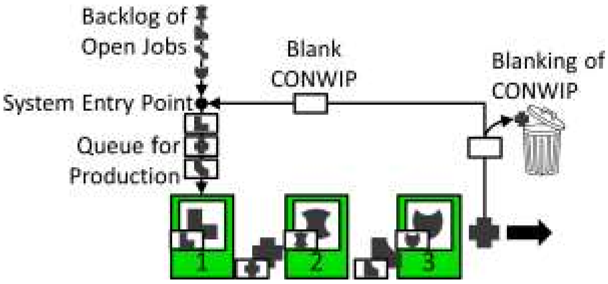


Figure 145: CONWIP (Image Roser)

Kanban and its variants are excellent tools to establish pull production. Unfortunately, these work only for make-to-stock production, and does not work for make-to-order production. However, there is a very similar pull system that manages make-to-order production. Unfortunately, this method lacks a well-known name. The most common name is CONWIP for *Constant Work in Progress*, but at Toyota it is also called *Type B Kanban*. Many companies use such a system without ever giving it a name.

The method is very similar to kanban. However, a kanban is permanently assigned to a certain part type, and you have different kanban for different part types. CONWIP is for make-to-order production, and the CONWIP card is blanked whenever a finished job leaves the system. A returning blank CONWIP card signals to start the next job. To know which job to start, you need a (prioritized) backlog of open jobs. A returning blank CONWIP card gets attached to the next available job in the backlog. This process is called "System Entry."

Overall, CONWIP limits the number of jobs in the system. Whenever a job leaves, a signal is given to start the next job. Hence, this, too, is a pull system, well suited for make-to-order. It can also easily be combined with kanban into a mixed kanban-CONWIP system.

20.5 POLCA

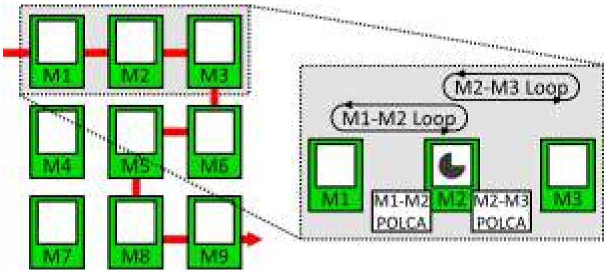


Figure 146: POLCA (Image Roser)

POLCA stands for "paired-cell overlapping loops of cards with authorization" and was developed by Rajan Suri around 1990. It is designed for low-volume-high-mix production and intended for job shops. It is an alternative to CONWIP. Both are possible for job shops. POLCA is a bit better in controlling the inventory, but is more cumbersome to implement and maintain. POLCA is also not designed for flow lines, but for job shops and networks of cells. CONWIP is easier to implement and maintain, but doesn't control the inventory in a job shop as nicely.

20.6 Reorder Point

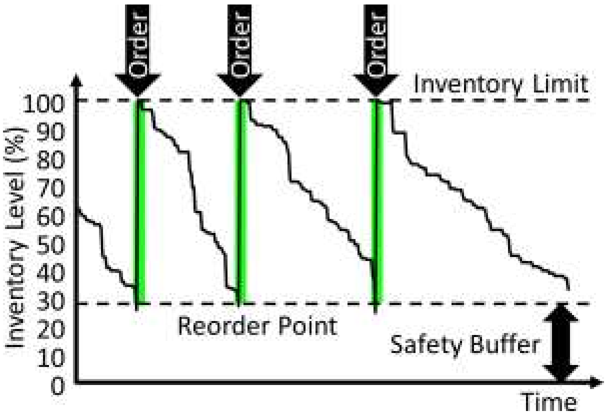


Figure 147: Reorder Point (Image Roser)

Reorder point and its closely related reorder period method for managing inventory is also a pull system. You have your target inventory and a reorder point. Whenever the inventory reaches the reorder point, you order enough material to re-fill the inventory to the target. As such it is also a pull system.

It is most commonly found in purchasing, but also sometimes in production, but always for make-to-stock or purchase-to-stock situations. Its function is very similar to the triangle kanban. I also consider this to be an excellent pull system especially for purchasing.

20.7 Drum-Buffer-Rope

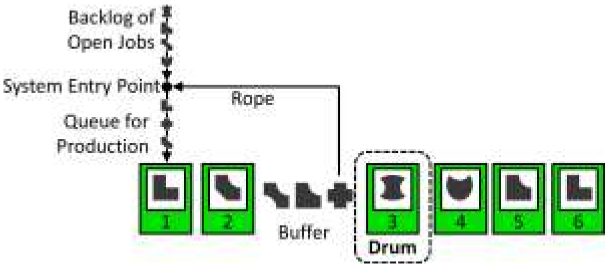


Figure 148: Drum Buffer Rope (Image Roser)

Drum-Buffer-Rope (DBR) originated with Goldratt and his Theory of Constraints. It is similar to kanban or CONWIP, but with a few differences. Drum-Buffer-Rope usually measures not a quantity of parts, but a workload in the system. Such a workload control is more accurate, but requires much more effort. Hence, I avoid workload control unless my parts have enormously different workloads, and even then I may just stick with kanban or CONWIP. Besides, you can also adjust CONWIP to use workload control, resulting in a system similar to Drum-Buffer-Rope, but much better.

CONWIP is better because Drum-Buffer-Rope also has the limitation that the pull loop ends at the bottleneck (or the customer). Hence, Drum-Buffer-Rope has only a single loop, which may not even cover the entire value stream. It also assumes that the bottleneck is fixed … which it rarely is. Unless you are a lover of Drum-Buffer-Rope, stay away from this.

20.8 COBACABANA (Theoretical Only)

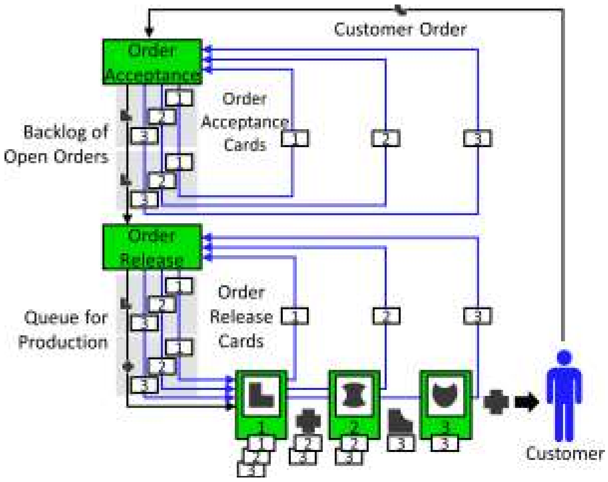


Figure 149: COBACABANA (Image Roser)

COBACABANA, developed by Martin Land and improved by Matthias Thürer, is also a pull system. It is entirely paper based, but rather complicated, requiring many different cards for each job. In theory it is a complicated but good system, but that is just it. To my knowledge there is no real world application of this method yet. Unless you love to try out new and untested methods, I would advise against COBACABANA (and for that reason it is only in the appendix of my book).

20.9 Summary

Overall, there are a lot of different methods to establish a pull system. You probably knew kanban, and maybe even some others, but I would be surprised if you knew all of them (unless you read my book, that is). Hence, you do have more options to establish pull than you may have though. But which one is right for you? This will be the topic of my next post (and also a chapter in my book). Now, **go out, use pull in your work, and organize your industry!**

21 What Are the Criteria to Decide on a Pull System?

Christoph Roser, May 25, 2021 Original at
https://www.allaboutlean.com/pull-system-decision-criteria/

Figure 150: Different Bearings, some disassembled (Image Katerina_Markelova with permission)

There are different ways to establish a pull system. In my last post I gave an overview of the different types of pull system. Before telling you which one to use when I want to show you the different factors that should go into your decision. What do you have to pay attention to if you want to select a pull system? This post is loosely based on chapter 3.1 of my new book All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production. Let's have a look:

This is also a cross-post with the same article on Planet Lean.

21.1 Make-to-Stock Versus Make-to-Order

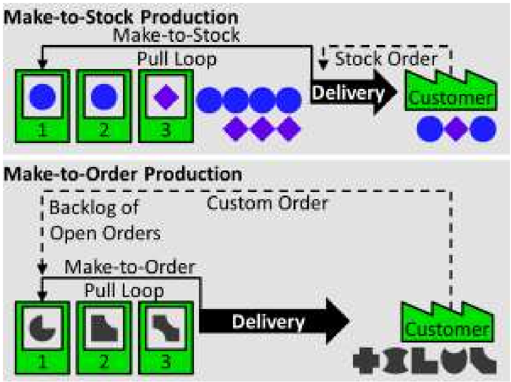


Figure 151: MTS MTO Loop (Image Roser)

There are different criteria that you have to look at when selecting the flavor of your pull system. The most important criteria is if you produce or ship make-to-stock, or if your product is make-to-order. Was the item produced, transported, or purchased before the customer order, or only after the customer order? High-volume-low-mix and low-volume-high-mix is something very similar, but the key question is still if you aim to always have a product in inventory (make-to-stock), or if you produce only if there is an order and the customer has to wait (make-to-order).

Make-to-stock and make-to-order have VERY different goals. **With make-to-stock, the goal is to always have parts available, while requiring as little inventory as possible**. You typically produce large quantities of identical products (high-volume-low-mix). The customer order starts a delivery of the item in stock, followed by the replenishment of an identical item. The item was produced in advance, and the customer (ideally) does not have to wait.

With make-to-order, production starts only after a customer order. You usually have a backlog of open orders waiting to enter the pull system. This backlog may also be sequenced according to its priority. Furthermore, a completed part is usually delivered right away after production, and you have little or no finished-goods inventory. Hence, **with make-to-order, the goal is to minimize the time between receiving the order and delivering the product, while keeping the system utilization reasonably high**. You typically produce many different products in small quantities or even completely unique items (low-volume-high-mix). Only after a customer order does production start. The customer always has to wait for delivery after making an order.

One important effect of this factor on your pull system is the level of detail needed for controlling your pull system. **For make-to-order production, it suffices to have only a generic inventory limit across all of your parts** within your pull loop. Different parts all contribute to the same inventory limit. **For make-to-stock production, however, you have to set a limit separately for every single part type** that is in your pull loop.

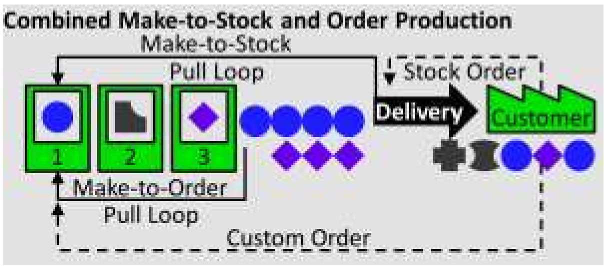


Figure 152: Combined MTS MTO Loop (Image Roser)

It is also possible to combine make-to-order and make-to-stock in the same system. In this case, you would need a pull system capable of handling both situations. This mix of make-to-order and make-to-stock is usually a combination of two different pull systems, often kanban and CONWIP. Such combinations of pull systems are absolutely feasible and can handle a mix of make-to-order and make-to-stock production.

21.2 Production/Development Versus Purchasing

Figure 153: Make or Buy (Image Roser)

A second important distinction is the capacity limitation. Are you producing or developing, or are you purchasing items from an external supplier? This is based on the capacity limit of your system. Can you get all the items you want at once (purchasing), or do you have to do it one at a time (development or production)? Do you have to worry about the production sequence of your items, or is it no problem to just get them all at the same time? In practicality, this is often the difference if you produce or develop items yourself or if you order them from suppliers.

Production systems usually produce one item after another. Hence the sequence of your orders is relevant. Your production system has a limited capacity, which could be measured in parts per day. If you want to produce too much at the same time, your production system gets clogged up. Some products may be completed early, others may take longer.

However, if you order different goods from different suppliers, you need not think about the sequence of your order. You don't think if you should order parts A from supplier X first and then parts B from supplier Y. You just order them all at the same time. Even if you order multiple parts from the same supplier, you rarely worry about the sequence of the order. Instead, you let the supplier figure it out.

21.3 Flow Shop Versus Job Shop

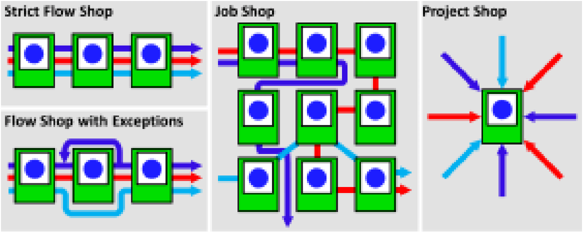


Figure 154: Strict Flow Shop Job Shop Project Shop (Image Roser)

Another less important factor relevant only to production but not to purchasing is if you have a job shop or a flow shop. Flow shops are much easier to handle. If you can turn your system into a flow shop, it will almost always be beneficial for your system. You only need to control the first process; the others are usually controlled automatically through a FIFO (First-In-First-Out).

If, however, you have a job shop, you need to manage not only what to produce with your system, but have to manage every process in the job shop. POLCA specializes in job shops, but requires more effort because job shops in general require more effort. For mixed systems that have some elements of a flow shop and some elements of a job shop, you may choose which concept fits your system better. Have you arranged your processes in a sequence that fits most products? Then it is probably closer to a flow shop. Were you unable to find a sequence since so many different products have different sequences? Then it is probably closer to a job shop.

21.4 High Demand Versus Low Demand

Figure 155: Forklift Next To Boxes And Green Up Arrow (Image ilixe48 with permission)

Another smaller factor relevant only for make-to-stock or ship-to-stock is the demand of a particular item. Do you sell large quantities or only a few items? This is also a relative factor. Judging if an item is high demand or low demand is relative to your system. This may also be very different depending on the product type. In particular, it may influence kanban systems to decide what variant of kanban you should use.

21.5 Small and Cheap Versus Expensive or Large

Figure 156: Do you stock iron ingots or gold? (Image Arnoldius and Slav4|Ariel Palmon under the CC-BY-SA 3.0 license)

Finally, a consideration for make-to-stock systems is also the cost and effort of having the item in inventory. Most times, this is based mostly on the value and the size of the item. If the item is expensive, you probably don’t want to tie up too much capital in excess inventory. If the item is large, you probably don’t want to use up too much storage space. In both cases you may invest additional effort to reduce the quantity and hence reduce the tied-up capital or required storage space. For example, if you make cars, you don’t want to put too many expensive and bulky engine drive trains on stock.

If the items are neither large nor expensive, you probably don’t worry too much about your inventory as long as you have enough. In this case, having a bit more material than needed is usually nothing to worry about. Hence, here you may choose a method that may not have the smallest possible inventory limit, but is easier on the management of the pull system.

In my next post I will use this info to give you more guidance on what pull system to use when. Until then, stay tuned, and **go out and organize your industry!**

22 Which Pull System Is Right for You?

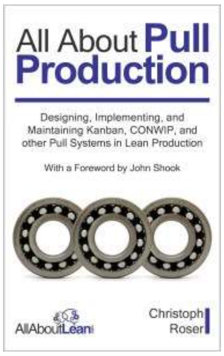
Christoph Roser, June 1, 2021 Original at
https://www.allaboutlean.com/which-pull-system-is-right-for-you/

Figure 157: AllAboutPull Three Ball bearings (Image Roser)

In my last few posts I showed you different types of pull systems, and an overview of the criteria on how to decide which one is right or you. In this post I finally give you a hands-on guide to decide which pull system to use. This blog post is loosely based on chapter 3.2 of my new book All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production. Let’s have a look:

This is a cross post with the same article on Planet Lean.

22.1 Introduction



All About Pull
Production

Designing, Implementing, and
Maintaining Kanban, CONWIP, and
other Pull Systems in Lean Production

With a Foreword by John Shook

AllAboutLean
Christoph
Roser

Figure 158: All About Pull Production Ebook Cover (Image Roser)

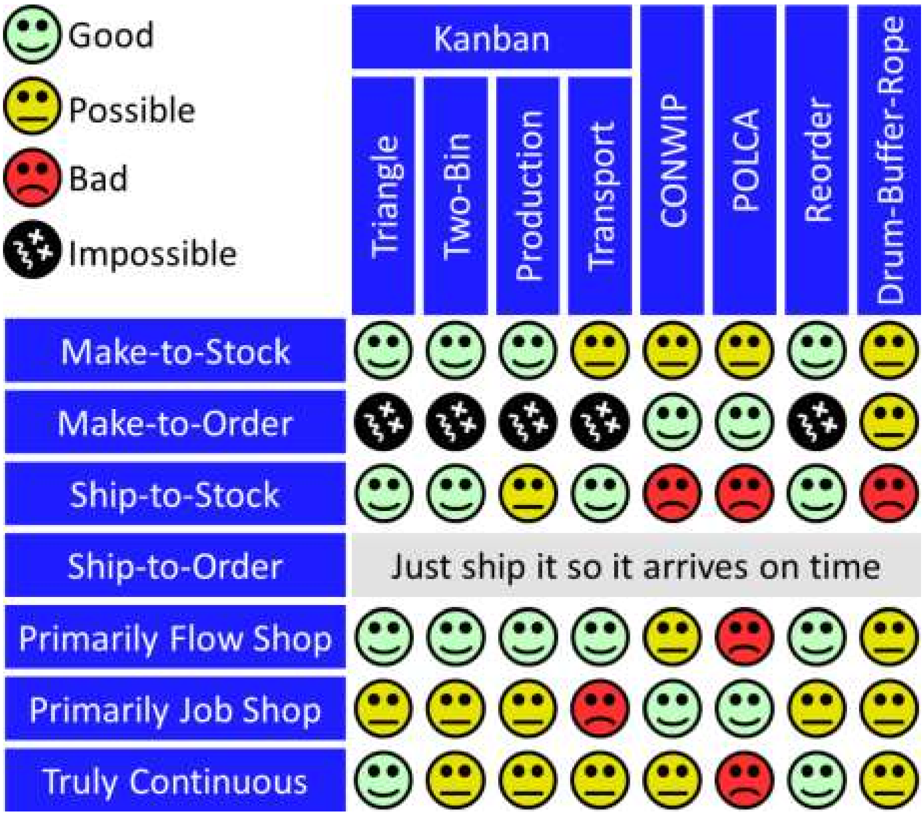
Two posts ago, I listed a number of different types of pull system. These are again listed below. This series of post is based on my new book, and you can find much more details on all these pull systems and how to use them in there.

- Kanban (for make-to-stock only, with variants of production kanban, transport kanban, two-bin kanban, and triangle kanban)
- CONWIP (similar to kanban but for make-to-order)
- POLCA (make-to-order for job shops)
- Reorder point and reorder period (mostly for purchasing)
- Drum-Buffer-Rope (if you are a hardcore fan of the Theory of Constraints)

COBACABANA (complicated, and no real-world implementation so far)

22.2 Suitability of Pull Systems

Let me first give you an (admittedly very subjective) evaluation of the different pull systems, and how well they fare with different requirements. In the image below, I summarize which type of pull system is compatible with make-to-stock, make-to-order, ship-to-stock, ship-to-order, and flow shops or job shops, as well as truly continuous processing of bulk materials. Please note that any kanban system and reorder systems are fundamentally incompatible with make-to-order. Also note that if you are shipping items based on a customer order, you do not really need a pull system; you merely need to ship the items so they arrive on time.



🙂 Good
😐 Possible
☹ Bad
😵 Impossible

	Kanban				CONWIP	POLCA	Reorder	Drum-Buffer-Rope
	Triangle	Two-Bin	Production	Transport				
Make-to-Stock	🙂	🙂	🙂	😐	😐	😐	🙂	😐
Make-to-Order	😵	😵	😵	😵	🙂	🙂	😵	😐
Ship-to-Stock	🙂	🙂	😐	🙂	☹	☹	🙂	☹
Ship-to-Order	Just ship it so it arrives on time							
Primarily Flow Shop	🙂	🙂	🙂	🙂	😐	☹	🙂	😐
Primarily Job Shop	😐	😐	😐	☹	🙂	🙂	😐	😐
Truly Continuous	🙂	😐	😐	😐	😐	☹	🙂	😐

Figure 159: AllAboutPull Pull System Suitability (Image Roser)

22.3 Pull System Selection Decision Tree for Manufacturing

Figure 160: Team competing in tug of war (Image Rawpixel.com with permission)

To help you in your decision of which pull system to use, I have created decision trees to help you select a suitable pull system for you. Please be aware that these recommendations include a lot of assumptions and generalizations. Yet overall, these recommended systems are all feasible options. Because of the length of these options, I have split them into a decision tree for production or development in this section and a decision tree for purchasing in the next section.

The first decision tree below looks at production or development. If you produce make-to-stock, your best choice is usually a variant of kanban. If you produce make-to-order, you have the choice between CONWIP and POLCA. POLCA is a bit better in controlling the inventory, but is more cumbersome to implement and maintain. POLCA is also not designed for flow lines, but for job shops and networks of cells. CONWIP is easier to implement and maintain, but doesn't control the inventory in a job shop as nicely.

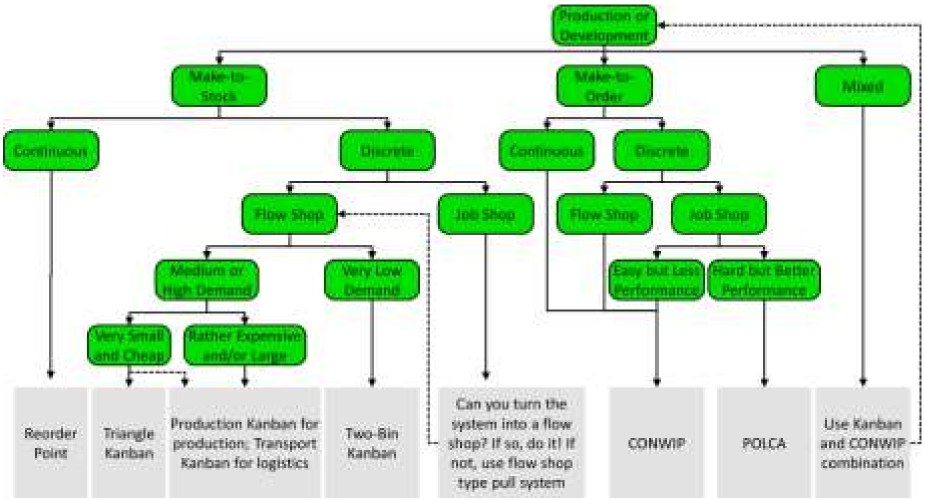


Figure 161: Production Pull System Decision Tree (Image Roser)

If you have a mixed system, you will need to choose two separate systems for the make-to-stock and the make-to-order items. Here, I recommend a combination of kanban and CONWIP.

Most systems are well suited for discrete production, where a card represents a fixed quantity. Even with continuous production, either the production or the sale is often in fixed quantities. However, with a truly continuous production, you cannot use cards for a fixed quantity of items. Here, it may be best to use reorder points for make-to-stock or CONWIP for make-to-order. However, many other systems can be adapted to continuous production with varying effort.

If you are producing make-to-stock, you have a few more decisions. First, if you are in the unfortunate situation to produce make-to-stock in a job shop, see if you can turn the job shop into a flow shop. If not, select a flow shop type pull system, although you additionally may have to take care of the routing of the items within the job shop.

If you produce make-to-stock in a flow shop, you can now fine-tune the system. If the demand is low and the demand during the replenishment time is consistently less than the content of a single container, then you may need only a two-bin system. This is a kanban system with only two cards.

If the demand is higher, you may look at the value and size of the items. If they are a bit expensive or bulky, use a normal kanban system with production and transport kanban to minimize inventory and hence minimize tied-up capital and/or storage space.

If the items are very small and very cheap, you may use a triangle kanban to reduce the number of times you have to produce, although you still may choose a normal kanban to create smaller lot sizes and improve leveling.

22.4 Pull System Selection Decision Tree for Purchasing

The decision tree is easier for purchasing. If you ship-to-order, you do not need a pull system at all. You just order all the items you need so they arrive on time when you need them. If the items are needed for your own production, the pull system of the production will decide when to produce what, and your ship-to-order items are derived from this make-to-order production system. Since you cannot produce before the parts arrive, the delivery times are part of the overall lead time for the customer order.

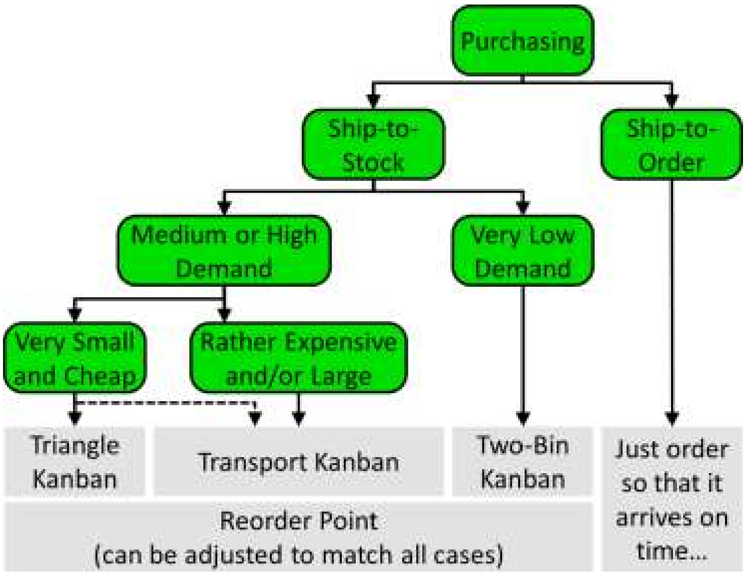


Figure 162: Purchasing Pull System Decision Tree (Image Roser)

If you order items to be on stock (ship-to-stock), the decision tree is similar to the make-to-order flow shops. If demand is very low, make sure you always have at least two items or batches. If one is consumed, order one more while the second item or batch ensures material availability.

If the demand is higher, you may use triangle kanban for very cheap and very small items, and transport kanban for larger or more expensive items. This is similar to the make-to-stock production. For all ship-to-stock methods, reorder systems are a valid alternative, as you can adjust the reorder points and reorder quantities to achieve a wide range of behaviors similar to the different kanban systems.

22.5 What About Drum-Buffer-Rope and COBACABANA?

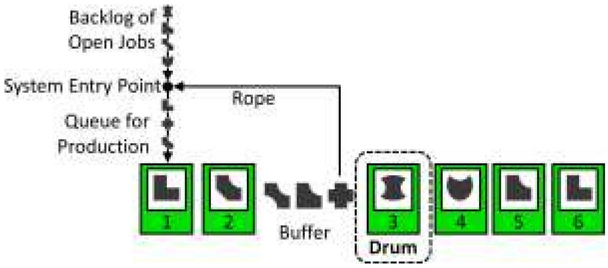


Figure 163: AllAboutPull Drum Buffer Rope (Image Roser)

You may wonder which decisions you have to make to get to Drum-Buffer-Rope, as none of the above decisions end up there. Drum-Buffer-Rope is in my view mostly inferior to kanban and CONWIP systems. Drum-Buffer-Rope requires the pull loop to end before the bottleneck, which in my view is a completely unnecessary restriction. If you ignore the restriction of the loop ending at the bottleneck, the system is actually very similar to CONWIP and quite workable.

There are real-world production systems that successfully use Drum-Buffer-Rope. Hence, if your plant successfully uses Drum-Buffer-Rope, has people skilled in it, and the method has the support of your people, by all means keep using it. I am fine with anything that works. Just don't artificially constrict yourself to end the loops at the bottleneck. If you have not yet done Drum-Buffer-Rope, however, I recommend that you stick to kanban and CONWIP systems. I also advise against COBACABANA, as it is complicated and untested in reality. **Now, go out, set up a good pull system for your products, and organize your industry!**

23 What Different Pull Systems Can Be Combined?

Christoph Roser, June 8, 2021 Original at https://www.allaboutlean.com/pull-system-combinations/

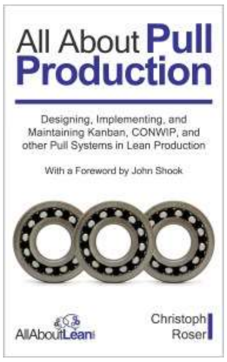
Figure 164: Different types of Bearings (Image maxxyustas with permission)

In my last few posts I have shown you different ways to establish pull systems, and which one is right for you. This post discusses how you can mix and combine these systems. You can combine some pull systems within the same pull loop, although there are some restrictions. Combinations of different kanban systems are very common, often also including a CONWIP system.

You can also combine different pull systems for sequential loop, where for example a kanban system feeds into a CONWIP system. This blog post is loosely based on chapter 3.3 and 11.1.7 of my new book [All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production](#).

This is a cross post with [the same article on Planet Lean](#).

23.1 What Pull Systems Can Be Combined in the Same Loop?



All About Pull
Production

Designing, Implementing, and
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other Pull Systems in Lean Production

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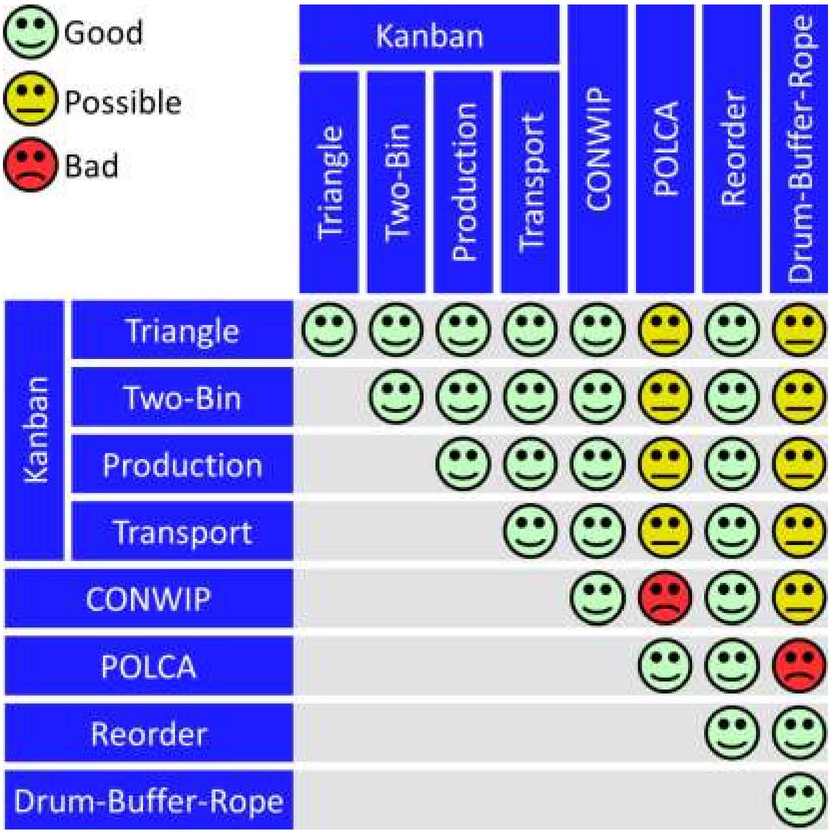
AllAboutLean

Christoph
Roser

Figure 165: All About Pull Production Ebook Cover (Image Roser)

Sometimes you may need only one type of pull system. In other situations, however, you may want to combine different types of pull systems for different part types in the same loop to fit your needs.

Most commonly, you have a combination of make-to-stock products and make-to-order products. This would usually need two different pull systems to achieve a smooth production. The diagram below shows a (again very subjective) compatibility of the different methods with each other within the same loop.



🙂 Good
😐 Possible
🙁 Bad

		Kanban							
		Triangle	Two-Bin	Production	Transport	CONWIP	POLCA	Reorder	Drum-Buffer-Rope
Kanban	Triangle	🙂	🙂	🙂	🙂	🙂	😐	🙂	😐
	Two-Bin		🙂	🙂	🙂	🙂	😐	🙂	😐
	Production			🙂	🙂	🙂	😐	🙂	😐
	Transport				🙂	🙂	😐	🙂	😐
CONWIP						🙂	🙁	🙂	😐
POLCA							🙂	🙂	🙁
Reorder								🙂	🙂
Drum-Buffer-Rope									🙂

Figure 166: Possible Pull Combinations Same Loop (Image Roser)

In general, any kanban system is compatible with any other kanban system. You merely change some information on the kanban. A CONWIP system is in its nature like a customizable kanban, and hence also very compatible with kanban. In general, for a combination of make-to-stock and make-to-order, it is recommended to use a mix of kanban and CONWIP.

Reorder systems are mostly used for purchasing, where you don't really need to worry about compatibility. The way you order one type of goods can be completely independent from the way you order another type of goods. You should worry only that you don't confuse your people with too many different systems.

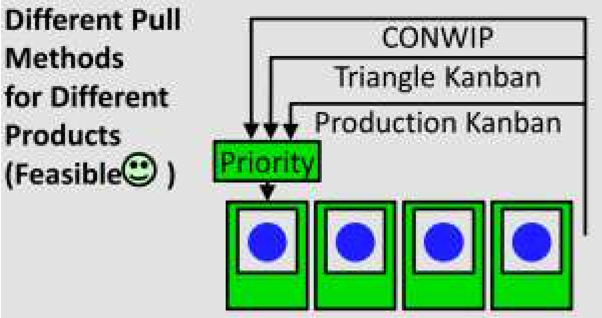


Figure 167: Loop Combinations (Image Roser)

It may be possible to combine pull systems with POLCA or Drum-Buffer-Rope. However, the outcome may range from awkward to even more awkward. In general, the fewer different systems you have, the less confusing it will be for your operators. If you use different systems, make sure your first process in the loop has a good standard on which signal takes priority over which other signal, as shown here.

Also, please note that this table applies to the pull system for different part or product types in the same pull loop. Do not use different pull systems for the same part type in the same segment of your value stream. It also does not apply to "overarching" nested pull systems, as shown below. You can find these sometimes in literature, but I seriously doubt the benefit of such nested systems.

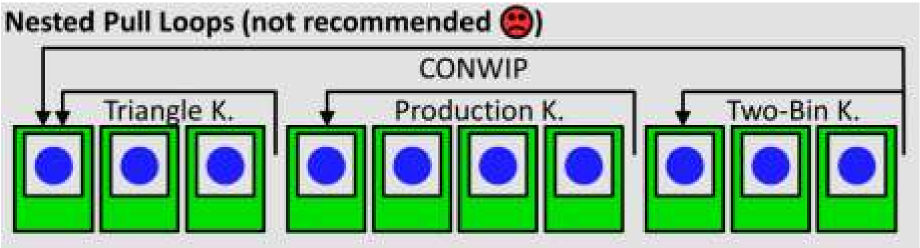


Figure 168: Not Good Combinations (Image Roser)

23.2 What Pull Systems Can Be Combined in Sequential Loops?

It is possible to combine different types of pull production (and sometimes even push if it cannot be helped) for your value stream. One or more kanban loops that feed into supermarkets can easily supply one or more CONWIP loops. Similar can also be done with many other pull methods. An example is shown below.

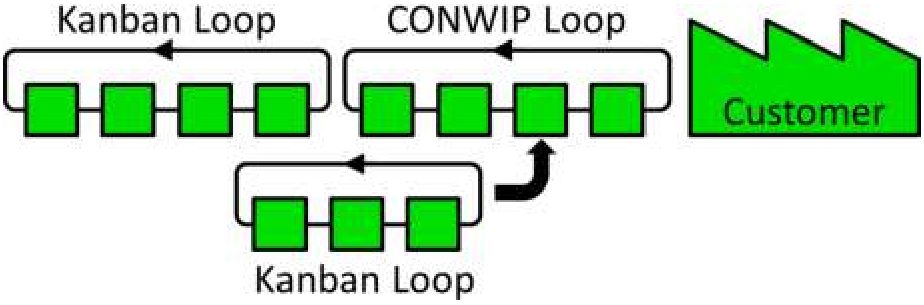
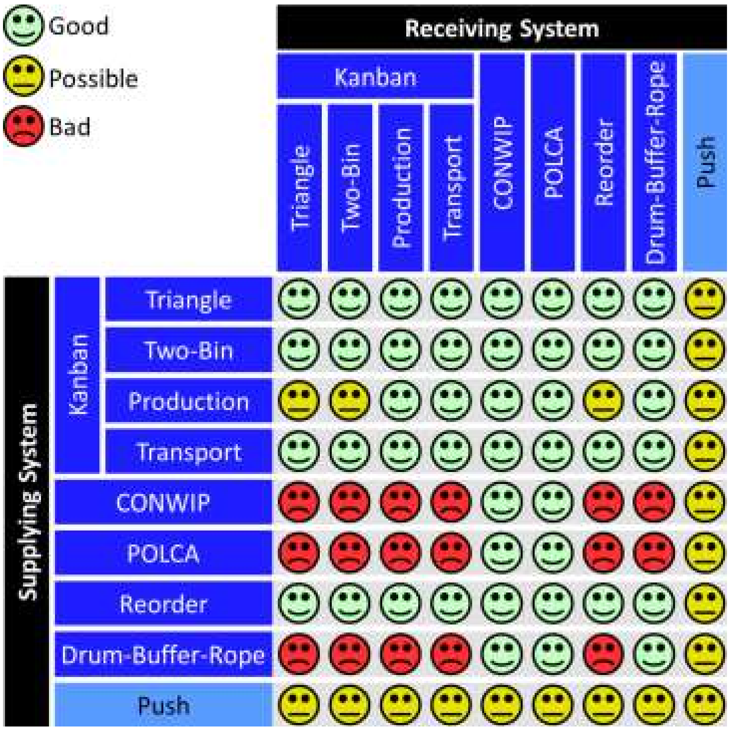


Figure 169: Serial Pull Loop Combination Example (Image Roser)

The table below gives you an overview of the possible combinations. Which type of pull system (or push) can feed into which other type of pull system (or push). There is a lot of compatibility, with only a few restrictions.



🙂 Good
😐 Possible
☹ Bad

			Receiving System								
			Kanban				CONWIP	POLCA	Reorder	Drum-Buffer-Rope	Push
			Triangle	Two-Bin	Production	Transport					
Supplying System	Kanban	Triangle	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	😐
		Two-Bin	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	😐
		Production	😐	😐	🙂	🙂	🙂	🙂	😐	🙂	😐
		Transport	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	😐
	CONWIP		☹	☹	☹	☹	🙂	🙂	☹	☹	😐
	POLCA		☹	☹	☹	☹	🙂	🙂	☹	☹	😐
	Reorder		🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	😐
	Drum-Buffer-Rope		☹	☹	☹	☹	🙂	🙂	☹	🙂	😐
	Push		😐	😐	😐	😐	😐	😐	😐	😐	😐

Figure 170: Serial Pull Loop Combination Table (Image Roser)

First, **avoid transitions from make-to-order to make-to-stock**. Systems suited for make-to-stock production, like kanban or reorder systems, can easily feed into systems suited to make-to-order production, like CONWIP or POLCA. However, the other direction of make-to-order feeding into make-to-stock is not suitable. If a CONWIP system supplies a kanban system, then you will have custom-made parts supplying make-to-stock products. Since the make-to-order part is only produced if there is a demand, the lead time for the entire system would be excessive. Hence, I advise against such combinations. Fortunately, it is rare to have a make-to-order system feeding into a make-to-stock system, as this usually makes no sense technically.

A second, smaller limitation tries to **avoid infrequent large orders for a preceding system that is set up for production of small quantities**. In particular, reorder systems may have large orders to refill the entire stock back to the target level, but triangle kanban and two-bin kanban systems can also batch demand into larger orders. Those systems do not convey the information of their demand until they reach the minimum inventory. Once they reach the minimum, they demand everything at the same time. It is possible to have a supply system that produces frequent small quantities for a receiving system that has infrequent but large orders. However, you need additional inventory to decouple these fluctuations. Hence, it may be better to have small orders from the receiving system. Altogether, to avoid large buffer inventories, it may be better to have another kanban system following the first kanban system instead of a reorder system. Yet, if the delta between the minimum level and the target level of the receiving reorder point system is small enough, it can work.

Finally, **all combinations involving push are marked neutral**, since pull is almost always superior to push. It is possible to have a push-pull combination in both directions if set up carefully. Push-pull boundaries can happen if a transition from push to pull has not yet transformed the entire value stream, or if some segments of your value stream are unsuitable for pull production. Still, go for pull if possible, and see push as a temporary situation until you have time to change it into a pull system. Such combinations along serial loop types can be from push to pull as well as from pull to push.

This concludes my small series on how to select and combine the different possible pull systems. Again, more can be found in my latest book. Now, **go out, pick the right pull system, get it working, and organize your industry!**

24 Performance Comparison of Job Shop and Flow Shop

Christoph Roser, June 15, 2021 Original at
https://www.allaboutlean.com/job-shop-flow-shop-comparison/

Figure 171: Buckau Lathe Department (Image Waldemar Titzenthaler in public domain)

Job shops are, in their nature, much more chaotic than flow shops. Previously, I have written a lot on this topic. In this post I would like to take a deeper and quantitative look at this effect. Using simulations, we take two systems and try to make them as identical as possible – except that one is a flow shop and the other is a job shop. This blog post is based on a thesis by my student Daniel Ballach.

24.1 The Two Systems

The goal was to make two systems as identical as possible. The flow shop was the easy part. You just have a sequence of processes with FIFO buffers in between. Below is an example shown with 5 processes, although we varied the number of processes between 1 and 50. The processes had all the same cycle time of 10 time units, randomly distributed using a gamma distribution. In front of every process was a FIFO with a maximum capacity of 10 parts. Both supply and demand was infinite.

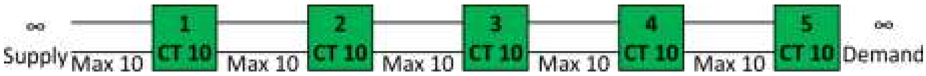


Figure 172: Flow Shop 5 Processes (Image Roser)

For the job shop, we kept the system as identical as possible, except the routing was changed. Every arriving part was randomly assigned to one of the different processes. A counter tracked how often a part has been processed already. After 5 iterations, the part leaves the system. This gives the same workload as with the flow shop. Parts that have not yet been processed 5 times go back to the random process assignment. Parts that come back have priority over parts that have not yet been processed at all. To avoid blocking situations, these parts that have been processed at least once may have to wait in a separate queue before the prioritization and random assignment. Similar to the flow shop, we also simulated systems between 1 iteration with 1 process and 50 iterations with 50 processes.

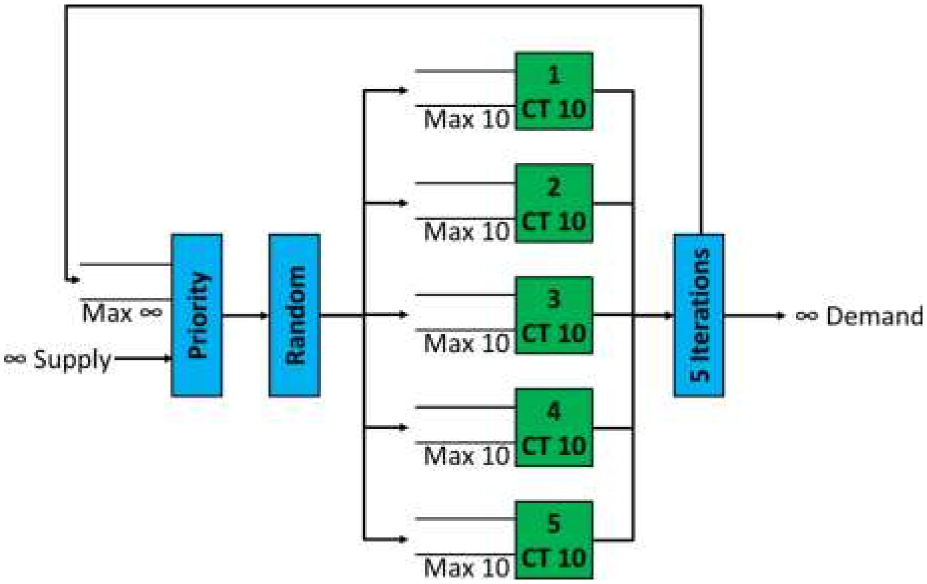


Figure 173: Job Shop 5 Processes (Image Roser)

The additional queue for the parts looping back will slightly increase the inventory, and hence the lead time. However, this was necessary to avoid blocking.

24.2 Utilization and Line Takt

Let's first have a look at the utilization. The blue line in the graph below is the average utilization in a flow shop. Again, all processes have the same cycle time distribution, meaning they all have the same speed. With a large buffer in between, these processes can work pretty much full-time, with utilizations ranging from 99.6% to 99.9%. Longer flow shops have very slightly lower utilization, although it does not make much difference. Of course, in reality your processes would have slightly different cycle times, you would have breakdowns, and your buffers may not be quite as large, resulting in lower utilizations.

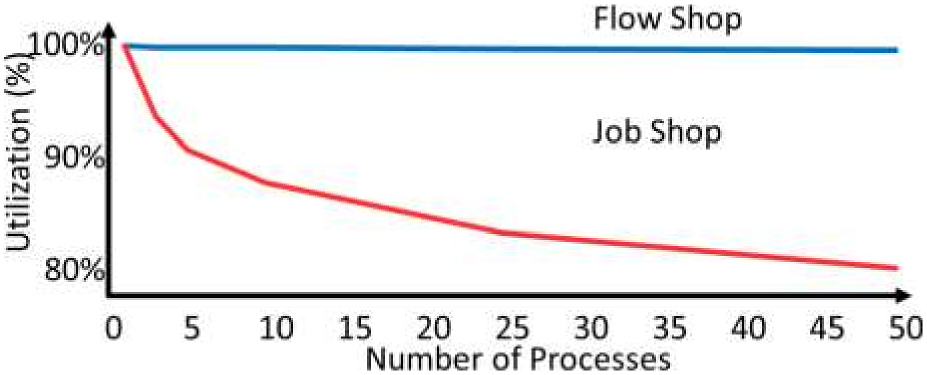


Figure 174: Job Shop Flow Shop Utilization (Image Roser)

The utilization in the job shop, however, showed a significant decline as the number of processes increased. The largest system with 50 processes had an utilization of 79.9%. Again, this is without any breakdowns, and with perfectly equal processes and equal process load. In reality, the utilization would be much lower.

The graph below shows the same data in a different way. Rather than the utilization, it shows the line takt (i.e., the average time between the completion of parts). Since a process on its own had an average cycle time of 10 time units, the system itself cannot be better than these 10 time units. The flow shop was able to stay very close to these 10 time units, taking around 10.04 time units to produce a part. The job shop, on the other hand, needed ever-increasing times to complete 1 part. With 50 processes, a part was completed every 12.5 time units … and again, this is under ideal circumstances with perfectly identical processed without any breakdowns.

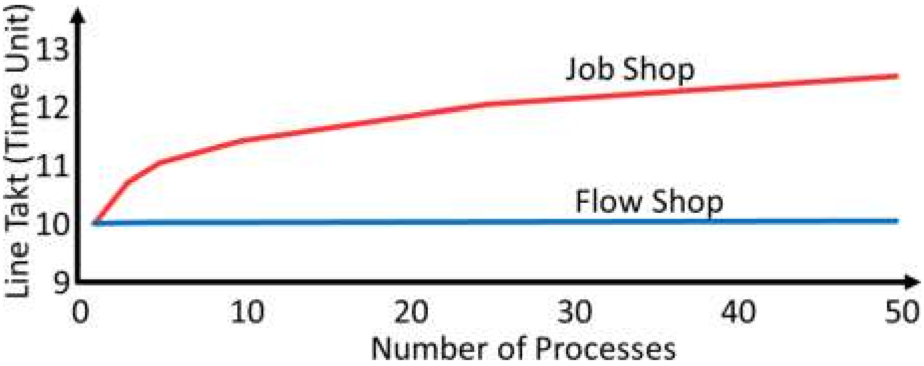


Figure 175: Job Shop Flow Shop Takt (Image Roser)

Overall, the flow shop is able to produce goods at a faster rate than the job shop. In fact, for the flow shop the number of processes made only a marginal difference, and the increase in the takt and the decrease in utilization is extremely small. Of course, in reality your system may not behave as nicely as our simulation, but even then I am confident that a flow shop will perform better than a similar job shop.

24.3 Inventory and Lead Time

We also looked at the inventory in the system and the closely related lead time for a part to pass through the system. Here, too, the flow shop performed much better. The graphs below show the total inventory in the system for different number of processes. To make the flow shop and the job shop as comparable as possible, we used identical buffer sizes. These buffers decouple fluctuations from the processes (for flow shops and job shops) and differences in the process sequence 8 (for job shops only).

However, the first buffer in the flow shop does not bring any benefit for the system. Since we have an unlimited supply, the first buffer in the flow shop will always be full. Removing the buffer would reduce the inventory by 10 pieces and similarly reduce the lead time. To show a full picture the graph below shows the inventory in the flow shop both with and without the first buffer. if you include the first buffer, the flow shop inventory is always 10 pieces larger.

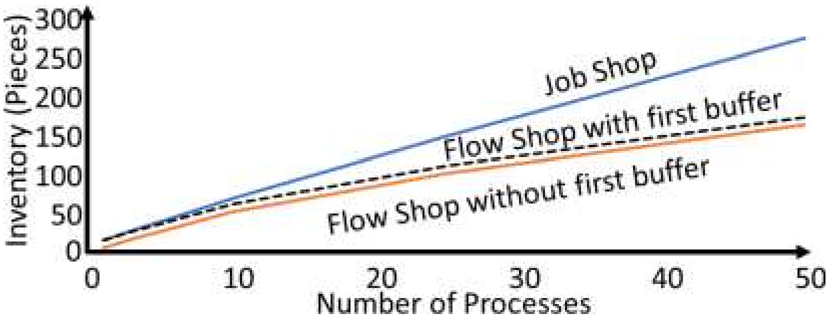


Figure 176: Job Shop Flow Shop Inventory (Image Roser)

Based on the inventory and the takt time, we can use [Little's law](#) to calculate the lead time. This is shown below. Similarly to the inventory, we display the flow shop both with and without the first buffer. Since the first buffer always has 10 parts, the difference will always be exactly 10 takt times.

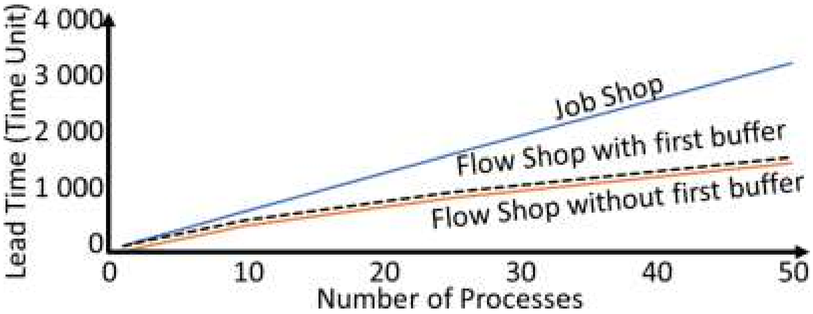


Figure 177: Job Shop Flow Shop Lead Time (Image Roser)

The inventory and the lead time are much better for the flow shop than the job shop. If we exclude the first buffer, both the lead time and the inventory of the flow shop are roughly half that of the job shop. This is a significant difference. **You can reduce your lead time by half if you switch from a job shop to a flow shop** (at least in theory)!

24.4 Other Effects

Figure 178: Confused Worker (Image SeventyFour with permission)

Again, I tried to keep the systems as similar as possible. This is also based only on a computer simulation. In reality, you will have more differences. Some of these effects will reduce the difference between flow shops and job shops. For example, your routing may not be as perfectly random as in this simulation. Other effects, however, will make the job shop even worse than the flow shop. For example, a job shop is almost always more difficult to understand and to manage, and in reality you may have to search for parts for the job or search for jobs for the workers. There will be much more friction and mistakes, and hence losses just in knowing what to do where and when. A flow shop will have much fewer problems of this type. See my post on Why Are Job Shops Always Such a Chaotic Mess? for a longer rant about job shops. But overall, I hope that I motivated you toward using flow shops. Now, **go out,** turn your job shop into a flow shop **to gain gargantuan benefits, and organize your Industry!**

24.5 Source

Daniel Ballach; "*Simulation und Gegenüberstellung verrichtungs- und flussorientierter Fertigungssysteme*"; Bachelor Thesis, Karlsruhe University of Applied Science, January 1st 2021.

25 Behavior of a Kanban Supermarket

Christoph Roser, June 22, 2021 Original at https://www.allaboutlean.com/behavior-of-a-kanban-supermarket/

Figure 179: Bottles in a Retail Supermarket (Image Roser)

Setting up a kanban system is tricky, especially determining the number of kanban. The kanban formula is at best a rough estimate. It is usually advisable to adjust the number of kanban as the system is running. In general, if you have too much inventory, reduce the number of kanban. If you run out of material – and the cause is a lack of kanban – then increase the number of kanban. However, this general recommendation can be refined a bit by looking at the supermarket inventory. Let me show you how to improve your kanban system by analyzing your supermarket inventory.

This blog post is loosely based on chapter 13.2 of my new book All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production.

25.1 Introduction: A Supermarket Inventory

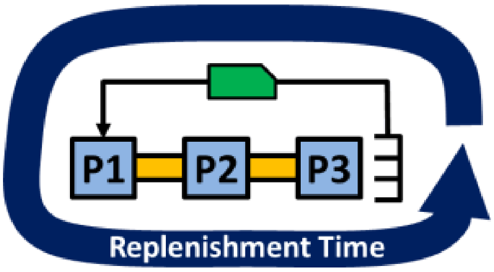


Figure 180: Replenishment Time (Image Roser)

A supermarket is an inventory arranged by product type in FIFO sequence at the end of a kanban loop. If an item leaves the supermarket, a signal (the kanban) is sent back to replenish the material. Depending on the fluctuations of the supply and demand, the inventory in the supermarket fluctuates (this is actually the main reason we have inventory in the supermarket). However, these fluctuations can look very different depending on the behavior of the system. Especially the replenishment time in relation to the fluctuations can make similarly performing systems look very different.

25.2 Supermarket Behavior for a Short Replenishment Time

Below is a timeline of a supermarket inventory for one part type for a system with a short replenishment time. I played around with the system to achieve delivery performances of approximately an excellent 99%, a mediocre 90%, or a bad 80%. The graphs below show a part of the entire timeline, as well as the histogram of the supermarket across the entire simulation. Due to the short replenishment time in comparison with the fluctuations, the timeline touches both the bottom (a stock-out) and the top (the inventory limit, i.e. all kanban in the supermarket) of the graph.

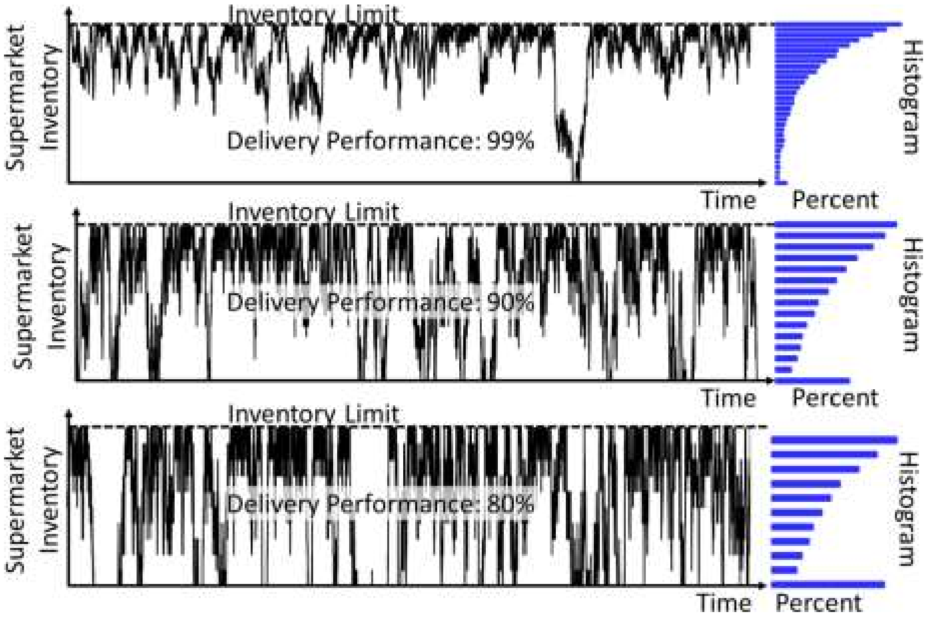


Figure 181: Supermarket Behavior for Short Replenishment Time (Image Roser)

Especially relevant is if the curve touches the bottom and you run out of material. For a delivery performance of 99%, this happens rarely. The first timeline touches the bottom only once. With a delivery performance of 90%, a stock-out is more common. Finally, a delivery performance of only 80% touches the bottom of the graph frequently. This can also be seen in the histograms. Please note that the number of kanban differ, and hence the three histograms are on a different scale. The first graph had a 98.87% delivery performance, and the supermarket was empty for 1.03% of the time (i.e., the bottom most bar in the first histogram is 1.03% of the time). The second simulation had a delivery performance of 91.33%, and the supermarket was empty for 8.55% of the time. Finally, the last simulation had a delivery performance of 80.90%, and the supermarket was empty for 18.93% of the time.

25.3 Supermarket Behavior for a Long Replenishment Time

I also simulated a very similar system, but now with a much longer replenishment time. Hence, most of the time a majority of the kanban were under replenishment. Regardless of the delivery performance, there were never all kanban in the supermarket. In fact, there were never more than half of the kanban in the supermarket, with the other half under replenishment, or “in the pipeline,” if you will. However, similarly to the short replenishment time, the curves touch the bottom line (i.e., zero inventory) occasionally.

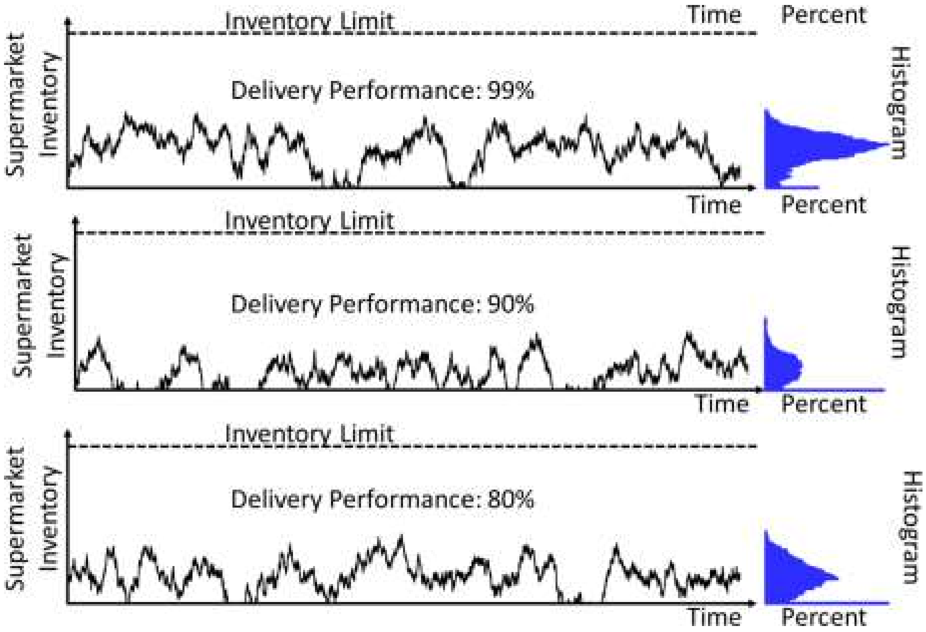


Figure 182: Supermarket Behavior for Long Replenishment Time (Image Roser)

This can also be seen in the histograms. Please note that again the histograms have different scales. Also, since the system with a long replenishment time needs more kanban for the same output, the histograms have many more entries. In any case, the percentage the supermarket was empty also correlates closely with the delivery performance of the system.

25.4 Extreme Supermarket Behavior

Just for comparison, I also simulated systems that had way too many kanban. Below are the timelines for the system with the short and the long replenishment times, as well as the corresponding histograms. Since there were way too many kanban, the supermarket was never empty. On the contrary, the supermarket was always more than half full. The system with the short replenishment time was often completely full (as expected), while the system with the long replenishment time was never completely full (also as expected).

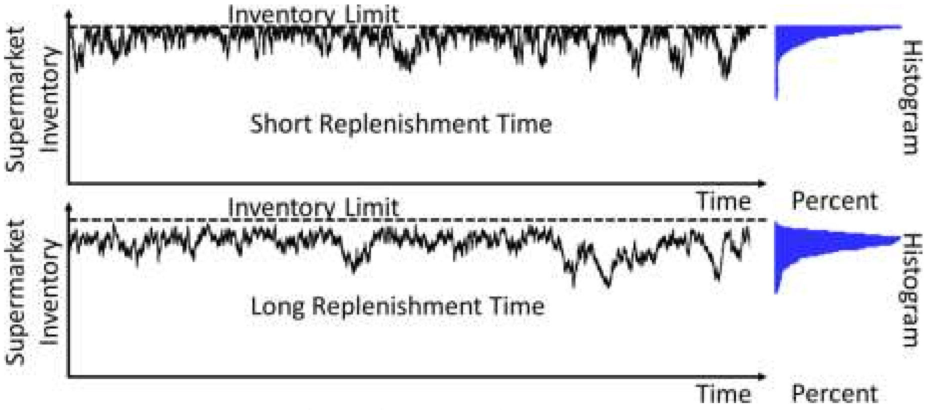


Figure 183: Supermarket Behavior with Excess Inventory (Image Roser)

If your supermarket shows a behavior like that for one part type, then this is a good indication that you have too many kanban. Reducing the number of kanban would not hurt the delivery performance, but improve your inventory cost. For such an extreme case as shown here, you may be able to remove half of all kanban … although to be on the safe side, I would start with removing one-third and then continue to observe before removing more.

25.5 Lack of Capacity Is Not the Fault of Kanban

The behavior of the supermarket and hence delivery performance can be influenced by the number of kanban. The number of kanban is needed to cover fluctuations like breakdowns or swings in customer demand. However, there are also other systematic problems that can affect your supermarket fill levels. The most important one is capacity. If you have and use too much capacity, your inventory in a push system would continue to increase. This is bad. However, since we have a kanban system and hence a pull system, the pull system puts a limit to the increase in inventory. So this side of the capacity problem is covered.

However, the other capacity problem is not having enough capacity. If your system is too small and does not have enough capacity, no amount of kanban will help. Even with enormous kanban quantities, most will be waiting for production (i.e., the bottleneck), and very few will be in the supermarket. Delivery performance will suffer.

Below are the two systems with a short and a long replenishment time, but this time with a demand being much higher than capacity. The supermarkets are empty most of the time. The system with a short replenishment time is full only a few times, but completely empty most of the time. The system with a long replenishment time started out with enough capacity and with almost full supermarkets, but then demand exceeded capacity and the supermarket is getting emptier and emptier until it is almost always empty in the last third of the graph. Again, no amount of kanban will help. You can only increase capacity (or decrease customer demand) to get back to a normal running system.

Figure 184: Supermarket Behavior with Insufficient Capacity (Image Roser)

Overall, the supermarket and especially the histogram of the supermarket give you a good estimate of the behavior of your kanban (or other pull) systems. You can also estimate the delivery performance based on the percentage of the time the supermarket is empty. Now, **go out, take a good look at your supermarket, and organize your industry!**

25.6 Source

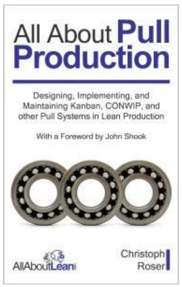


Figure 185: All About Pull Production Ebook Cover (Image Roser)

This blog post is summarized from my latest book on pull production, where you will find many more details on all of these systems and how they can work together. You will also find a foreword by John Shook.

Roser, Christoph. All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production. 441 pages: AllAboutLean.com Publishing 2021.

26 How Much to Adjust the Pull Inventory Limit

Christoph Roser, June 29, 2021 Original at *https://www.allaboutlean.com/how-much-to-adjust-the-pull-inventory-limit/*

Figure 186: Retail Supermarket with Tea (Image Roser)

In my last post I looked at the behavior of the supermarket inventory for different kanban systems. In this post I will use this information to estimate how much the material availability of a system changes if you increase or decrease the inventory limit of your pull system (i.e., number of kanban).

Parts of this blog post are loosely based on chapter 13.2 of my new book All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production.

26.1 Estimating the Delivery Performance using the Supermarket Inventory

Relevant for understanding the performance of a kanban system is an understanding of the supermarket behavior. This behavior is best seen in a histogram. If the supermarket histogram never goes empty, your delivery performance is 100% … and you may even have too many kanban. The image below shows the histograms of three different systems that had a perfect 100% delivery performance, and the supermarket was never empty.

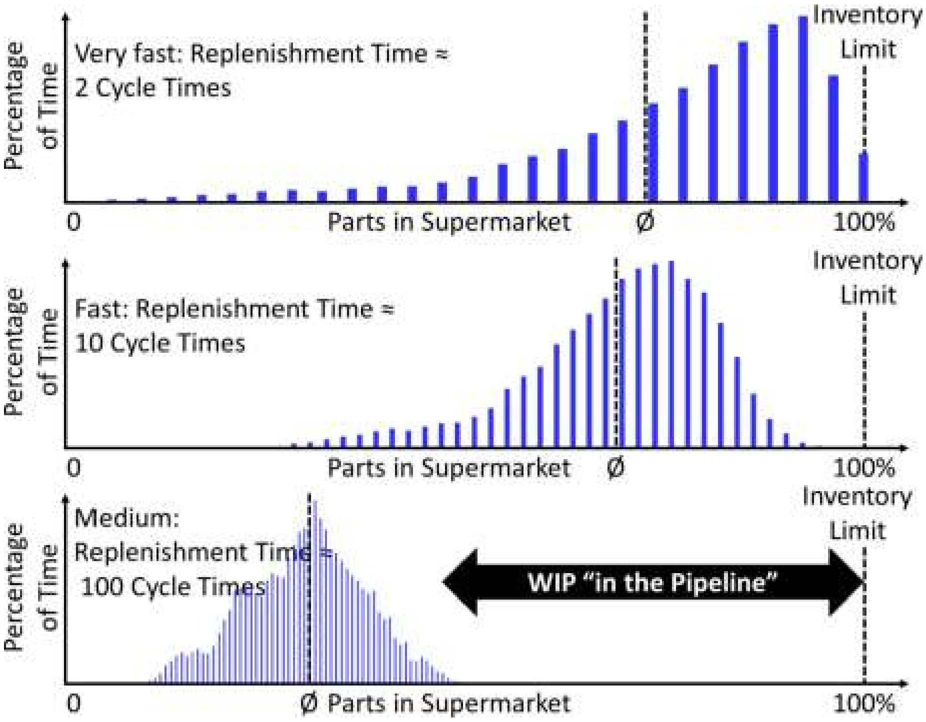


Figure 187: Supermarket Behavior Histogram Different Replenishment Times (Image Roser)

Depending on the duration of the replenishment time in relation to the cycle time, the histograms still look very different. A very fast replenishment time had usually most parts waiting in the supermarket. A much longer replenishment time of 100 cycles usually had only one-third of the parts in the supermarket. Nevertheless, the supermarket never ran empty.

An example histogram of a supermarket that DID run empty is shown below. Relevant for the performance is how often the supermarket is empty. In the example below, the supermarket was empty for 4.95% of the time. The delivery performance was 95.02%, meaning that 95.02% of the customers did not have to wait for their part. This correlates very closely with the percentage that the supermarket was NOT empty of 100% – 4.95% = 95.05%

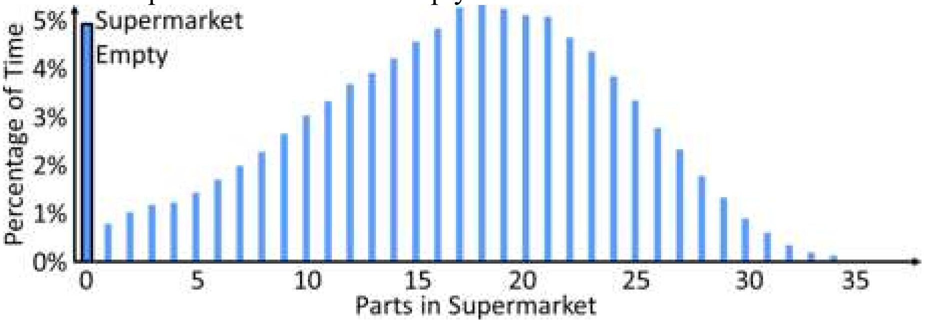


Figure 188: Supermarket Behavior Histogram Example (Image Roser)

This estimate of the delivery performance on the percentage that the supermarket is NOT empty will be the basis for understanding the effect of changing the number of kanban. But first, let's check more carefully. Below is the delivery performance (black line) and the estimated delivery performance (dashed red line) of a kanban system with different number of kanban. The lines overlap almost perfectly. Just to show how small the difference is, the second graph below shows the actual error (i.e., the delta between the actual delivery performance and the estimated delivery performance based on the percentage of the supermarket being NOT empty). This error is very small.

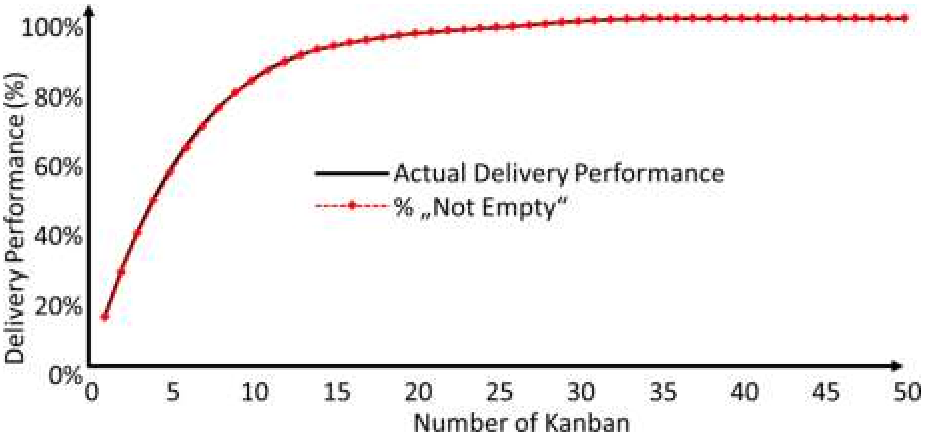


Figure 189: Estimated vs Actual Delivery Performance (Image Roser)

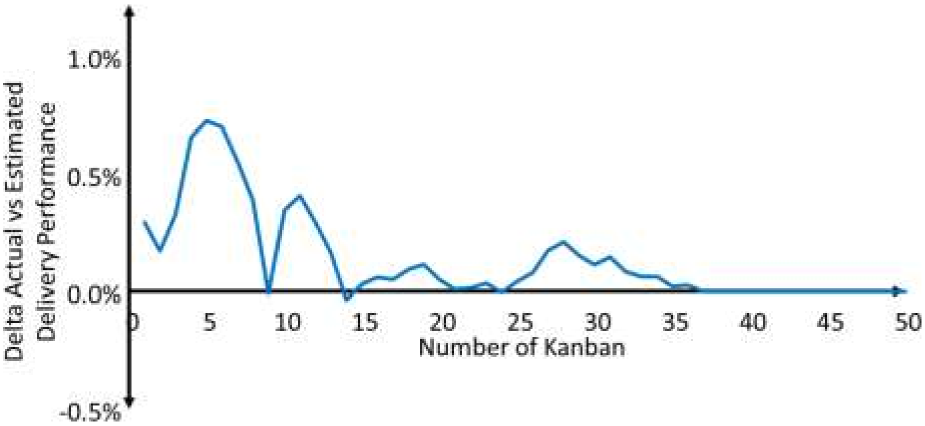


Figure 190: Supermarket Delta Estimated vs Actual Delivery Performance (Image Roser)

Of course, these are simulations. In reality, you will have two effects that reduce this accuracy. First, we try to predict future behavior based on historic data… which has the risk that the future may be somewhat different than the past. Your future system behavior both in demand and supply may be slightly different from in the past, meaning your past predicted delivery performance may be different from the actual future delivery performance, since the actual delivery performance has changed.

Second, you don't just sit idle and watch your supermarket run empty. You take action and try to prevent this! Hence, the closer your supermarket gets to empty, the more likely you (or someone else) will be trying to prevent this from happening. However, even with those two uncertainties, the percentage of the time a supermarket is empty (or not) is a good estimator for the delivery performance.

26.2 Reducing the Number of Kanban

The easier part of the prediction is reducing the number of kanban. The image below shows what happens if you reduce the inventory limit by two pieces, or reduce number of kanban by two if one kanban represents one piece. We add the percentage of the time that the supermarket had exactly one or two parts to the percentage of the time that the supermarket was empty. In this example, the predicted percentage of the time that the supermarket is empty is now 4.95% + 0.79% + 1.02% = 6.76%. This in turn predicts a delivery performance of 100% – 6.76% = 93.24%. The actual measured delivery performance was almost identical of 93.21%.

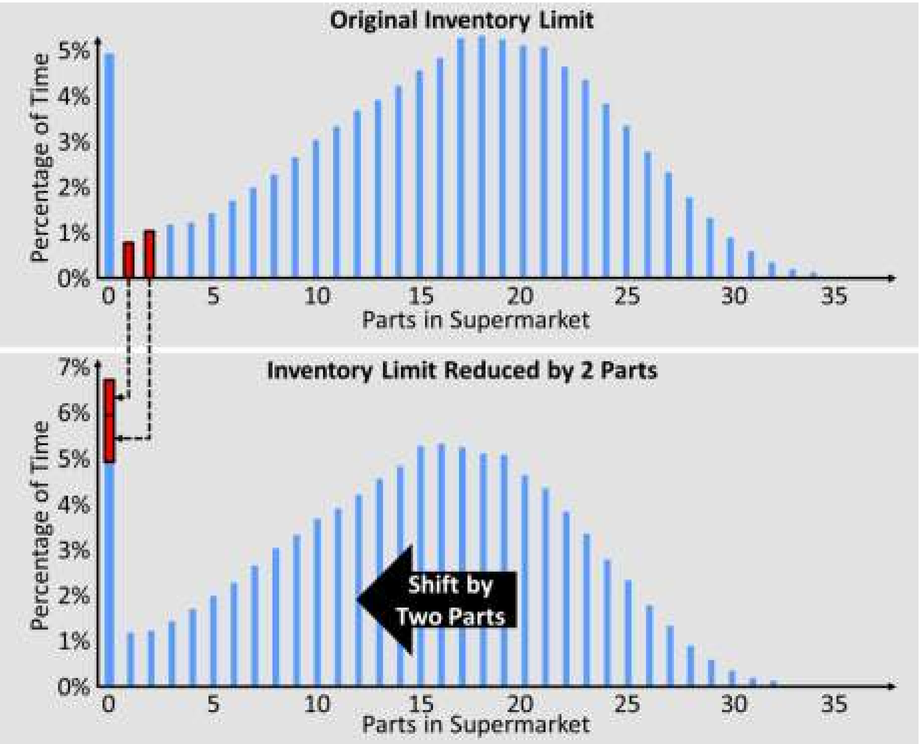


Figure 191: Supermarket Behavior Reducing Kanban (Image Roser)

26.3 Increasing the Number of Kanban

However, reducing the number of kanban makes the delivery performance worse, and usually plants want it the other way around. The more common question on shop floors is "How many kanban do I have to add to achieve a delivery performance of x%?" This can also be estimated with the supermarket histogram, but it is mathematically not quite as easy. You would have to estimate how the histogram would continue if you move it away from zero parts. You could use mathematical curve fitting, which is exciting but not easy. An easier and practically still *good enough* approach is to simply eyeball the curve. This is shown in the example below.

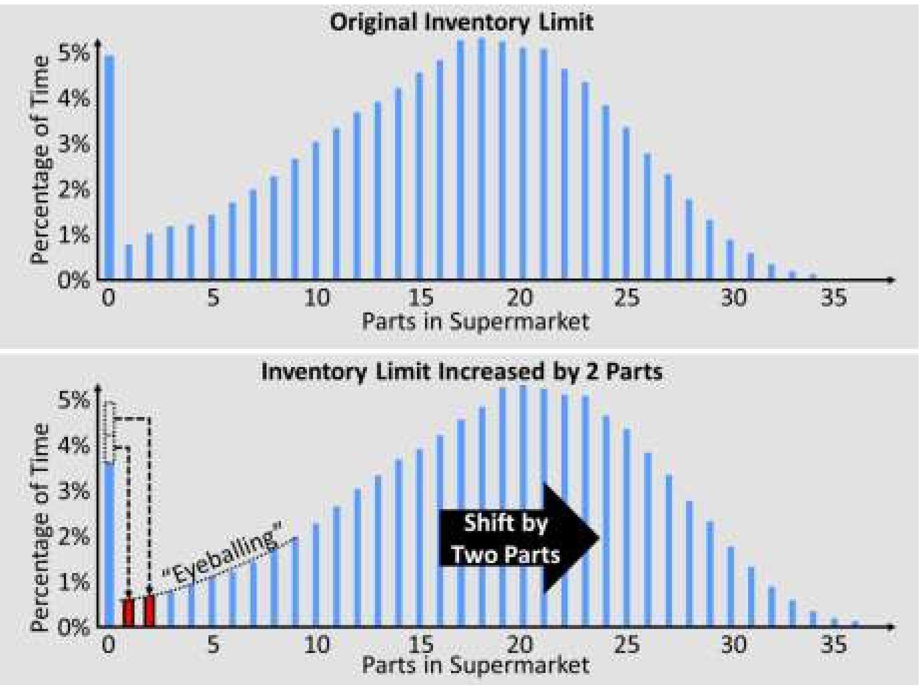


Figure 192: Supermarket Behavior Increasing Kanban (Image Roser)

The number of kanban was increased by two. I eyeballed that, with two more parts, there will be exactly two parts in the supermarket for 0.7% of the time, and exactly one part for 0.65% of the time, with everything else being shifted two parts to the right. Hence, with two more parts 0.7% + 0.65% = 1.35% of the additional time, the supermarket will no longer be empty. This reduces the percentage of the time the supermarket is empty from 4.95% to roughly 3.6%. This would correspond to a delivery performance of 100 – 3.6% = 96.4%. The actual simulated delivery performance was 96.46%, which again is very close.

26.4 Summary

Overall, the histogram of the supermarket tells you not only how your kanban system performs, but also how it will probably perform if you increase or decrease the inventory limit (i.e., increase or decrease the number of kanban). Like all such estimations, the bigger your change is, the more your prediction will be off. Hence, check again after you change the inventory limit or the number of kanban if the system performs as expected, and adjust if necessary. Now, **go out, take a close look at your supermarket, see if you need to adjust the number of kanban, and organize your industry!**

26.5 Source

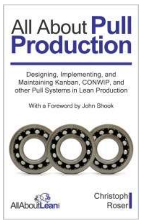


Figure 193: All About Pull Production Ebook Cover (Image Roser)

This blog post is based on my latest book on pull production, where you will find many more details on all of these systems and how they can work together. You will also find a foreword by John Shook.

Roser, Christoph. All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production. 441 pages: AllAboutLean.com Publishing 2021.

27 Standards Part 1: What Are Standards?

Christoph Roser, July 6, 2021 Original at https://www.allaboutlean.com/standards-1-definition/

Figure 194: Illustration for Standard 4 (Image Murrstock with permission)

Standards. You know they are important for manufacturing. You know Toyota and hence lean uses them extensively. But you may also know that they are not easy. I was thinking about writing a few blog posts on standards for a long time, but… it is a challenging topic. Let me give you my thoughts on standards and how to use them in lean manufacturing. But before going deeper into the use of standards over a few blog posts, I'll provide a quick introduction on standards.

27.1 Introduction

Figure 195: Power Outlets (Image various authors in public domain)

According to the dictionary, standards are "something established by authority, custom, or general consent as a model or example." Standards make all kinds of things a lot easier, cheaper, and safer, often without the end user even knowing the standard. Imagine if there were no standards for power outlets. And I don't just mean different standards that you see when you travel internationally. You would have to fiddle around with wires to connect to an unknown voltage, hoping that it works for your device. This is somewhere between annoying and deadly. No wonder the electricity grid was standardized early in the 20th century… albeit different countries use different standards, or even different standards within the country (Eastern Japan has 110V at 50Hz and Western Japan has 110V at 60hz, leading to blackouts after the 2011 Tōhoku earthquake and tsunami, where the west had enough electricity but couldn't get it into the eastern network).

27.2 Types of Standards

27.2.1 Range

Figure 196: Metric screws: A worldwide part standard (Image Roser)

Standards may have different ranges where they are valid. There are, for example, international standards that are used **worldwide**. The metric screw standard is one such example (and yes, you can get them even in America, even though the unified thread standard is more common). Since these are so common and need to be interchangeable, the same standard may be used all over the world, and could be called a norm. Other standards are used only within a **country or region**, or within one **company**, within a **plant**, or may apply to only one machine or **process** in the company. For example, if your company has a press, there may be a standard on how to change the tools. This standard may apply to only a single press in one plant of one company.

27.2.2 Enforcement

Figure 197: Pick your screw thread standard… (Image Roser)

Standards could be **mandatory**. For example, your car has a lot of safety features that are legally required. Other standards are optional, and if you don't like metric screws, you can opt for a Whitworth or unified thread standard, or even make your own. Hence, this is **optional**. Although, using a metric screw would be also **sensible** (except the US, of course). However, later when we dig deeper into standards in lean manufacturing, I will strongly advise against "optional" standards. If you create a standard in your plant, then this standard should be followed, even if it is only within your plant, or even a single machine in your plant. If you make a standard in your plant but make it optional, then you would not have needed to bother with a standard in the first place…

27.2.3 Application

Figure 198: Danly press at Toyota (Image Roser)

There are also different applications of standards. Some are standards for **parts**. Take again the example of the standard metric screw (a standard for a part). The standard defines the geometry of the thread. The screw pictured here would be ISO (International Organization for Standardization) 3014 standard for a hex head screw with a shaft, using a metric M12 thread based on ISO 261, made from steel with 8.8 strength according to ISO 898, and galvanically coated with zinc which could be ISO 14713 (although I am not sure on the last one). For more complex machinery, the function can also be standardized. For example, your car headlight has standardized tolerances on how bright it can be or what color it can be. In Europe this is regulated in the ECE R48 (where UNECE stands for United Nations Economic Commission for Europe but is usually shortened to ECE).

Figure 199: Standards for manual work (Image The Light Writer 33 with permission)

Other standards are for processes, where not the product is standardized, but the use of a product, tool, or machine. Here I would like to distinguish between processes done by a machine and processes done by humans. **Machine processes** are, for example, settings for machines. You may have a standard for the temperature, pressure, and speed for your injection molding machine if you use a certain type of polymer with a certain mold. Finally, there are **manual processes**, where humans handle a product, tool, or machine. For example, the sequence of steps to change a press tool could be standardized as part of a SMED changeover optimization. This is actually the focus of the subsequent posts since this is often trickiest to implement. It is easier to standardize the shape of the speed limit sign than to have the human drivers actually follow the speed limit.

Figure 200: Standard work for assembly lines (Image Siyuwj under the CC-BY-SA 3.0 license)

A lot of lean literature focuses in particular on the standards for manufacturing or assembly work. This is called standard work, or slightly better **standardized work**. With standardized work, you set up the standards for the different workstations so they can match the customer takt time. I have written quite a bit related to this in my series on Toyota Standard Work, but I will add a bit more in this series. Standardized work is differently from a **work standard**. A work standard tells you how to do a certain task. Standard work is an approach to fit the tasks into a customer takt time. However, these two are often confused, and I have to admit that I sometimes mix up these two terms too. In any case, standard work and work standard is very similar.

There is also the term **leader standard work**, albeit it is much fuzzier. In general, it is a standard on how the leader (i.e., the manager, supervisor, etc.) has to do his work.

Of course, there can also be a combination of part, machine processes, or manual processes in the same standard. The operator has to use a M12 screw when changing the press tools and set the machine to certain process parameters.

27.2.4 Range of Actions

Figure 201: SCANIA Screws Torque Measure (Image Roser)

There are more ways to distinguish standards. A standard could tell you **exactly what to** do. For example, you must install the part in one certain orientation. A standard could also tell you **exactly what NOT to do**. Do not touch the 220 volt contacts! Finally, standards can give you a **permissible (or forbidden) range** or a tolerance. For example, the screw needs to be tightened with a moment between 30 and 42 Nm. Or your car must not be loaded with more than 550 kg.

Overall, there are many different types and uses of standards. In its basics, a standard is a set of rules that the people agree to always use. In my next post I will discuss in more detail why and where to do standards. Now, **go out, look at your problems and possible standards to counter them, and organize your industry!**

28 Standards Part 2: Why and Where to Do Standards

Christoph Roser, July 13, 2021 Original at [*https://www.allaboutlean.com/standards-2-why-and-where/*](https://www.allaboutlean.com/standards-2-why-and-where/)

Figure 202: Illustration for Standard 5 (Image Wrightstudio with permission)

Standards are crucial to making your manufacturing system work smoothly. But where should you have standards? Sometimes you hear the answer, “Everywhere,” but this is not really helpful and I also think not really correct, either. Hence, let me talk a bit on why and where to have standards. This applies to all kinds of standards, not just the standardized work that is the most widely discussed one when talking about standards in lean.

28.1 Why Do We Have Standards?

Figure 203: ISO 9001 certified workplace (Image Chris 73 under the CC-BY-SA 3.0 license)

Standards serve a very clear purpose. They aim to make a process or product more uniform and better. Ideally, every single item produced or every single task done is identical to the previous item or task. Additionally, the item or task is better than before. This could be related to the four main goals in manufacturing, which are safety, cost, quality, and delivery time. A standard aims to improve at least one of these four, often more.

In mathematical language, we aim to **reduce the variability** of a measurement while at the same time **improving the average** of our measurement. For example, for a work standard we want to **figure out a better way to do it, and then have all workers do it consistently in this better way**. Please note that I did not write “the best possible way,” as that is impossible. A core philosophy in lean is continuous improvement (kaizen), and hence you can never reach perfection, but should continually strive for it. If there would be a a perfect standard, then there would never ever be the need to improve it… which I just don’t believe.

For standards of manual work, this can also be expressed in a different, more functional way. There are two reasons to use a standard:

To make sure the worker doesn’t make a mistake or forget a step.
To allow managers to verify the correct use of the standard.

Please note that **a standard does not replace the training of the workers!** Even with a very good standard, proper training both in theory and on-the-job is important for a worker to do a job properly. Naturally, the standard can be incorporated into the training, but it is not a substitute. Later on, the standard only helps the worker to not forget an important step.

28.2 Where to Have Standards?

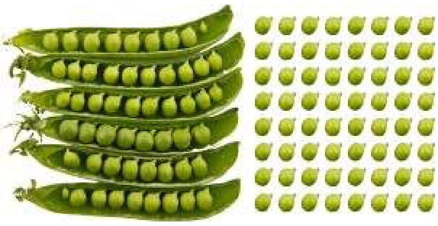


Figure 204: Should you sort your peas? (Image Bill Ebbesen under the CC-BY-SA 3.0 license)

The next question is: Where should you have standards? Some people just like standards. They like to dot the i’s and cross the t’s, they like to count their beans individually, and they do it just because it is aesthetically pleasing. And since they want everything to be nice, they apply standards everywhere, down to the color of the underwear. I am not kidding. Many Japanese schools have a standard for the color of the underwear of their students (white, of course), and yes, they do inspect! Yikes! Cringe! Shudder! Also: Why???

To get to the point, **just because you can have a standard does not mean that you should have a standard**.

Figure 205: Standards are for improvement! (Image PixelsAway with permission)

Standards have a clear purpose, and that is NOT related to the aesthetically pleasing features of undergarment. **A standard is for improvement!** You should use a standard only if you want to improve something. If there is no need to improve, then there is no need to implement or change a standard. Hence, like almost everything in lean, **you must start with a problem**, or in some cases a **foreseeable problem** if you don’t have a standard or an **improvement potential**. And not just any problem or potential, but a relevant problem. Implementing or improving a standard is an effort, and you should try to get the most out of this effort. Hence, **do not set out to create a standard. Set out to improve a process**, which leads (often) to the creation of a standard.

However, please note that this includes situations where it is obvious that without a good standard there will be major problems soon. If you install a new assembly line, you better do a standardized work for the operators before it becomes a mess. If you buy potentially dangerous equipment, make a standard for safety before the first person gets injured or dies.

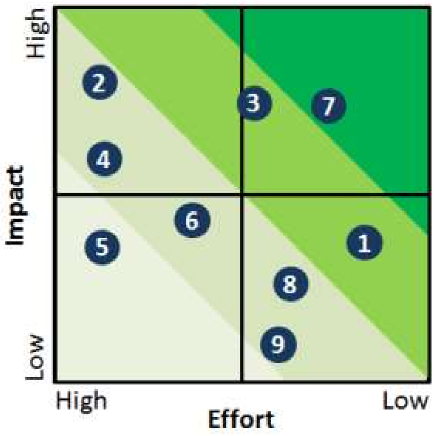


Figure 206: Impact effort matrix (Image Roser)

In lean literature it is often said that the problem to address and the standard to implement should be aligned with the company principles, or the Hoshin Kanri. This is true, but there are also often smaller changes or adjustments that are much less effort. If a quick fix makes it a little bit better, I may just do it, even though it may not be the most important problem the company is facing. If I have to pick a problem among many different possible issues, I do a impact effort matrix. I try to identify the problem with the biggest bang for the buck, even if it is only a small "bang" but for a small" buck."

But again, focus on your problems! Pick your battles! The problem solving and the standard must aim to make your company better. It must **improve either safety, cost, quality, or delivery time** (or a combination thereof).

Even if you encounter a problem that you want to address, it does not automatically lead to the creation of a standard. After you **pick a problem to solve**, **check if there is already a standard** that is applicable. If not, you may have to **create a standard**. Please note that when I say "create a standard" or "improve a standard," this implies a lot of other activities. It is not only writing down how it is supposed to be, but it is primarily a problem-solving process, where the creation or updating of a standard is one of the later steps. More on this in the next post.

Figure 207: I found your Scapegoat (Image Лобачев Владимир in public domain)

If there is a standard, **check if the standard was followed**. If so, you may have to update or improve the standard. If it was not followed, **would the standard have worked?** Make sure to ask the operators about their opinion before deciding if the standard would have been good enough. Especially if it is a standard primarily created by management (not good in the first place), the tendency is to blame the operators (even worse), even though it is the standard that was simply not good enough. Unfortunately the culture in many companies is, if there is a problem, they first look for somebody to blame. Put your energy into problem solving, not into blaming others.

Anyway, if the problem was caused by a flawed standard, then the **standard has to be improved**. If the standard was good, but was used incorrectly, then you may have to **train and educate your workforce** in the use of the standard. This may also include topics like motivation and verification of the correct use of the standard. It could also mean to enforce the standard, but try not to merely pile pressure on the operators if they don't follow the standard.

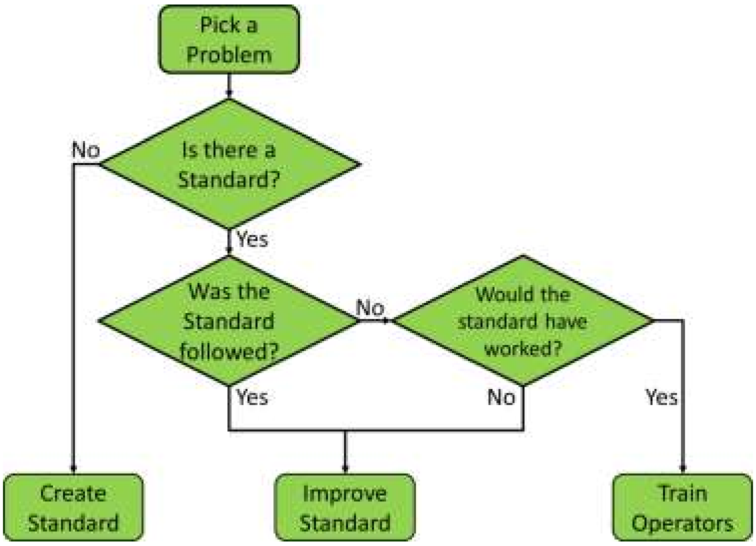


Figure 208: Problem Solving Standard Sequence (Image Roser)

Using this approach to use standards as part of the problem-solving tool, Toyota even standardized their standardization approach. Standards are one of the key parts of improvement. As Taiichi Ohno has said, “Where there is no standard, there can be no kaizen.” It is much better to have a few good standards than many inferior standards. Quality before quantity! In my next post I will talk in more detail on how to create a standard. Until then, stay tuned, and **go out and organize your industry!**

29 Standards Part 3: How to Write a Standard

Christoph Roser, July 20, 2021 Original at https://www.allaboutlean.com/standards-3-how-to-write/

Figure 209: Illustration for Standard 2 (Image Wrightstudio with permission)

Standards are the result of problem solving. In this article I will talk more about how to write a standard, but this is the outcome or the last steps of the problem-solving process. From this post onward I will look more at work standards, although the following is applicable to a lesser extent to part standards. Again, a standard is not something done on its own, but is part of a problem-solving process.

29.1 It's All About Problem Solving!

Figure 210: Problem & Solution (Image Kenishirotie with permission)

A standard should not be done on its own. This would have the risk of creating a standard for the sake of having a standard, which is useless. Instead, a standard is the result of a problem-solving process. **You must start by selecting a problem you want to solve!** This could also be a **foreseeable** problem if you don't have a standard, or an improvement potential that brings you other benefits.

Hence, the whole thing starts with a problem-solving process. Without going into too much detail, here is a brief overview of possible steps you can do. The links go to blog posts of mine with more details.

- Select a problem that is relevant and gives a good benefit for the invested effort.
- If applicable, create a team for the problem solving, including some people who later have to use the standard, and set up a workshop or on-site meeting (Gemba!).
- Start an A3 report. This will guide you through the problem-solving process. The following points are part of the A3 process:
- Analyze the current state and understand the problem.
- Define a goal.
- Do a root cause analysis to understand what causes the problem.
- Develop a solution, or – even better – multiple solutions and select the best one.
- Implement the solution, including preparation, timeline, etc. if needed.
- Check if a) the solution works, and b) you have reached your goal.
- If your goal has not yet been reached, understand why and continue to improve until you have achieved the goal. This would be the Check and Act of Plan-Do-Check-Act (PDCA), and failing to do so is in my view the primary reason for a failed lean project.

Figure 211: PDCA Circle (Image Roser)

Only when you get to the end of this whole problem-solving process can you start to think about writing a standard. To be fair, the problem solving does not have to be fully completed, and you can already start writing the standard before you are done with the Check and Act of the PDCA; although in this case you have to update your standard if you update your solution. In general, there are two possibilities:

- If you start to **write your standard during the "Do" part of the PDCA**, then changes during the Check and Act need to be reflected in the standard.
- If you **write your standard after the PDCA is completed successfully**, you have to do a separate "Check" and "Act" for the standard to see if the standard is workable and actually describes your working solution well.

Figure 212: Let's start writing! (Image BRAD with permission)

Both are possible, but I have a slight preference to already start writing the standard toward the end of the "Do" phase of the PDCA, but either way works. Now, let's go into more detail on how to actually write the standard. There are a couple of points when writing a standard. Below are the first three, more in the next post of this series.

29.2 A Standard Is for Tasks or Items That Are Used Repeatedly

Figure 213: An assembly line usually is highly repetitive (Image The Light Writer 33 with permission)

Standards are useful only if you use them more than once. If you do something only once, then there is no point in writing a standard. Luckily, pretty much all things in industry have at least some repeating elements. This is what you can standardize. If you produce custom injection molding tools, you do not write a standard specifically for a certain tool that you produce only once. However, you can write a standard about the general development process, or using certain milling machine specifications matching different mold materials, etc. Just as a side note, of course you can and sometimes even should write down what you did only once, but this a documentation, not a standard.

29.3 A Standard Should Find a Balance between Too Much and Too Little Detail

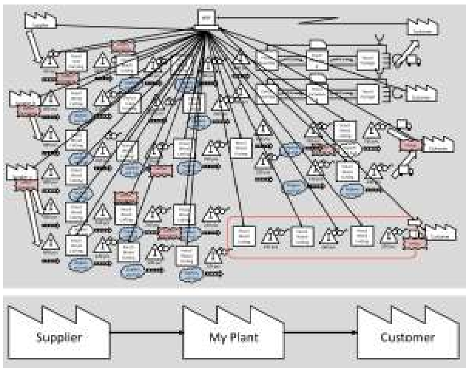


Figure 214: Too Much or Too Little Detail VSM (Image Roser)

This is for two reasons. One is to **provide the user of the standard with the necessary details while not overloading him with data garbage**. The second one is to **find a balance between the effort of making a standard and the benefit of having a standard**. This is related to the frequency of the repetition. If you make the same part every 60 seconds, it may be worthwhile to write down the actions in great detail. I have used standards that detailed, in intervals of less than 10 seconds, what the right hand should do and also what the left hand should do, plus occasionally an eye or foot movement. This was possible because the work was also optimized on this level of detail. Again, this makes sense if you do the work very, VERY often. If you repeat the work less frequently, the standard has a much coarser guidance. If you produce one molding machine per week, you probably would not write down the actions for the left hand and the right hand for every worker in five-second intervals, but the standard could look more like a checklist and may not even have a time schedule.

29.4 A Standard Must Be Easy to Understand

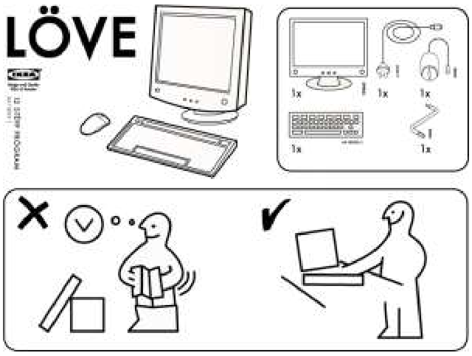
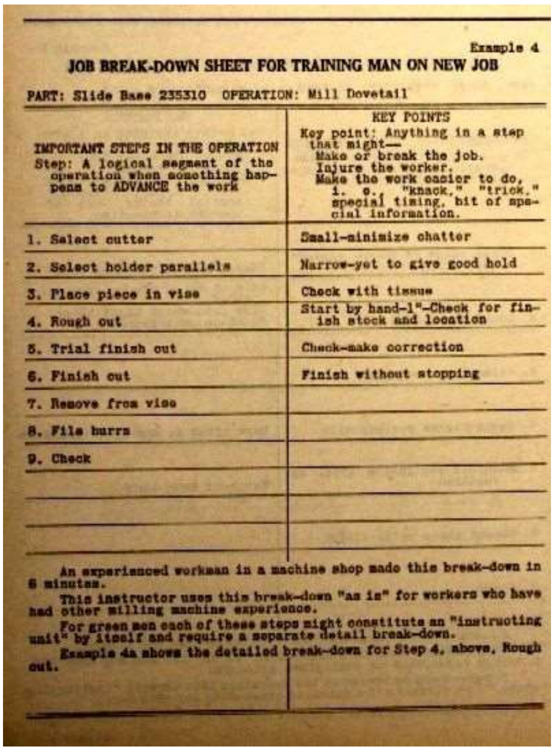


Figure 215: Ikea Löve Parody (Image Ola Einang under the CC-BY-SA 2.0 license)

This is obvious, and also somewhat depends on the balance between too little and too much detail above. The standard is a written document (or sometimes an Ikea-style cartoon depending on the literacy and language abilities in your plant) that should describe the standard. Especially for work instructions it helps to have photos, other images, and diagrams. It can also benefit from visual management highlighting key aspects of the work. If you managed to include poka yoke (mistake proofing) in your problem solution, it will simplify your standard. Anything that can be done only one way by design does not need an explanation in the standard on the different ways it could have been done.

In general, it should outline the key steps of the work. But it should also go into more detail of key points. Below is an older standard from TWI for milling a dovetail. Notice the basic steps and the key points for some of them. Nowadays this could also include images and (very important for standardized work) the duration needed to do these steps.



Example 4

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Slide Base 235310 OPERATION: Mill Dovetail

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	KEY POINTS Key point: Anything in a step that might— Make or break the job. Injure the worker. Make the work easier to do, i. e., "knack," "trick," special timing, bit of special information.
1. Select cutter	Small-minimize chatter
2. Select holder parallels	Narrow-yet to give good hold
3. Place piece in vise	Check with tissue
4. Rough out	Start by hand-1"-Check for finish stock and location
5. Trial finish cut	Check-make correction
6. Finish cut	Finish without stopping
7. Remove from vise	
8. File burrs	
9. Check	

An experienced workman in a machine shop made this break-down in 6 minutes.

This instructor uses this break-down "as is" for workers who have had other milling machine experience.

For green men each of these steps might constitute an "instructing unit" by itself and require a separate detail break-down.

Example 4a shows the detailed break-down for Step 4, above, Rough out.

Figure 216: TWI Mill Dovetail Instructions (Image unknown author in public domain)

These are the first few points on writing a standard, but there are more. I will continue this in my next post before also talking about how to improve a standard, and will eventually look deeper at the all popular standardized work for assembly or manufacturing operations. Now, **go out, polish your standards a bit more, and organize your industry!**

30 Standards Part 4: How to Write a Standard (Continued)

Christoph Roser, July 27, 2021 Original at https://www.allaboutlean.com/standards-4-how-to-write-ctd/

Figure 217: Illustration for Standard 1 (Image Wrightstudio with permission)

Standards are one of the cornerstones of modern manufacturing. However, they are not easy to write, and a bad standard can make things even worse than before. In my previous post I started to introduce how to write a standard. This post continues the topic of writing a standard with a few more tips.

30.1 A Standard Should Not Have Options

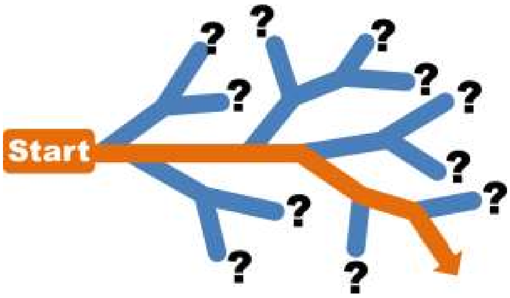


Figure 218: Too many Options (Image Roser)

This is related to the point from the previous post of making a standard easy to understand. If your standard has options like "If situation A then do x, if situation B then do Y," then it makes the standard more complicated. You cannot always avoid such *if-then* clauses or similar branching in the flow of work, but the fewer you have the better. Especially for standard work (i.e., assembly or manufacturing) any branches will be *mura* (unevenness) and will cause the cycle time to fluctuate. Unfortunately, you can't always avoid such branching options, especially if it is not assembly or manufacturing work, but do try to keep them in check. The fewer options the better.

30.2 Involve the Employees

Figure 219: Ask us! (Image Cherie A. Thurlby in public domain)

I mentioned this in my last post when setting up an improvement team (and I will mention it again further down during testing if the standard actually works). When creating the standard, actively involve the employees. Depending on how you do the actual writing (Excel, specialized software, pen and paper, etc.), it may be easier for one person to do the typing, but the workers on the team should be continuously updated. This helps to improve the standard, because the workers will usually quickly catch anything that could cause problems or won't work.

The standard should be written by a person as close to the process as possible but that can still create structured written documents. But it must also involve the people even closer to the process, even if they can't write.

30.3 Don't Forget the Organizational Header

The key part of a standard, especially a work standard, is the actual instructions on how to do the work. But there is also some organizational framework around it. The standard should have somewhere (usually in a header) some of the following elements:

- **Title**: What is the standard called.
- **Area of the Standard**: Which department does the standard belong to, and which part or machine is the standard used for.
- **Version Number and Date**: Standards are (ideally) often updated as part of the continuous improvement process. You need to keep track of which version of the standard it is. If you visit an unfamiliar shop floor, the date on a standard also gives you an indication on how active the improvement process is on this particular shop floor.
- **Index Number**: Especially if you manage your standards with a central database, the standard should have an unique number (including the version) that the database can reference to.
- **Responsible**: The person or persons responsible for the standard should be named. This could even have multiple names for "prepared," "confirmed," and "approved" or similar including dates of the preparation/confirmation/approval.

In general, try to use similar headers for your standards. If you have too many different formats, it can be come confusing for the users.

30.4 Test and Improve the Standard before Implementation

Figure 220: PDCA Circle (Image Roser)

You have written your standard… or the first draft thereof. Next is the check if the standard actually works. This is very important. This is the "Check" part of the PDCA. Give the standard to the people that actually use them later on, and have them try it out. It is especially helpful if it is an experienced person who knows the process well, and double especially helpful if that person was involved in the creation of the standard.

Figure 221: Testing of a machine (Image shisuka with permission)

Ideally you should try out the standard a few times. How often depends on the situation, in particular on the duration of the standard. If it is an assembly line with a part being completed every 60 seconds, then you could easily try 15, 30, or even more times. If it is a standard for a changeover workshop that happens only 10 times per year, you may get away with only one try. The more often you try during this testing of the standard, the fewer hiccups your standard will have and the easier it will be to use the standard.

When trying out the standard, take notes on what works and what either does not work at all or feels wrong. These are the items that would need to be looked at and hopefully improved before the standard is released. In a few lucky cases, you may not find anything at all. However, chances are that you will find some issues that either must or should to be fixed before the standard is widely adopted. Effectively, you may have multiple PDCA loops before the standard is working as flawless as you can manage. It is the responsibility of the person issuing the standard to provide the users with a good working standard. Any sloppiness during the creation of the standard will cause much bigger problems later on during the use of the standard.

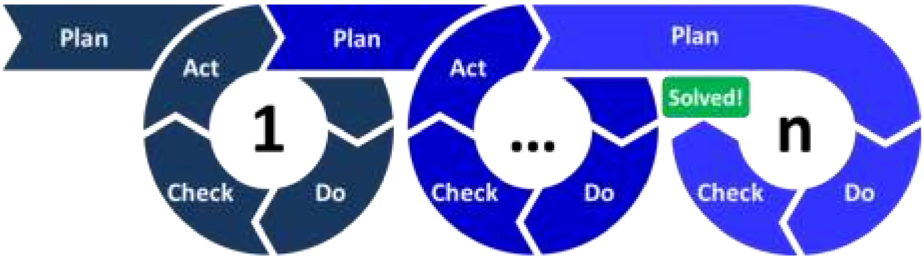


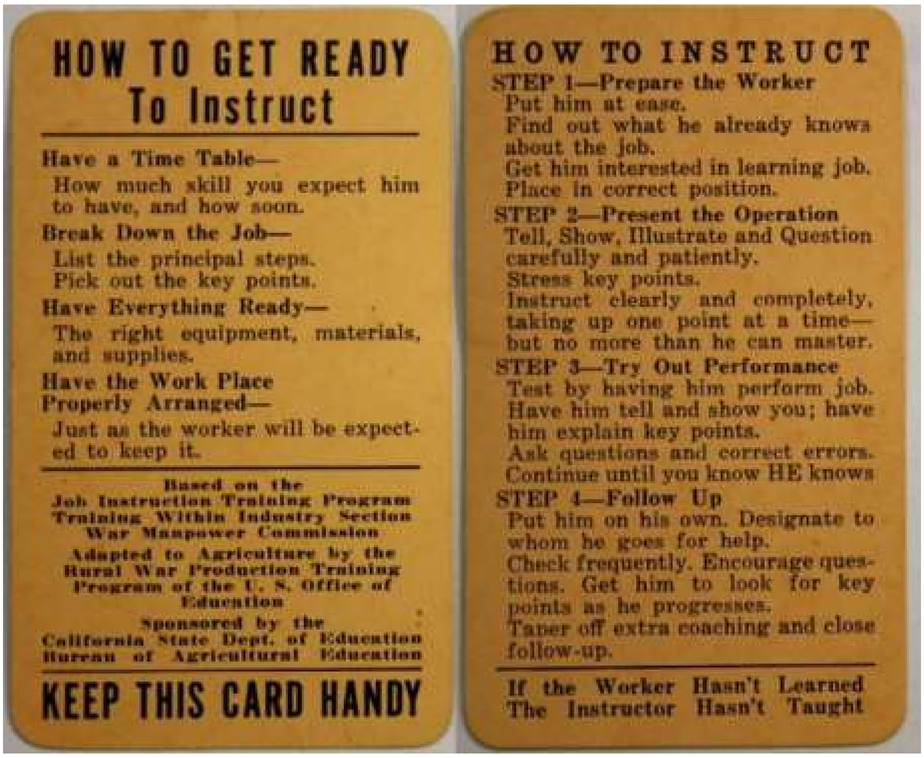
Figure 222: PDCA Circle Sequence (Image Roser)

30.5 Teach the Standard to Your People

Figure 223: Student working (Image auremar with permission)

Once you are certain that the standard is good, the standard can be rolled out for general use. The main part here is to teach the workers in the use of the standard. This follows the common approach for training. It also depends how well the operators know the work already. If the workers know the work well and the new standard is only a few minor modifications, explain the new standard to them and also why there are changes, before having them try it out a few times.

If the worker is new to the standard and has to be trained completely in the use of the standard, then I find the Training within Industry Job Instructions very helpful. The card below is the summary of the four steps on how to instruct people in their job.



HOW TO GET READY
To Instruct

Have a Time Table—
How much skill you expect him to have, and how soon.

Break Down the Job—
List the principal steps.
Pick out the key points.

Have Everything Ready—
The right equipment, materials, and supplies.

Have the Work Place Properly Arranged—
Just as the worker will be expected to keep it.

Based on the
Job Instruction Training Program
Training Within Industry Section
War Manpower Commission

Adapted to Agriculture by the
Rural War Production Training
Program of the U. S. Office of
Education

Sponsored by the
California State Dept. of Education
Bureau of Agricultural Education

KEEP THIS CARD HANDY

HOW TO INSTRUCT

STEP 1—Prepare the Worker
Put him at ease.
Find out what he already knows about the job.
Get him interested in learning job.
Place in correct position.

STEP 2—Present the Operation
Tell, Show, Illustrate and Question carefully and patiently.
Stress key points.
Instruct clearly and completely, taking up one point at a time—but no more than he can master.

STEP 3—Try Out Performance
Test by having him perform job.
Have him tell and show you; have him explain key points.
Ask questions and correct errors.
Continue until you know HE knows

STEP 4—Follow Up
Put him on his own. Designate to whom he goes for help.
Check frequently. Encourage questions. Get him to look for key points as he progresses.
Taper off extra coaching and close follow-up.

**If the Worker Hasn't Learned
The Instructor Hasn't Taught**

Figure 224: JI Card (Image War Manpower Commission in public domain)

Like any training, it may involve some documentation of who is trained and in what, or an update to the skills matrix. In any case, do not forget to verify at a later time that the workers actually follow the standard. In my next post I will look in more detail at how to use and improve a standard. There are also different ways how to do that. Now, **go out, improve your standards, and organize your industry!**

31 Standards Part 5: How to Use and Improve a Standard

Christoph Roser, August 3, 2021 Original at
https://www.allaboutlean.com/standards-5-use-and-improve/

Figure 225: Illustration for Standard 3 (Image Murrstock with permission)

This post of this series on standards looks at how to use the standard correctly, and how to improve a standard. Hint: It is all about the people actually using the standard. This series is again getting longer than I thought, as there is much detail to be discussed. The next post will finally look more at standardized work.

31.1 Document the Standard

Figure 226: Put it where you can find it again! (Image Frank Reynolds in public domain)

The last step (excluding of course the always present improvement activities) is to document the new standard. Naturally, there will be a file somewhere on your hard disk or server, and probably some entries in the list of standards that your company has, including the release date, the version number, etc. This is one of the very few steps in the creation of a standard where you may not need the frontline operators that later have to work with the standard.

31.2 Put the Standard Near the Corresponding Workplace

Figure 227: The standard should be where it is needed. (Image The Light Writer 33 with permission)

However, the completed standard should additionally also be in printed form at the location where it is used. These are commonly folders (either ring binders or merely a box with laminated cards) that are placed close to the workspace. I have also seen the standard displayed on a monitor. Either way is fine. This way you can display the currently valid standard (e.g., for the current part in production).

31.3 Put Up the Standard for the Worker

Figure 228: Workplace with Monitor for Displaying Standards (Image Roser)

The current standard should also be displayed out of the box. Overall, there are two possible approaches for displaying the standard.

If the standard is used infrequently with long breaks between the standards, the operators can use the standards as a guide to jog their memory. For example, if there is an exotic product that is done only a few times per year, the operators may not remember the standard well. In this case, the standard should be taken out of a folder or box close to the workstation and put on the workstation so that **the operator can see them**. Alternatively, there can be a monitor displaying the current standard to be used for the operations. The operator then can look up at the standard whenever there is something unclear.

31.4 Put Up the Standard for the Manager

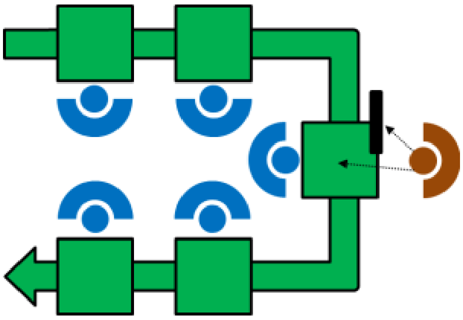


Figure 229: Manager observing Work Standard (Image Roser)

If the standard is used very frequently and highly repetitive with short cycle times, then the operators will quickly know the standard by heart. If an operator assembles a mobile phone every 60 seconds, they do not need to see the standard but have memorized the steps very well. The operators probably even dream of assembling mobile phones. In this case, there is no need to put the standard in front of the operator.

However, in this case the standard is primarily for the managers and put up so that **the manager can see them**. The manager may not have memorized all standards in his area. This way the manager can read the standard while verifying that the operator is actually following the standard. Depending on the layout of the workspace, this may for a U-line even be on the other side of the workplace. The managers stands outside of the U-line and observes the worker while reading the standard. This allows also the manager to **verify that the standard is used correctly**. Often the needs of the worker and the manager are combined and the standard is put up in a spot where both the manager and the worker can easily see them. (Thanks to Michel Baudin for the good article on this topic.)

31.5 Improve the Standard When Needed

Figure 230: Continuous improvement (Image Olivier Le Moal with permission)

Finally, as part of the continuous improvement activities, you should improve the standard. Of course, continuous improvement does not mean that every standard has to be improved all the time. Similar to the creation of the first standard, **for the change of an existing standard there should be a (foreseeable) problem or an improvement potential**. If the benefit of solving the problem or capturing the potential is worth the effort of doing so, then please do. This again is related to the cost and benefit of an improvement, and where you want to focus your energy on.

All the subsequent steps are also very similar to the creation of the first standard. We **select a problem that is relevant**, and **started a problem-solving team,** the size of which may be reflected by the size of a problem. For simple cases it may be merely one or two operators and a supervisor to update their existing standard. For anything but the simplest improvements, an **A3 report** can help. Analyze the **current state**, define a **goal**, do a **root cause analysis**, **develop solutions**, and **implement** the best one. Then you can update the standard. Don't forget to update the version number too!

Figure 231: Don't forget the Check and Act! (Image Roser)

However, before you make the standard live, **do not forget the Check and Act of the PDCA!** Test out the standard, see if it works, improve (or in the worst case, crap the improvement) if it does not work. Only if you are confident that the standard works well should you put the standard live and update or train all the relevant operators.

31.6 The Standard is Owned by the Operators

Figure 232: It is OUR standard! (Image Cherie A. Thurlby in public domain)

By its nature, the people most familiar with the standard are the people that use the standard regularly. In most cases, they are also the first to see problems or observe improvement potentials.

Now they could start the long trek through hierarchy to get the attention of the shop floor manager, then get his valuable time to start the improvement, and maybe, just maybe, half a year later a standard will come down from management that maybe even fixes the problem that they wanted to fix. Sounds familiar? Yeah, this is not good.

Figure 233: Management's role is to support and encourage (Image pressmaster with permission)

For many standards it is much easier if the ownership resides on the shop floor. Especially for smaller changes the operators should be able to do it themselves, maybe with a supervisor updating the standard document. Again, make sure that they do the check and act of the PDCA (i.e., they test the standard a few times before going life). If there are multiple shifts, there should also be a coordination between the shifts, otherwise the other shift will be surprised by a new standard that they think may not even work. Trust your employees! Recognize their contribution! If you think there are possible unforeseen consequences where a good change at one location can make lots of problems elsewhere, require management approval of the standard. But again, it is rarely the management that gives the answers and makes the standard. If anything, management must ask the right questions and support the operators to help the workers create a better standard.

In my next post I will look at standardized work (or sometimes also standard work), which is a framework for balancing a line and setting up proper standards. Until then, stay tuned, **go out, use your standard, and organize your industry!**

32 Standards Part 6: Standardized Work

Christoph Roser, August 10, 2021 Original at https://www.allaboutlean.com/standards-6-standardized-work/

Figure 234: Illustration for Standard 6 (Image Wrightstudio with permission)

Standard work, or better called standardized work, is a popular method in lean manufacturing. It is closely related to standards and hence part of this longer series on standards, but with a focus on manufacturing or assembly. The actual creation of the work standard is only one of the last steps, and a lot of time is put into balancing the production and matching the customer takt. I have written a lot about some of these aspects before, but let me give you an overview.

32.1 Introduction

Figure 235: Standardized work is for assembly (Image The Light Writer 33 with permission)

The terminology here is not really standardized (like for many other methods in lean). If you go down to the details, a **work standard** is an instruction on how to do a manual work. A **standard work** not only reverses the order of these words, but is a method to go from the customer takt to the line balancing to a work standard. **Standardized work** is the same as standard work, but the wording implies a bit more flexibility and less rigor… which is often a good thing. In practice, all these terms are often mixed together and used interchangeably.

Standardized work is therefore for manufacturing or assembly, where you not only repeat the standardized manual work frequently, but also have to fit the work content within the customer takt. Let me give you an overview of the steps. I won't go into great detail, since I have already written about the different details elsewhere. Hence there will be plenty of links to other blog posts of mine.

32.2 Step 1: Customer Takt, OEE, and Cycle Time

Figure 236: The takt… (Image Mr Bound under the CC-BY-SA 3.0 license)

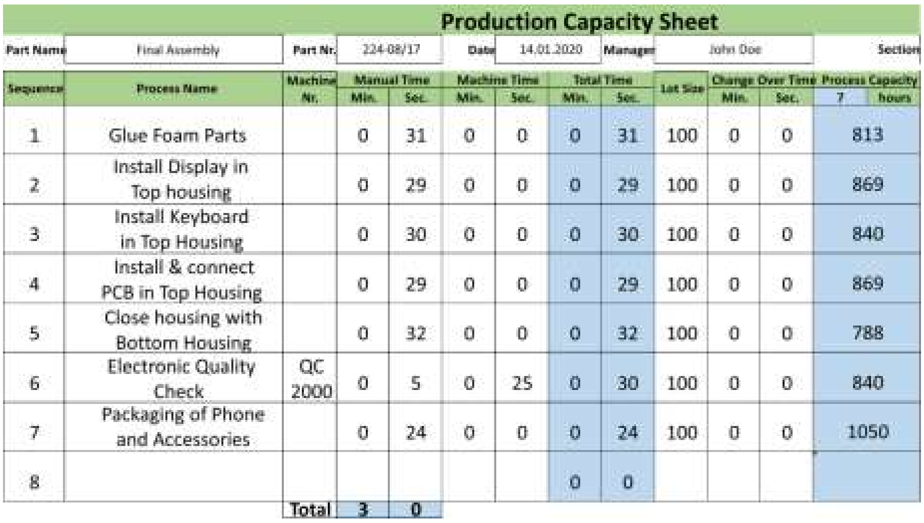
The first step in setting up standards for assembly or manufacturing is to determine the customer takt. How much time do you have to make one part and still match the customer takt. The customer takt is the available work time divided by the demand of the customer during this available work time. This can be calculated either for one product type, or for a combination of all products that have to go through the process. For more, see my posts How to determine Takt Times and Pitfalls of Takt Times.

$$Customer\ Takt = \frac{Available\ Work\ Time}{Customer\ Demand\ during\ available\ Work\ Time}$$

The takt includes all the losses, problems, and other troubles. The customer takt is also our target for the line takt, i.e. the average production of our line (or, generally, process). However, we also need the cycle time, which is the time needed for one cycle under ideal circumstances, excluding all losses, problems, and other troubles. The difference between the takt time and the cycle time is the OEE. For example, if your customer takt is 40 seconds per piece, and you estimate your OEE to be 80%, then the target cycle time is 40s·80% = 32s. You have to make a part every 32 seconds under ideal circumstances to get an average of a part every 40 seconds under not ideal circumstances. For more details, see my articles on How to Measure Cycle Times Part 1 and Part 2, Cycle Times for Manual Processes, and my series on the OEE.

32.3 Step 2: Production Capacity Sheet

Next you need to get an overview of the tasks. This is often called the production capacity sheet. What steps need to be done, and how much time do they need. An example is shown below. I go into more details at Toyota Standard Work – Part 1: Production Capacity.



Production Capacity Sheet

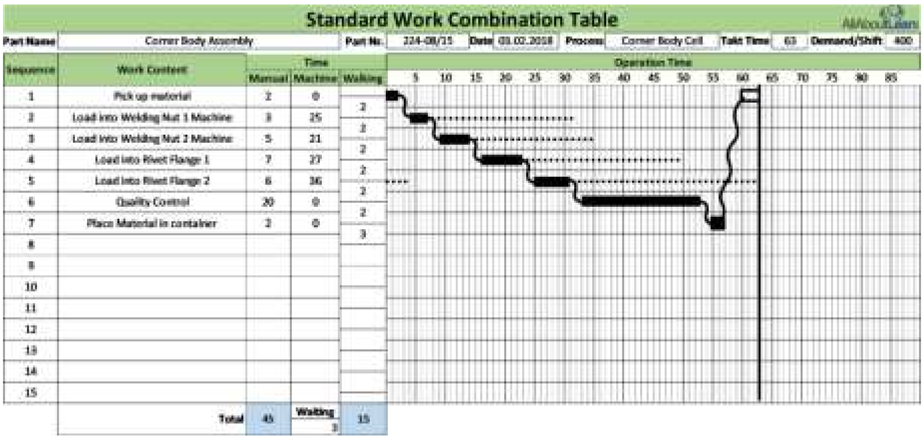
Part Name: Final Assembly
Part Nr.: 224-08/17
Date: 14.01.2020
Manage: John Doe
Section

Sequence	Process Name	Machine Nr.	Manual Time		Machine Time		Total Time		Lot Size	Change Over Time		Process Capacity	
			Min.	Sec.	Min.	Sec.	Min.	Sec.		Min.	Sec.	7	hours
1	Glue Foam Parts		0	31	0	0	0	31	100	0	0	813	
2	Install Display in Top housing		0	29	0	0	0	29	100	0	0	869	
3	Install Keyboard in Top Housing		0	30	0	0	0	30	100	0	0	840	
4	Install & connect PCB in Top Housing		0	29	0	0	0	29	100	0	0	869	
5	Close housing with Bottom Housing		0	32	0	0	0	32	100	0	0	788	
6	Electronic Quality Check	QC 2000	0	5	0	25	0	30	100	0	0	840	
7	Packaging of Phone and Accessories		0	24	0	0	0	24	100	0	0	1050	
8							0	0					
		Total	3	0									

Figure 237: Flexible manpower example production capacity sheet (Image Roser)

32.4 Step 3: Standard Work Combination Table (i.e., Line Balancing)

Next you need to arrange the tasks in a feasible sequence, with the work content in each station fitting within the target cycle time. This is called Standard Work Combination Table if you use the style that Toyota does. More on this in my post Toyota Standard Work – Part 2: Standard Work Combination Table. However, there are also other approaches possible. I have an extensive six post series on line balancing, and another four-post series on how to do this for flexible manpower lines, of which especially the third post with an example is useful here. For very small lot sizes, mixed model sequencing may also be relevant, and I have a 12 post series on that too.



Standard Work Combination Table

Part Name: Corner Body Assembly
Part Nr.: 224-08/15
Date: 03.02.2018
Process: Corner Body Cell
Takt Time: 63
Demand/Shift: 400

Sequence	Work Content	Time Manual	Time Machine	Time Walking
1	Pick up material	2	0	2
2	Load into Welding Nut 1 Machine	3	25	2
3	Load into Welding Nut 2 Machine	5	21	2
4	Load into Rivet Flange 1	7	27	2
5	Load into Rivet Flange 2	6	36	2
6	Quality Control	20	0	2
7	Place Material in container	2	0	3
8				
9				
10				
11				
12				
13				
14				
15				
	Total	45	Waiting 3	15

Figure 238: Toyota Standard Work combination example (Image Roser)

32.5 Step 4: Line Layout

If you establish a completely new line, you may also think about the line layout. At Toyota this is called the Standard Work Layout, and I wrote about it in a previous blog post. But line layout is also a complex topic, and you can find more on this in another series of blog posts on mine on line layout.

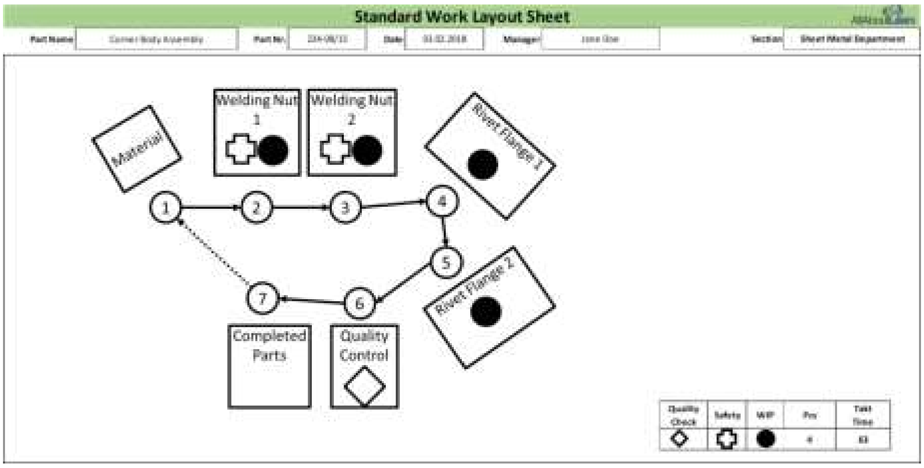


Figure 239: Toyota standard work layout example (Image Roser)

32.6 Step 5: Work Standard

Now you should know which tasks have to be done at which station and how fast. Now you can create the work standard, standardizing the repetitive task for the operators. The previous posts of this current series on standards have a lot of good information on standards in general, and also apply to this work standard. This works standard describes the work sequence in the necessary detail (not too much detail, mind you). In my next post I will show you a work standard I have created as an example of what it could look like.

32.7 Step 6: Iterate, PDCA, Improve

Figure 240: PDCA Circle (Image Roser)

These steps above are shown as a simple sequence. However, this is not quite true. You may see at step 3 a possibility to reduce the time for a task. Then you go back to step 2 to update the production capacity sheet, and then update step 3. Or you may see a problem at step 4, where a machine cannot be moved to where you wanted it to be, and the worker has to walk a bit more. This means redoing step 3. In sum, there is a lot of back and forth between the steps. This is a hassle, but it makes a better standard.

Also, make sure your standard works! Do not forget the Check and Act parts, but verify on the shop floor if the standard works as good as it should be. Ask the operators if they agree. Fix the standard if it is not good enough.

Finally there is continuous improvement. This of course does not mean to work on the standard all the time, but it does mean to work on improvement in general frequently. If the standardized work you have created causes problems, you may have to improve the system and then standard to fix the problem. If you see an worthwhile improvement potential with the standardized work, update the system and the standard to capture this potential.

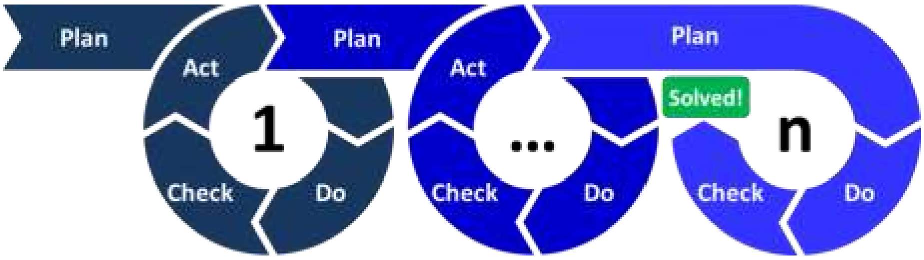


Figure 241: PDCA Circle Sequence (Image Roser)

As you see, there is plenty to do to create a good standardized work. In my next post, I will show you an example of a work standard, which is one of the last steps of standardized work. Now, **go out, get your standardized work in order, and organize your industry!**

33 Standards Part 7: How to Write a Work Standard

Christoph Roser, August 17, 2021 Original at
https://www.allaboutlean.com/standards-7-work-standard/

Figure 242: Illustration for Standard 7 (Image Wrightstudio with permission)

In my last post I talked about the different steps on how to do standard work. In this post I will go into more detail on how to write the actual work standard that is put up at the workplace. This will include quite a few examples in different styles, before I will go into a bit more detail for one example in my next post.

33.1 Introduction and Purpose

A work standard should describe the work **understandably** in the **necessary detail**. Understandably means to use plain language, and can be enhanced with pictures, diagrams, checklists, and so on. But what is a necessary detail? It is NOT a replacement for instructing the worker on how to do the job. Hence you don't need to state the obvious. If an assembly station has a powered drill hanging over the table, you do not need to include in the standard where the drill is found. The detail of the standard depends on the two functions of a work standard:

- **To make sure the worker doesn't make a mistake or forget a step.**
- **To allow managers to verify the correct use of the standard.**

Figure 243: I just read the standard … let's do it! (Image U.S. Department of Defense in public domain)

Important: **A standard is not a substitute for proper training,** both on-the-job and theoretical. The standard can be used by the trainer to help with the training, but do not simply give the worker the standard and tell him to do it. This will not be good for quality, performance, and safety. Let's have a look at what goes into a standard before I show you a couple of examples.

33.2 What Goes into a Work Standard

Figure 244: Checklist (Image Clker-Free-Vector-Images in public domain)

A work standard has a few common elements that are found in pretty much every work standard. The basis of a work standard is a **list of steps**. These could even be simple bullet points or a checklist, but some sort of tabular arrangement is more common. Each step of the work is explained in not too little but also not too much details. Remember, it is not a exhaustive instruction but more of a checklist for workers or managers. They can go into more detail where mistakes can be made, but glossing over details that are obvious to the worker and also obvious or irrelevant to the manager observing the work. The level of detail also depends on the frequency of the task. A task repeated every 60 seconds for the entire shift may have great detail and describing steps of only a few seconds, sometimes even splitting a right-hand and left-hand action. A task taking days and repeated once per week will have much less detail and may summarize an entry covering multiple minutes or even hours into one instruction. The latter requires higher skilled workers with more experience.

Sometimes these steps are also grouped in sub-steps or even sub-sub steps, but try not to overdo it. Often, relevant **key points** for safety or quality are highlighted or may even have a separate column in a table. These steps are often **numbered**. Sometimes they also include the **duration of the step**, although many standards omit these. Just because you have the time does not mean that you should include them in the standard. Judge if it is helpful for either the worker or the manager before including it.

Figure 245: Images help Lego Plane (Image Roser)

Most modern standards have not only text, but also include photos, diagrams, or other **illustrations**. These can help to make the standard easier to use and understand. But again judge if it is really necessary to include a picture of everything. It may be obvious to the operator, and the observing manager may also figure it out by himself if he observes the operator. Only if it has real value for either of them should the image be included.

33.3 Things to Consider

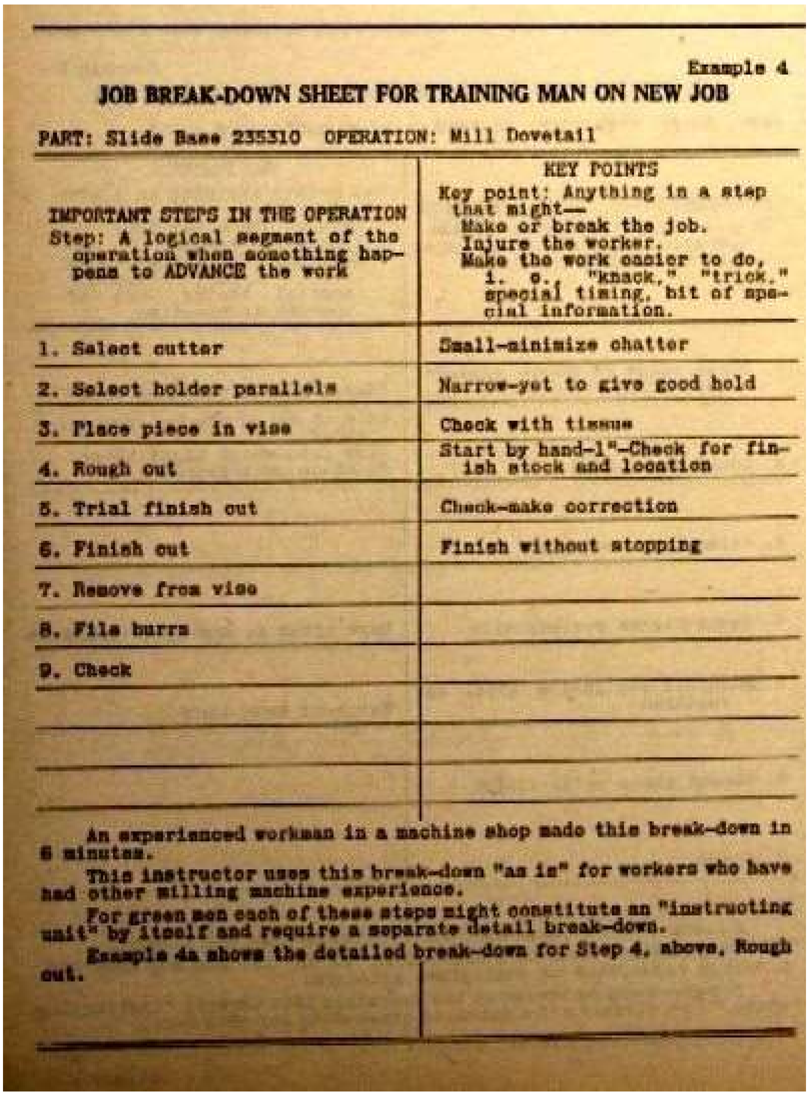
Figure 246: PDCA Circle (Image Roser)

Like all standards, you should test the standard and **iterate** a few times until you have a good workable standard. Plan-Do-Check-Act (**PDCA**) is quite relevant here too. Also try to make the standard short. The standard should **fit on one page** if possible, so it can be displayed at the workstation. If the manager or the operator need to flip pages, then they will never look at the second page. It is a bit of an art to decide what to leave out to make it fit, but please do put in some effort even though adding stuff feels more natural to us than removing stuff.

33.4 Example Standards

Here are a few example standards. Due to copyright reasons I am limited at what I can show you here, but I hope they do inspire you.

The first is an standard from an older Training within Industry manual, and out of copyright. It is only text (no graphic editing computer in 1945, sorry), but they do highlight key points of the milling of a dovetail.



Example 4

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Slide Base 235310 OPERATION: Mill Dovetail

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	KEY POINTS Key point: Anything in a step that might— Make or break the job. Injure the worker. Make the work easier to do, i. e., "knack," "trick," special timing, bit of special information.
1. Select cutter	Small-minimize chatter
2. Select holder parallels	Narrow-yet to give good hold
3. Place piece in vise	Check with tissue
4. Rough out	Start by hand-1"-Check for finish stock and location
5. Trial finish cut	Check-make correction
6. Finish cut	Finish without stopping
7. Remove from vise	
8. File burrs	
9. Check	

An experienced workman in a machine shop made this break-down in 6 minutes.

This instructor uses this break-down "as is" for workers who have had other milling machine experience.

For green men each of these steps might constitute an "instructing unit" by itself and require a separate detail break-down.

Example 4a shows the detailed break-down for Step 4, above, Rough cut.

Figure 247: TWI Mill Dovetail Instructions (Image unknown author in public domain)

The second example is completely without text, since the "operators" do not speak a common language. It is an Ikea-style standard with pictures only. For copyright reasons I cannot show an real Ikea standard, but this crop of a "Löve" parody by Ola Einang should give you an idea. Different from "normal" standards, there is also no proper on-the-job training on how to assembly Ikea shelves. Maybe that's why I sometimes put a piece in the wrong way? However, it is a lot of effort to get a good picture-only standard, and text is commonly used in industry. Nevertheless, I have heard of cartoon-style standards in some plants where the workforce is illiterate due to a dysfunctional education system.

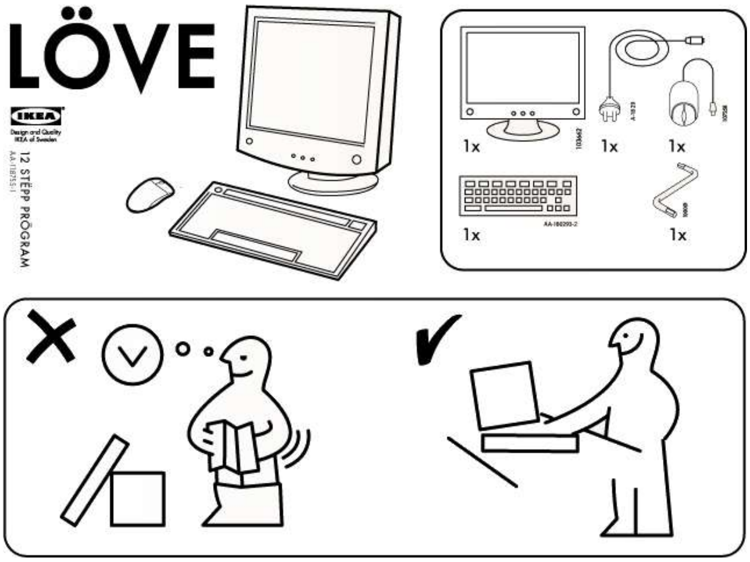


Figure 248: Ikea Löve Parody (Image Ola Einang under the CC-BY-SA 2.0 license)

Another image-only standard is for operators who have not yet started their education. Lego is for age 4 and up, and hence also only in pictures. The images below are for a small model I made using the free LDCad, with the subsequent instructions created using the also free Web Lic. Both are specialized for Lego. I later also twiddled a bit with the images in PowerPoint.

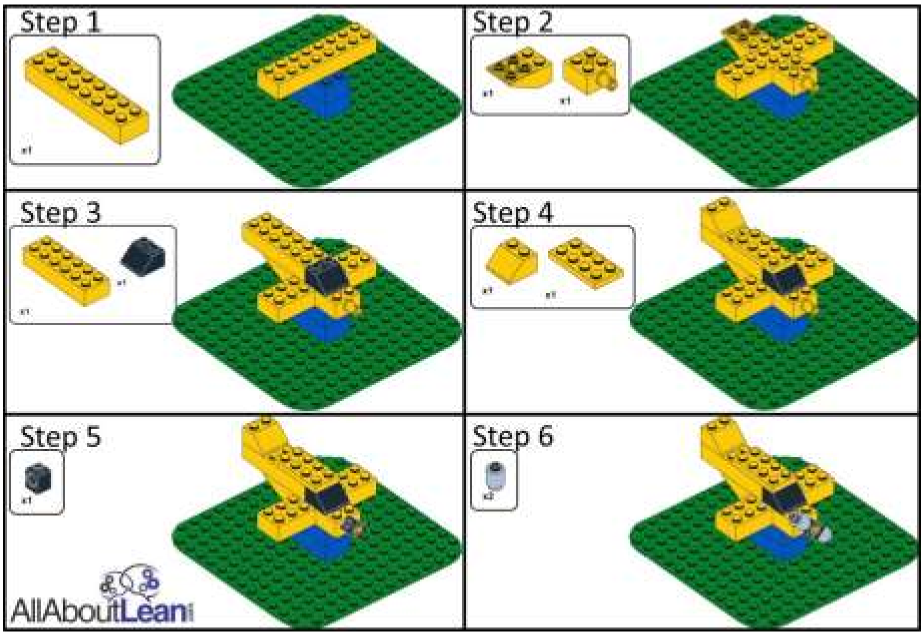
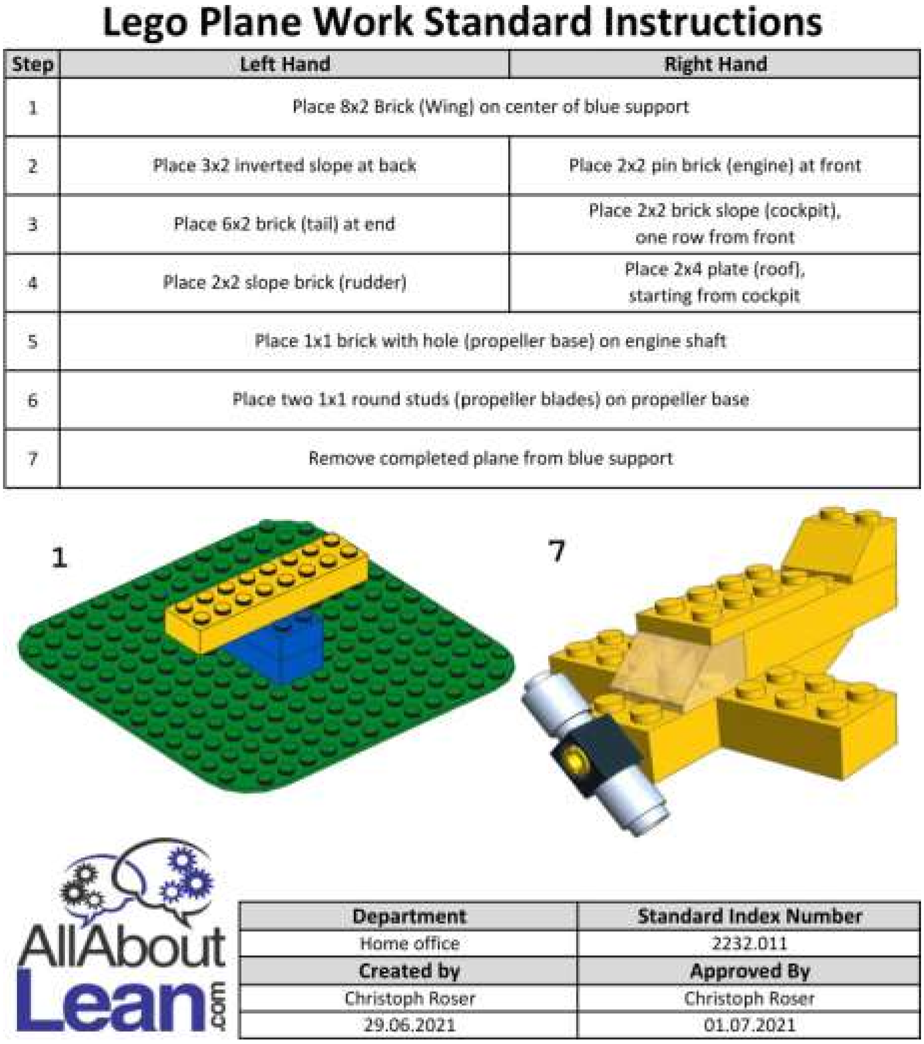


Figure 249: Lego Plane Standard (Image Roser)

Now for a more industrial-looking standard that distinguishes between the left-hand and right-hand action. The example is also the Lego plane from above. Such a "*left-hand-right-hand*" standard is useful for assembly with short cycle times, and is used for example at Bosch. This one can go into great details to optimize the work for efficiency. This example also includes images, but much less than the Lego standard above.



Lego Plane Work Standard Instructions

Step	Left Hand	Right Hand
1	Place 8x2 Brick (Wing) on center of blue support	
2	Place 3x2 inverted slope at back	Place 2x2 pin brick (engine) at front
3	Place 6x2 brick (tail) at end	Place 2x2 brick slope (cockpit), one row from front
4	Place 2x2 slope brick (rudder)	Place 2x4 plate (roof), starting from cockpit
5	Place 1x1 brick with hole (propeller base) on engine shaft	
6	Place two 1x1 round studs (propeller blades) on propeller base	
7	Remove completed plane from blue support	

Department	Standard Index Number
Home office	2232.011
Created by	**Approved By**
Christoph Roser	Christoph Roser
29.06.2021	01.07.2021

Figure 250: Left Hand Right Hand Lego Plane Standard (Image Roser)

Here is another industrial standard, although I made this myself with the help of an software tool Soft4Lean SWI as an example for a standard to cook a cup of ramen. More on the standard and the Soft4Lean tool in my next post. This standard includes a column for times, and has a hierarchy of subheadings ("Key Points") and sub-sub headings ("Reasons"). It also has a columns with symbols to highlight certain (sub-)steps. It also has plenty of images. The entire standard is two pages long, and hence a bit too long for my taste.

Figure 251: Cup Ramen Standard 3rd version Page 1 (Image Roser)

Here is the cup of ramen standard again, but this time with a slightly different format. Now there is only one hierarchy level. I also eliminated some of the images and twiddled a bit with the steps, so that the entire standard fits onto one page. This makes it much easier to display.

Standard Work Instruction

Figure 252: Cup Ramen Standard 5th version (Image Roser)

Hopefully this article will give you some ideas and inspiration on how to write a good work standard. In my next post I will go into more detail on how to make the cup of ramen standard. Until then, stay tuned, and **go out and organize your industry!**

34 Standards Part 8: Example for a Work Standard

Christoph Roser, August 24, 2021 Original at
https://www.allaboutlean.com/standards-8-work-standard-example/

Figure 253: Cup Ramen Cupboard (Image Roser)

In this series I have talked a lot about standards in general, work standards, standardized work. Let me now show you an example of a work standard, an actual instruction on how to do a work. Since standards in industry are usually confidential, I present you my own standard on how to make a cup of ramen noodles. I used a software tool Soft4Lean SWI to help me with the format; more on that later.

34.1 Why to Make a Standard

I have made instant ramen before, and it always worked out. Hence, the actual process is not a problem… which straight out goes against my first advice, **you must start with a problem**. Sorry. I just need a standard to show it to you… Which again contradicts my earlier advice, **just because you can have a standard does not mean that you should have a standard**. Oops. Sorry again. Not a good start for this standard, but it will get better, I promise. And I will iterate and do the PDCA.

34.2 The Task

The Animation by Christoph Roser is available on AllAboutLean.com at
https://www.allaboutlean.com/standards-8-work-standard-example/foil-package-scrape-crop/

The task is basically simple: You take a cup of ramen, fill it with boiling water, wait three minutes, remove water, add the sauce, stir, and eat. You probably have done this before. But there are a few tricks and critical points:

- After filling the cup with boiling water, you put the lid back on. But sometimes the lid does not sit right. This can easily be checked by rotating the lid a bit. If it rotates easily but does not come off, then it is tight and will not fall down when you drain the hot water later.
- When draining the hot water, make sure to keep your fingers out of the rising steam. Most people figure that out after the first time, but why burn yourself once?
- While draining the water, some ingredients get stuck to the lid. If you drop the cup carefully from 10–15 cm height upright, the impact will drop some of these ingredients back into the cup. Important for a perpetually hungry guy like me.
- A particularly nifty trick is for getting all the sauce out of the sauce package. You open the sauce package, put it into the cup with only a corner sticking out, and then press the lid down on the cup. If you now pull out the sauce package, the lid will scrape all the sauce out of the package easily and quickly. See animated GIF for an example. By the way, this also works with most similar foil packages, and also e.g. between a pot and a pot lid. Overall this reduces the waste of sauce that remains in the package.

34.3 1st Round: Basic Steps

Figure 254: Soft4Lean Android app for mobile and tablet (Image Roser)

The first round is merely to get an overview. I made myself a cup of ramen, noting down the steps I had to do. The Soft4lean SWI app on my tablet allowed me to note down the steps, and also take some pictures. This did not yet include much details, but merely gave me a first draft of the steps. I ended up with three pages of standards, the first one is shown below. You can also [download this first version as a PDF here]().

Figure 255: Cup Ramen Standard 1st version Page 1 (Image Roser)

34.4 2nd Round: Refine Steps

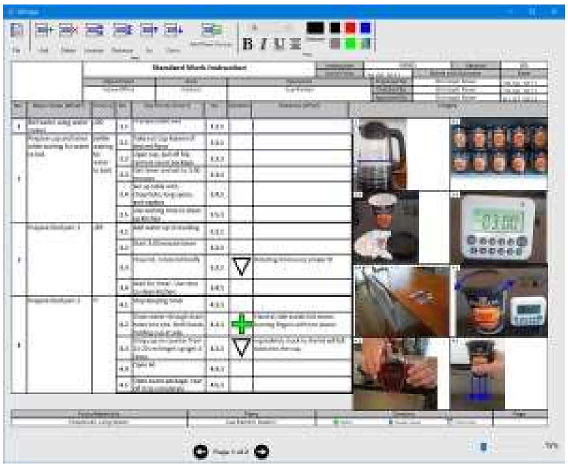


Figure 256: Soft4Lean SWI screenshot (Image Roser)

I switched to the Soft4Lean SWI software on my PC, since typing on a tablet is tough. I added more text. While trying out this second version, I added more pictures and also decided to also tweak the sequence a bit. I also reduced the row height to save space, but it is still two pages long.

Note how I did not fill out all fields of the reasons column? This is intentional. Try to focus on the more important steps, and if there is nothing to write in detail, then you should not add unnecessary fluff. The first page of this two-page standard is shown below. You can download this second version as a PDF here.

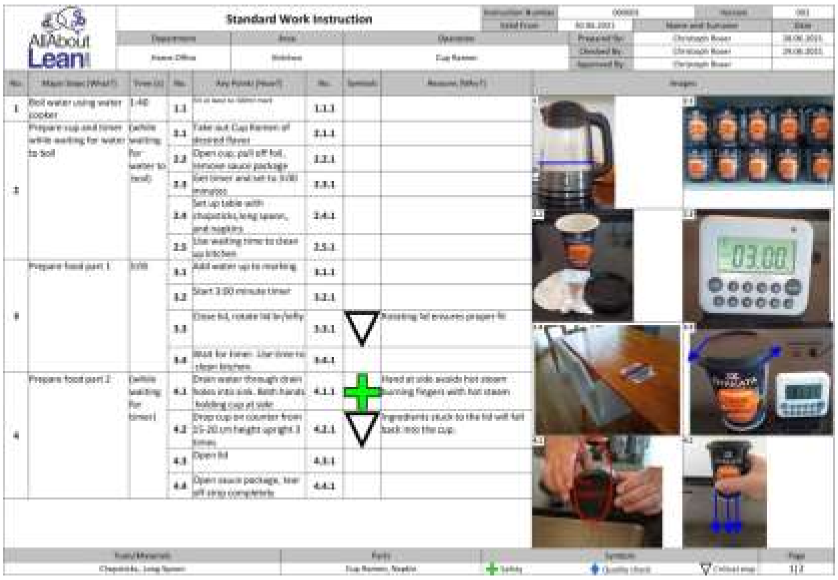


Figure 257: Cup Ramen Standard 2nd version Page 1 (Image Roser)

34.5 3rd Round: Verify

Next I wanted to verify the quality of the standard. I printed out the standard and had another cup of ramen while following the standard. For example, I added that I should turn off the beeping timer (Step 4.1), which I forgot in the first two versions. Other than that I did not change much, indicating that the standard seems to work. But it is still two pages long. The first one is shown below, but you can download the full standard of this 3rd version as a PDF here.

Figure 258: Cup Ramen Standard 3rd version Page 1 (Image Roser)

34.6 4th Round: Shorten

The standard is overall good, but still two pages long. This makes it more difficult to display without flipping some pages. Hence, I tried to narrow it down to a single page. I changed the template style in the Soft4Lean SWI software to a simpler style. I merged some steps, getting down from 24 steps to 18. I also removed some images that may not have been fully necessary. Below is the updated standard, now on a single page. You can also find this 4th version of the standard as a PDF for download here.

Figure 259: *Cup Ramen Standard 4th version (Image Roser)*

34.7 5th Round: Verify again

Trying out the standard one more time, I decided to merge step 2 & 3 and remove the image from step 3 as it did not add value neither to the operator nor to the observing manager. Since there were no other changes, I think the standard is good for now, or at least until the next improvement round. I did all of this over the course of a couple of days, not because it takes so long, but because I did not want to eat 5 cups of ramen in one sitting. Below is the final standard, which is also available as a PDF here. While I did not mention it explicitly, all those iterations are also **loops of a PDCA**. Always see if it works, and improve if not.

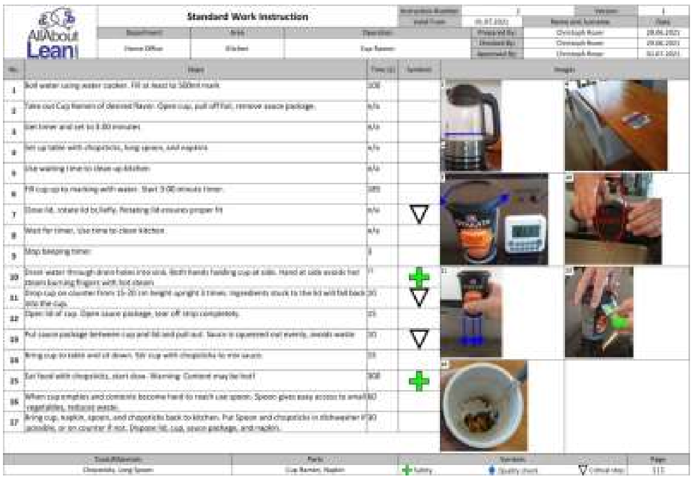


Figure 260: Cup Ramen Standard 5th version (Image Roser)

34.8 Put Standard at Workplace and Train Operators

Figure 261: Still life with standards and fruits (Image Roser)

After creating the standard, I put it up in my kitchen. And just if you are wondering, *my kitchen always looks very clean and has attractive fruits lying around. It is not like I spent one hour cleaning my kitchen* *before taking pictures. Don't believe anybody that claims otherwise!* My kitchen pictures are not modified, just like people on Instagram would not use a filter to make them look better than they do, right?

So now I have to train the other operators … which means … *I have to train my wife in the use of the kitchen …*

I have the feeling that telling my wife how to cook may be not good for my health and lead to an untimely end for my blog, just a week before its 8th birthday. Hence, let's just assume I have trained all operators, okay?

34.9 The Software Tool Soft4Lean SWI

Soft4Lean
SWI

Figure 262: Soft4lean SWI Logo (Image Soft4Lean with permission)

I got an offer from Tomasz Koch from the Lean Enterprise Institute Poland to try out the software tool Soft4Lean SWI that helps in creating a standard. It helped me in creating this example standard for my cup of ramen. (This app is also available in Portugal through the Lean Academy Portugal)

Disclosure: Tomasz and I have known each other for quite some time now for our mutual benefit, and occasionally even do business together. I did not receive any compensation for this post.

Soft4Lean SWI worked for me and made creating a standard quite a bit easier compared to the usual messing around with Excel. Overall it was quite intuitive and easy to use even without a manual. It also exports into PDF and MS Excel format if you want to do further tweaking. However, I am not an expert in standardized work software, and there are also many other tools out there like Dozuki, Starling, VKS, EaseWorks, Cioplenu, and many more. As far as I can see, they don't offer groundbreaking new ideas, but they do make the grunt work of putting a standard into Excel (PowerPoint? Word?) much easier.

Now, **go out, write your standards, improve them, make sure they actually work, and organize your industry!**

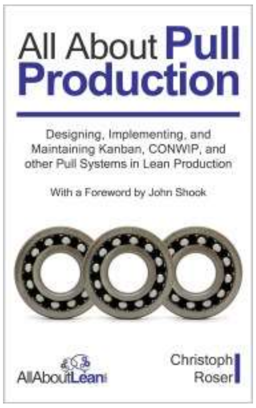
35 Happy 8th Birthday AllAboutLean.com

Christoph Roser, September 1, 2021 Original at https://www.allaboutlean.com/happy-8th-birthday-allaboutlean-com/

Figure 263: Eight Birthday Cake (Image Andrjuss with permission)

AllAboutLean.com turned eight years old today. During these years I have written [421 posts](#) plus quite a few [pages](#), helping others in doing lean (and also learning a lot myself!). Time to look back at the last twelve months.

35.1 All About Pull Production



All About Pull Production

Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production

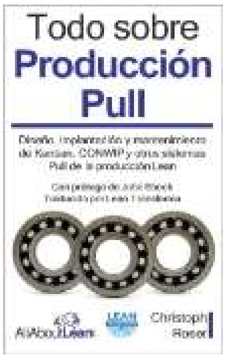
With a Foreword by John Shook

AllAboutLean

Christoph Roser

Figure 264: All About Pull Production Ebook Cover (Image Roser)

My biggest milestone was the publication of my book [All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP, and other Pull Systems in Lean Production](#) in April 2021. This is a practical guide for anyone looking to implement pull systems. It is not a high-level philosophical discussion of lean, but a book to help you roll up your sleeves and get the job done. It is written for the practitioner. With a foreword by John Shook.



Todo sobre Producción Pull

Figure 265: All About Pull Production Spanish Ebook Cover (Image Roser)

The book has been very well received, and is also selling well. Besides **English**, multiple translations are in preparation, including

- **German** (*Alles über Verbrauchssteuerung*, translated by me, which should be available before the end of the year),

- **Spanish** (*Todo sobre Producción Pull*, translated by Jorge Valle from LEAN Transforma), and
- **Chinese** (关于拉动生产的一切 translated by 涛杰 华 [Taojie] from Bosch).
- **Farsi** is planned by Kazem Moutabian from the Iran Lean Institute,
- **Italian** by Roberto Ronzani from the Istituto Lean Management, and
- **Brazilian Portugese** (*Tudo sobre Produção Puxada* translated by Wellington Batista from The Lean Times).

Many thanks to all translators! Please let me know if you are interested in translating other languages.

35.2 Collected Blog Posts of AllAboutLean.com 2020

Figure 266: AllAboutLean Collected Post Cover 2020 (Image Roser)

My book *All About Pull Production* was not the only book I published. I also continued to publish my annual collection of blog posts, by now in its 8th volume Collected Blog Posts of AllAboutLean.com 2020. This is simply a (minimally edited) collection of all blog posts of the year 2020.

Since my blog posts are available for free on my blog, I also make this book (and all others in this Collected Blog Posts of AllAboutLean.com series) available for free as a PDF. It is also available almost free as an ebook on Amazon. It is also available as a paperback on Amazon, but due to the color printing that is a bit more expensive.

35.3 Most Popular Posts

Figure 267: Top 10 (Image Roser)

The top ten posts for this year were as follows:

1. How Cheap Can You Make it?
2. The Kingman Formula – Variation, Utilization, and Lead Time
3. The Inner Workings of Amazon Fulfillment Centers – Part 2
4. Production Sequences: FCFS, EDD, and Others
5. The History of Manufacturing – Part 1: Prehistory to Antiquity
6. Line Layout Strategies – Part 2: I-, U-, S-, and L-Lines
7. What Exactly Is Jidoka?
8. What Is Your Production Capacity?
9. The Amazon Robotics Family: Kiva, Pegasus, Xanthus, and more…
10. The (True) Difference Between Push and Pull (This one is probably the most popular post of all time. It makes the top of the list every year since it was first published in 2015.)

35.4 Organizational

Figure 268: Under-the-hood maintenance (Image Gobierno de la Ciudad de Buenos Aires under the CC-BY 2.0 license)

I also had some minor changes in the background of my blog. Nothing that you as a reader would really notice, but for example I disabled TrackBack (automatic back-links if someone posts a link to my blog) since I was getting too much spam through this. I also tried out a CDN (content delivery network) to make my website load faster. However, this turned out to be buggy, so I switched it off again. In any case, since I have no advertising, a pretty lean and lightweight WordPress theme (GeneratePress), and almost no cookies (I try to protect your privacy!), my website is pretty fast even without a CDN.

Figure 269: Highly relevant content???? (Image unknown author in public domain)

As my website is getting more popular, I am also getting more and more dubious offers. I regularly get contacted by others offering to write me a "*higH quAliTy*" article on topics highly related to my website like … dog food???? What the….?

I really did a double-take when I saw that offer. In any case, I get such requests so frequently nowadays that I don't even bother to answer. So far, all of the content on my blog has been written by me only (with the sole exception being a guest post by John Shook, but that is very high-quality content!).

I also get more and more offers promising me to make my website much more visible on Google, but these offers also get refused. Besides, I don't want anybody messing around with my blog posts (except, of course, Christy, my trusted spell checker, who works very hard to make me sound intelligent 😉).

Anyway, I enjoyed writing all about lean for you, and it gave me something to do during the home office pandemic. I hope my work is helpful for you, and that you will keep on reading. Thanks for your interest in my work. **Now go out and organize your industry!**

36 Standards Part 9: Leader Standard Work

Christoph Roser, September 7, 2021 Original at https://www.allaboutlean.com/standards-9-leader-standard-work/

Figure 270: Illustration for Standard 9 (Image Wrightstudio with permission)

Leader standard work. Sometimes also called standard work for leaders. A term that floats around quite a bit in lean manufacturing, but I always find it hard to make it more specific. The idea follows the lean concept to standardize things, and tries to standardize the work of managers or leaders. The idea itself is not bad, but it always feels like nailing Jell-O to a wall. There are definitely some worthwhile elements, but sometimes it appears almost mystical. Let's have a look:

36.1 Introduction

Figure 271: Cup Ramen Standard 5th version (Image Roser)

Work standards describe work in the necessary detail. Their purpose is for operators to do good work and to not miss a critical step, and for managers to be able to verify if the worker follows the standard. It is usually a list of steps. On a bigger scale, work standards help to reduce fluctuations (mura), and improve quality, cost, speed, or safety, i.e. reduce waste (muda).

Most work standards are for frontline workers actually working on the products. The idea of leader standard work is to extend this standardization to supervisors and managers in order to also reduce fluctuations and waste. So far, so good.

36.2 What Works

Figure 272: Standard for shop floor meeting attendance (Image Wavebreak Media Ltd with permission)

Let’s start with the easy part: where standards actually work for managers. A work standard is useful only for repetitive work, or for the parts of the work that is repetitive. It is useless for work that is different every time. Managing others by its nature includes a lot of tasks that are not repetitive. More on that later.

But the repetitive tasks do benefit from standardization, also for managers. Hence, it is quite feasible to create standards or checklists for these repetitive elements. These could be work that is only for the managers, or it could be work that the manager has to do just like everybody else. A few examples:

- The plant manager has to attend a shop floor meeting every morning when he is in-house. The departments are Monday casting, Tuesday milling, Wednesday assembly, Thursday sheet metals, and Friday electronics.
- The shop floor manager needs to check and sign off the standardized production sheets for all departments daily.
- Business travel has to be requested using “Travel Request Form 2241.”

36.3 What Makes Standards for Leaders Difficult

Figure 273: One is repetitive, the other is not. (Image auremar with permission)

Standards for leadership are more difficult than standards for operators. I already mentioned that the **share of repetitive work goes down** as you climb up in the hierarchy. This is often combined with the **standards becoming fuzzier**. If you assemble a product, there is one place where a component must go, and it is easy to verify if it is there or not. Hence, verifying the standard has a clear yes/no answer. If a standard requires managers to treat people with respect, how do you verify that? It is nearly impossible to give a clear yes/no answer, but you will end up with a wish-washy gray zone in between. Difficult! But there are even more problems.

Figure 274: You are talking to me? (Image igorp17 with permission)

For one, people usually do not like to be told how to do their work. This increases the more huff-puff-important a person is. **Managers are more opposed to people telling them what to do than workers.** This also depends on the culture in the company. In some companies, you need to always know everything (or at least pretend to do so) in order to make a career. Someone telling the manager how to do their work implies that the manager did not know how to do it before, which will hurt their career aspect.

Figure 275: Frederick Taylor (Image unknown author in public domain)

For a historic example, Frederick Winslow Taylor (1856–1915) is well known for Taylorism, standardizing the work of operators. The American Society of Mechanical Engineers (ASME) took note and liked his idea. They elected him as their president in 1906 in order to reorganize themselves. Taylor got to work and started to tell all those important doctors, professors, and other huff-puffs how to do their work. This did not go down well. He got kicked out after less than one year. The ASME, which before his presidency regularly published papers about Taylorism, published almost nothing about him and his work afterwards. That's what you get for telling important people how to do their work…

Finally, a standard needs to be verified by and occasionally observed by a manager. This, naturally, should be a manager from a higher hierarchy level. Yet, the higher up you go, the further away managers are from the real work, and the less time they have. Eventually at the top there will be nobody above the CEO. Overall, **it is difficult to verify the correct use of a standard for managers by a higher-up manager**.

36.4 What Does NOT Work

So far, the parts of leader standard work described above is pretty much a normal work standard, with the limitations that come with management tasks. But some sources for leader standard work go further, and that's where it becomes more mythical than practical.

Figure 276: It is not yet my takt… (Image Elnur with permission)

First, a *work standard* is a set of instructions on how to do a task. *Standard work* (or standardized work) is bigger, trying to fit the task in a takt time. It includes the customer takt, an analyses of the available capacity, line balancing, line layout, before eventually creating a work standard.

Please tell me, *what is the takt time for managers? How many minutes per decision is their customer takt? Or what is their capacity in decisions per day? How does a management decision line layout look like?* Overall, this does not work. While work standard and standard work are often confused, the additional parts of standard work does not fit well with management tasks. To me it feels like taking a (meaningful) buzzword (standard work), and applying it without understanding it.

Figure 277: Standardize this! (Image vent du sud with permission)

But it gets worse. Some sources use “Leader Standard Work” to talk about leadership philosophy, general management behavior, going to gemba and using visual management, or, simply all of lean manufacturing. This is a meaningless mashing together of buzzwords. There is not even a good definition on what lean actually is. I believe lean is a culture, but I cannot even define it myself. What is the American/German/Indian/… culture? So, how on earth will you make a standard for a lean culture or philosophy??? Sorry, this is garbage.

36.5 Summary

In sum, management can benefit from using standards for repetitive tasks or the repetitive elements of tasks that can be described well. There are some difficulties, like managers always knowing better and having less supervision, but that works. Calling it “Leader Standard Work” for me is an unfortunate term since standard work includes, for example, a takt time, which does not work for managers. Including the whole lean philosophy and claiming it to be leader standard work is bad buzzword bullshitting. Hopefully this post helped you to pick the useful elements of standards for managers (please don’t call it *leader standard work*). No, **go out, not only create standards for others but also use standards for yourself if applicable, and organize your industry!**

P.S.: This post was initiated by a question from Tom. Thanks for asking!

37 About Just in Time and Fluctuations (Like… a Pandemic…)

Christoph Roser, September 14, 2021 Original at https://www.allaboutlean.com/about-just-in-time-and-fluctuations-like-a-pandemic/

Figure 278: Global logistics network (Image Golden Sikorka with permission)

Just in Time (JIT) is a powerful tool in lean. However, it is not an easy tool. Using it without understanding the requirements can quickly make things worse. I have written about related topics before, but during the COVID-19 pandemic, Just in Time was often blamed for a lack of material, usually by people who do not understand how just in time works.

37.1 Just in Time

Figure 279: Relay Race Hand Over (Image tableatny under the CC-BY 2.0 license)

The basic idea of Just in Time is that *material arrives just when it is needed, in the quantity it is needed, at the right location, and in good quality*. Or, more realistically, trying to get close to this target with as little inventory as possible. This reduces your inventory, all costs related with the inventory, and also the waiting times of the inventory and hence the lead time. Overall, this can be very good for your business success. I have written a whole series on Just in Time, but this post will look in more detail at the relation of Just in Time with leveling.

37.2 Inventory

Figure 280: Inventory (Image Axisadman under the CC-BY-SA 3.0 license)

However, inventory does serve a purpose. Besides actually having something to work with, the key purpose of **inventory** is to buffer fluctuations. It is not the only way to decouple fluctuations, but especially for short-term fluctuations, it is often the most efficient way to decouple fluctuations.

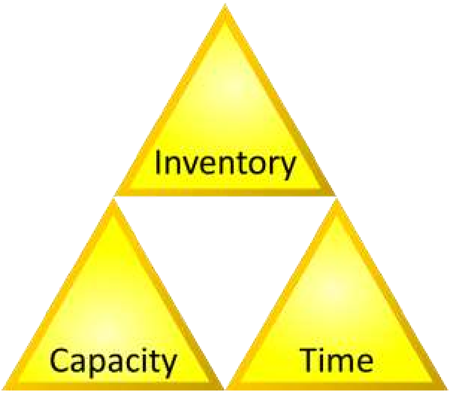


Figure 281: Triforce Inventory Capacity Time (Image Roser)

For long-term fluctuations (e.g., seasonality) you can also decouple by adjusting the **capacity**. This can also be very efficient but usually is a bit slower and takes more time to adjust. If you cannot decouple fluctuation by inventory or capacity, then the system will automatically decouple using **time** (i.e., your parts, workers, machines, and customers have to wait). There are systems that successfully decouple by letting their customers wait (e.g., the production of commercial aircraft), but for most companies, letting their customers and others wait is quite bad.

37.3 Just in Time vs. Inventory

Hence, merely eliminating your inventory is very dangerous if your system is not ready for it. Just in Time requires a careful timing of the arriving material when it is needed, with little buffer stocks. But merely reducing the buffer stocks will wreak havoc with your system.

Figure 282: "This is our Just in Time inventory." (Image Eric Lewis under the CC-BY-SA 2.0 license)

If you want to do Just in Time, there are two ways out of this dilemma. The easy way is to leave everything as it is and just call it a JIT inventory, regardless of how big it is. Obviously, this won't improve your system, but it makes others (and maybe even yourself) believe it even though it is not. Unfortunately, this is more common than I would like, and I have seen way too many warehouses where I was told, "This is our Just in Time inventory." No, this is **NOT** Just in Time; this is just make-believe.

Figure 283: Punishment of Sisyph by Titian (Image Titian in public domain)

The real way to make Just in Time work is by reducing fluctuations (and, of course, I have a whole series on that topic too). Unfortunately, this is hard, never-ending, Sisyphusian work. Fluctuations will always increase. This is true not only for your shop floor, but also for the entire universe due to the second law of thermodynamics.

Even worse, no matter how good you are at reducing fluctuations, once in a while there will be a fluctuation coming along that you could not prevent and that is bigger than your buffer inventory, and you will run out of material or stock.

37.4 The COVID-19 Pandemic

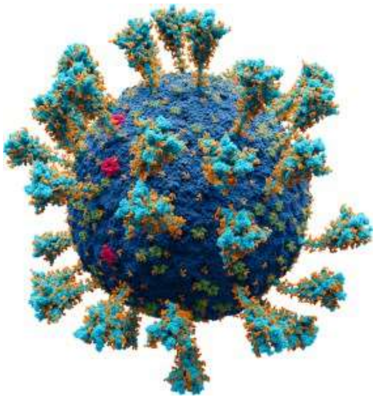


Figure 284: Corona Virus (Image Alexey Solodovnikov and Valeria Arkhipova under the CC-BY-SA 4.0 License.)

Case in point, the COVID-19 pandemic that started in 2019. This messed up supply chains pretty bad, and there were lots of stock-outs all over the place. From masks to computer chips (graphic cards, automobiles, etc.) to toilet paper, there were lots of different shortages.

In the press this was often described as a failure of Just in Time and too much optimization of the supply chains. They claimed that industry was cutting costs too much, which caused lots of problems.

Figure 285: Uh-oh… (Image NASA in public domain)

Also, there were other factors that impacted many supply chains, from a container ship stuck in the Suez Canal to Britain leaving the European Union to bitcoin mining buying all the graphic cards, etc.

Figure 286: GeForce RTX 2080 (Image HiyoriX under the CC-BY-SA 3.0 license)

Well, let’s have a look at the alternatives. These articles suggest that more inventory would have helped. Maybe it would have, but at what cost? Let’s take graphic cards. A graphic card costs normally between a few hundred and maybe a thousand+ dollars. If we consider the lower value along the supply chain, lets assume $300 of inventory value for each card. Ten thousand cards would have an inventory value of $3 million. And, 10,000 cards were nothing in the current demand. Yet, simply having the inventory would cost you 30–65% of the inventory value per year. Hence, you would have expenses of $1-2 million per year just to have 10,000 graphic cards in inventory just in case a pandemic comes along. Naturally, these costs would eventually have to be paid by the customer through higher prices for their graphic cards. Hence, everything would become more expensive.

Figure 287: Toilet paper diamond & fan fold (Image Roser)

It is all a question of the cost of the inventory versus the cost of a stock-out. Sometimes it may make sense to stock up, and some governments at different times have, for example, a strategic reserve of oil (in the US e.g. ca. 30 days' supply) or toilet paper (West Berlin stocked 180 days' worth of toilet paper and other goods during the Cold War). Running out of oil would be worse than the cost of a continuous inventory, and I leave it up to you to judge the need on toilet paper.

Well, the (hypothetical) counterargument, then, would be to only build up stock if you need it. **D'oh!** If industry would have known about the pandemic one year in advance, they of course would have built up stocks. It is always much easier to run a company in hindsight rather than foresight, but usually companies don't have the luxury of knowing the future, even less so for once-in-a-century (hopefully not more) pandemics.

Nevertheless, some companies by negligence or ignorance made their situation worse. Rather than decreasing fluctuations, they increased fluctuations. Volkswagen (and other car makers), for example, abruptly cut their orders of chips at the beginning of the pandemic, predicting a drop in sales. As it turned out, lots of government assistance increased the cash flow for many, and the car makers now struggle to get enough chips. What the car makers did was the opposite of leveling, reducing orders of chips much more than needed due to a prediction, and then trying to ramp up again. Unfortunately, you cannot turn a wafer fab on and off like a flashlight. Due to long lead times, ramping up production will take quite some time, combined with an overall higher demand for chips.

In one aspect, however, I agree with the news articles on logistics and the pandemic: many supply chains are just way too long. Goods are shipped around the globe multiple times to chase a few cents in savings. Long supply chains increase fluctuations, and you cannot really have Just in Time delivery by ship from Asia to Europe or the USA (unless, of course, you just call any inventory a Just in Time inventory…). Shortening supply chains will help to make companies more robust against global disruptions, no matter if it is a pandemic, a stuck container ship, an embargo, or a war. However, lean manufacturing has always been in favor of shorter supply chains. Toyota tries to have many suppliers close to the final assembly plants. Most Japanese suppliers are within three hours' drive around Toyota City. Toyota produces a large number of its car engines for the American factories within the USA. If you chase a small saving around the world, you will quickly find that the delays and fluctuations eat up more than you saved.

Overall, Just in Time and lean manufacturing are set up for such situations, and the inventory needs to correspond the impact of a stock-out. Now, **go out, level your material flow, adjust your inventories, and organize your industry!**

38 About the Value of Disagreement for Leadership

Christoph Roser, September 21, 2021 Original at https://www.allaboutlean.com/about-the-value-of-disagreement-for-leadership/

Figure 288: Manager discussing with Employee (Image fizkes with permission)

Leaders not only make decisions, but also have a large impact on the mood and the culture in a company. Often, they like to be right. Yet, they are only humans, they don't know everything, and they do make mistakes. Hence, a good culture for disagreement is important to make better decisions. In this post I would like to talk more about the value of disagreement, and why it is not common to find it in industry.

38.1 Analogies from Aviation

38.1.1 Tenerife Airport Disaster

Figure 289: Tenerife Airport Crash (Image unknown author in public domain)

October 27, 1977 was a busy day at the Tenerife airport, despite heavy fog and low visibility. Due to the closure of another airport, many aircraft were diverted, the taxiway was filled up with planes, and planes had to use the runway to get into starting position. In this environment, a Pan Am Boeing 747 was just about to leave the runway back to the taxiway, when a KLM Boeing 747 started to take off. The crash caused the loss of 583 lives.

Many factors came together to cause this accident, from bad weather to ambiguous communication. But there was also a hierarchical barrier for disagreement in the KLM cockpit. The captain of the KLM plane was a highly respected captain, but was a bit in a rush to take off. Both the co-pilot and the flight engineer at different times voiced hesitation and concern that the runway was not yet clear, yet they were snubbed by the captain. Again, this was not the only cause of the catastrophe, but if the captain would have listened to the co-pilot and flight engineer, disaster could have been avoided.

38.1.2 Korean Air Flight 801

Figure 290: Korean Airlines flight 801 crash site (Image Rex B. Cordell in public domain)

Korean Air Flight 801 crashed on August 6, 1997 near Guam. Heavy rain and low visibility required an instrument landing. However, the instrument landing system at the runway was out of service. The captain though he picked up a signal. The crew disagreed, and the flight engineer later also protested that the descend was too steep and said multiple times that there is no airport in sight. Yet, the captain pressed on and crashed into a hill, leading to the death of 229 of the 254 occupants of the plane.

38.1.3 United Airlines Flight 173

Figure 291: Portland International Airport (Image mike teague under the CC-BY-SA 3.0 license)

When United Airlines Flight 173 was approaching Portland in December 28, 1978, they encountered a problem with the landing gear. The pilot entered a holding pattern to resolve the problem, circling for over one hour. The first officer and flight engineer indicated that they were running low on fuel, but the captain reacted too late. Ten people died in the resulting crash.

38.2 The Aviation Response: Crew Resource Management

Figure 292: A380 Cockpit and Crew (Image Steve Jurvetson under the CC-BY 2.0 license)

In response in particular to the Tenerife disaster, and later to the **United Airlines Flight 173** crash, aviation regulations started to train for crew resource management. The goal is to provide a free exchange of information among the crew and to reduce the power distance. Crew members are trained to voice their concerns and to hear the concerns of others regardless of the level of hierarchy. They aim to improve interpersonal communication, leadership, and decision making. It is nowadays a mandatory training at most airline regulation bodies. Crew resource management expanded from aviation also to many other fields, like shipping, firefighting, and medicine, although the quality of the implementation varies.

38.3 How About Manufacturing?

Figure 293: Valve Assembly Line (Image The Light Writer 33 with permission)

At this point, you are probably wondering if this can be applied to manufacturing. Definitely. If you are working in manufacturing, you probably know plenty of examples when people knew that something would not work, but either did not dare speak up or if they spoke up they were not heard. The all-knowing decision maker put more trust in his own opinion than his underlings', and the (for all but one) predictable outcome happened. A manufacturing version of crew resource management could definitely help.

38.4 The Challenge in Manufacturing

Figure 294: I am always correct… (Image igorp17 with permission)

However, it is a bit more difficult in manufacturing than in aviation (although not impossible). In aviation, a crew works together for long hours, they know each other, and they have plenty of opportunity for human interaction. It is also much less a question of outdoing someone else to get promoted. In manufacturing, this can be quite different. An upper-level manager may spend quite some time with the level below him, but the farther down you go in hierarchy, the less actual contact the manager has with the people.

Figure 295: No more than 50 friends, please… (Image Evan Williams under the CC-BY-SA 4.0 license)

At one point, another employee is no longer seen as a person, but merely a number. This is also called the monkey circle. Bands of monkeys can have up to fifty members; after that frictions increase and the groups tend to split, since a monkey can no longer really know his peers. For humans, it is estimated that we have around 150 people with whom we truly have a relationship; everybody else is just a statistic.

The larger number of people involved combined with a higher pressure on looking promotable often hinders open communication. What one side considers a helpful suggestion may be seen as a personal attack by the other side. On top of that is my opinion that, especially higher up, you will find a lot of managers that need the feeling of power and supremacy. And, it is a well known fact that there is a much higher likelihood to find a psychopath in management than in the general population.

38.5 How to Do Crew Resource Management

Figure 296: Solving the problem… (Image ndoeljindoel with permission)

The goal of crew resource management is clear: voice your opinion (respectfully) and listen to others. However, telling someone to "just do crew resource management" won't really help. One key part is for the person in the lower hierarchy to know how to communicate an issue politely and respectfully.

38.5.1 How to Raise an Issue

Below are five key steps, copied from the Wikipedia article on crew resource management, which look like a good approach to me:

- **Opening or attention getter** – Address the individual: "Hey Chief," or "Captain Smith," or "Bob," or whatever name or title will get the person's attention.
- **State your concern** – Express your analysis of the situation in a direct manner while owning your emotions about it. "I'm concerned that we may not have enough fuel to fly around this storm system," or "I'm worried that the roof might collapse."
- **State the problem as you see it** – "We're showing only 40 minutes of fuel left," or "This building has a lightweight steel truss roof, and we may have fire extension into the roof structure."
- **State a solution** – "Let's divert to another airport and refuel," or "I think we should pull some tiles and take a look with the thermal imaging camera before we commit crews inside."
- **Obtain agreement (or buy-in)** – "Does that sound good to you, Captain?"

38.5.2 Common Sender Errors

There are also a few common mistakes both for the receiver and the sender of the information. Also from Wikipedia, here are common sender errors:

Figure 297: Angry Manager (Image Elnur with permission)

- **No frame of reference** – If the receiver is missing context for the message, they are less likely to understand accurately.
- **Omission of information** – The sender neglects to clarify important parts of the message, leaving ambiguity.
- **Inserting bias** – The sender inserts a personal opinion into a message that should be unbiased facts. This can cause the message to seem less trustworthy, or mislead the receiver about critical facts.
- **Ignoring body language** – It is quite possible to send an unintended message with body language and tone, or lack thereof in a medium that does not properly convey it.
- **Being unwilling to repeat information** – Especially in the presence of distraction, it is easy for a receiver to miss something important.

- **Disrespectful communication** – It is hard to think logically about a message presented in a hostile way.

38.5.3 Common Receiver Errors

And finally, here are the common mistakes by the receiver:

- **Listening with prejudice** – If the listener's mind is already made up before the sender speaks, vital details may be missed.
- **Poor preparation** – Listening is an active and conscious process that must be treated as such.
- **Thinking ahead of the sender** – Extrapolating, putting words in the sender's mouth. The sender saying "Hear me out!" may be a sign of this.
- **Ignoring nonverbal cues** – Failure to understand the full intended effect of the message.
- **Failure to ask for clarification** – When in doubt, rather than try to guess what the sender means, simply asking can be a lot more effective.
- **Disrespectful communication** – Replying with a knee-jerk insult will degrade communication.

Now, **go out, talk, and especially LISTEN to people, and organize your industry!**

39 How to Convince Your People to Do a Lean Transformation

Christoph Roser, September 28, 2021 Original at https://www.allaboutlean.com/how-to-convince-your-people-to-do-a-lean-transformation/

Figure 298: Workers in Factory (Image Nopphon1987 with permission)

Many companies want to achieve a lean production system. For this, these companies conduct lean transformations. And this in turn needs the buy-in of the people who will be working with the transformed system later on, usually the operators. However, a problem many lean transformations encounter is that … the operators don't want to transform! This is of course a challenge. Let's have a look at why this happens, and how you can prevent and overcome the issue.

39.1 Why Do Operators Resist Change in a Lean Transformation?

Figure 299: I don't want it… (Image Chatchai.wa with permission)

There are a number of different reasons why operators may resist a lean transformation, or generally any change to their working environment. First of all, **people don't like change**. They have adapted to the current situation, and changing this takes a mental effort. If you have the option to change or not, no change is usually the easier one.

This is closely related to the worry that a change project will **cause extra work for the operators**. Changing your system is a lot of effort, and some of the effort has to come from the operators, most likely the supervisors. Faced with extra work, some operators would rather not change.

Figure 300: Worried Worker (Image zorandim with permission)

A change also causes **uncertainty**. Of course, management promises that all will be better afterwards, but is it really true? After all, the promise of management does not hold much weight in all companies – sometimes even justifiably so. There are plenty of factories where the employees got burned by a previous Six Sigma or other project that made everything worse. In some factories this has even happened multiple times, and – understandably – operators are hesitant about the next crazy idea raining down from management.

Figure 301: PDCA Circle (Image Roser)

The operators may also have a **lack of trust** in the skills of the management or the lean transformation in general. Even if the planned change could work, operators may have been disappointed in the past by getting a half-finished system. The overall change was implemented, but nobody stayed around and helped the operators with the fine tuning, the fixing of all the small bugs and kinks, and the effort to make it into a workable system. Or, to use lean language, they did not do the "Check" and "Act" of the PDCA, which for me is the cornerstone of any lean project.

Finally, there is also the possibility that the future state – while being better for the company altogether – **may be worse** for the individual operators. For example, transforming a job shop into a flow shop is almost always beneficial for the plant. However, for an operator it is much easier to slack off in the chaos of a job shop, and management may have much more control over the workload in a flow shop. Hopefully, not too many operators in your plant want to slack off, but this may be a reason for some (although they probably won't say it outright).

39.2 How NOT to Get Operator Buy-In

Figure 302: I am here to motivate you… (Image kopitinphoto with permission)

Before I go into more detail on how to get the buy-in of the operators, let me first state how NOT to do it. **Do not use threats**, do not intimidate, and use pressure only in moderation or not at all. Do not do it like Captain Bligh on the *Bounty*, who supposedly said that "the beatings will continue until morale improves." Like Captain Bligh, you may have a mutiny on your hands. Also, do not use a death match scenario (the better plant will not be closed)

A newbie manager fresh from university may sometimes think that he is in control. Experienced managers know that it is more of a mutual cooperation. You cannot force workers to do something. Of course they will do it while you are looking, but the moment you turn around they will fall back into their old ways.

Figure 303: These are not the droids you are looking for … (Image The Conmunity – Pop Culture Geek under the CC-BY 2.0 license)

Also, your operators are not mindless drones. There are no three-step *Jedi* mind tricks to turn them into instant followers. Trying any cheap tricks is a serious lack of respect and has a high risk of backfiring. To work with your people, you need to respect your people!

39.3 How to Get Operator Buy-In

There are a couple of steps you can take to get the operator to cooperate and support the transformation. As mentioned above, these are not a three-step trick to switch them to your side, but these are actions that can increase your chances of success.

Figure 304: Talk with us. (Image Cherie A. Thurlby in public domain)

First, **explain to them why this transformation is necessary** – before you do the transformation. What are the targets? Does it increase quality? Does it reduce cost? How does this relate to the overall goals of the company?

This explanation is not easy. It is not just stating three bullet points, but it should be a serious attempt to convince your people of the need for change. This is usually easier during a crisis, because it will be more obvious to the employees that the company is at risk.

I also helps to **work on a problem that is also a problem for the operators**. If the workers often have machine problems, or lack of material, it will be much easier to get them on board to solve these problems.

Figure 305: Convince the alpha… (Image Brooks Tracy in public domain)

Probably the most important factor is to **involve the operators**. If the operators contribute to the decision making for the lean transformation, they will have a higher trust that it actually will work (because if you include the workers, chances are much better that it actually will work). Since you usually cannot include everybody on the project team, try to pick a respected operator who has the clout to convince the others. Include the alpha male (or female) in the transformation project team.

If you plan do to many similar transformations (e.g., turn a job shop into multiple flow shops, or to convert the entire value stream into pull, etc.), it may be worthwhile to **start with one section**. Sell it to the operators as an tryout (which it actually somewhat is) to let them become familiar with the new situation on a small scale before changing the entire plant.

And again, you need to show respect for your people and do the PDCA to have a chance at success. Now, go out, get the people on your side, and organize your industry!

40 Work Improvement before Equipment Improvement

Christoph Roser, October 5, 2021 Original at https://www.allaboutlean.com/work-improvement-before-equipment-improvement/

Figure 306: Maintenance Work in Industry (Image Somsak Sarabua with permission)

When improving a system, Western engineers love to take the technical approach and to optimize the machines and tools. However, at Toyota this is seen differently. At Toyota, they try to address a problem by first training the people, followed by improving the standards and the layout, before improving the equipment and finally twiddling with the design. Let's have a closer look at how Toyota is approaching improvements.

40.1 Introduction

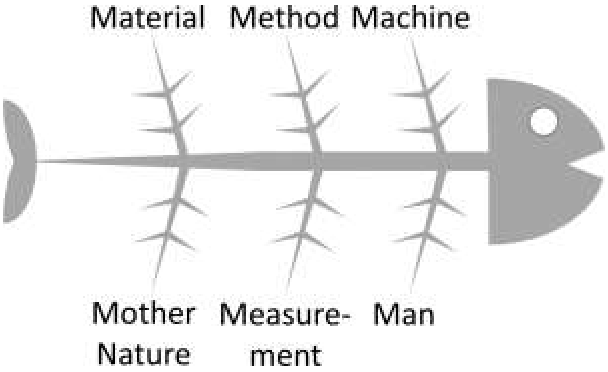


Figure 307: Fishbone Diagram (Image Roser)

There are different ways to improve a system or to remove problems. These different approaches can be grouped, and some structures are popular in the West. For example, when doing a fishbone diagram, it is often structured after the 4M: **man**, **machine**, **material**, **method**. Sometimes this is also expanded to 6M, with mother nature or milieu (i.e., the environment) and measurements. Even 8M (adding management and money) is possible.

You may be able to find solutions to your problem in any of these categories. If you are in the comfortable situation that you can choose your solution, Toyota recommends to go from man (training) to method (standards and layout) to machine (equipment) and finally to the product design (material). Of course, sometimes you do not have the luxury to choose from different solutions, and may have to go to, for example, machine right away. But if you do, following the sequence from Toyota is helpful.

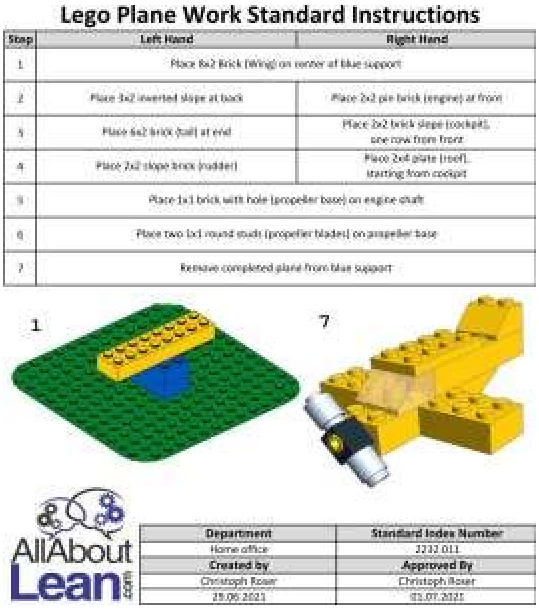
This sequence of **training-standards/layout-equipment-product design** is not arbitrary, but is based on important factors like **flexibility, speed, and cost**.

40.2 Training

Figure 308: Child at School (Image Russell Lee in public domain)

One of the easiest methods of improving a situation is by training the operators. And, Toyota puts a lot of effort into training. Compared to some other methods, training has the least impact on cost, and it is also very flexible. Training is usually connected to the use of a standard. This, of course, requires the standard to be good. Otherwise you may have to improve the standard.

40.3 Standards and Layout



Lego Plane Work Standard Instructions

<table>
<tr><th>Step</th><th>Left Hand</th><th>Right Hand</th></tr>
<tr><td>1</td><td colspan="2">Place 8x2 Brick (Wing) on center of blue support</td></tr>
<tr><td>2</td><td>Place 3x2 inverted slope at back</td><td>Place 2x2 pin brick (engine) at front</td></tr>
<tr><td>3</td><td>Place 6x2 brick (tail) at end</td><td>Place 2x2 brick slope (cockpit),
one row from front</td></tr>
<tr><td>4</td><td>Place 2x2 slope brick (rudder)</td><td>Place 2x4 plate (roof),
starting from cockpit</td></tr>
<tr><td>5</td><td colspan="2">Place 1x1 brick with hole (propeller base) on engine shaft</td></tr>
<tr><td>6</td><td colspan="2">Place two 1x1 round studs (propeller blades) on propeller base</td></tr>
<tr><td>7</td><td colspan="2">Remove completed plane from blue support</td></tr>
</table>

Department	Standard Index Number
Home office	2232.011
Created by	**Approved By**
Christoph Roser	Christoph Roser
29.06.2021	01.07.2021

Figure 309: Left Hand Right Hand Lego Plane Standard (Image Roser)

The next possible step is to improve the standard. For more details on standards, see my 9 post series on standards. This is still comparatively easy to do. However, in order to change the standard, you do have put in quite a bit of effort to make sure that the new standard is actually better than the old standard, not just different or even worse.

Figure 310: PDCA Circle (Image Roser)

Depending on the standard it may take a few people a few days to create a better standard. Do not forget the PDCA! If for some reason it turns out that the new standard is actually worse, it is a bummer but not a disaster. Changing a standard can (and should) be done regularly, and you have lots of flexibility to try things out.

You also need to train the operators in the use of the new standard. This may not require a full training, but maybe just an update. Nevertheless, you (or someone) should verify that the operators use the new standard.

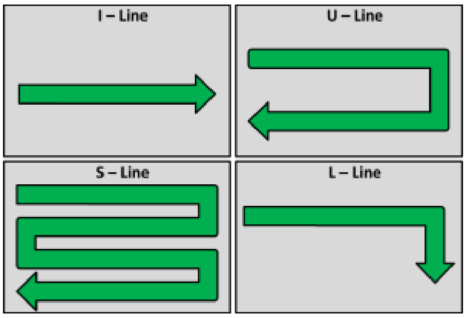


Figure 311: I U L S Line layouts (Image Roser)

Toyota also considers changing the layout something that can be done quickly and easily. Toyota actually aims to build manufacturing lines that can be rearranged quickly. See my post on this for more details. Especially for manual assembly of smaller parts, some companies opt to have all machines and tables on wheels, with flexible connections to electricity and pneumatics. If you want to rearrange the line, just unlock the brakes and unplug the gear, move the stuff around as you want, and then connect the lines again and lock the brakes. Hence, changing a line layout is something Toyota likes to do frequently, and it can be done even on a trial-and-error basis.

40.4 Equipment

Figure 312: Tractor Assembly (Image Oskanov with permission)

Now we finally get to change the equipment. As you can imagine, it becomes more expensive, will take more time, and becomes harder to undo. Like many methods in lean manufacturing, it is quite obvious once you start to think about it. To improve a machine, you also need to do a project. The difference from a project to improve the standard is that now you also need (more expensive?) engineers and technicians. You also need new parts or even new machines. It may also take longer. All of this makes it more expensive.

This does not yet even include the possibilities that the equipment modification may fail – while to me it appears that Western managers often expect any project to be a success, and failure is not an option. Well, in reality projects do fail. You may have to backtrack, do some trial and error, and may need multiple iterations to achieve the goals. PDCA is highly relevant for machine improvements, too! All of this, unfortunately, costs money and makes the whole process more expensive than simply changing the standard.

New, or at least different, equipment also may need an update to the standards, and an update to the operator training. Hence, all of the expenses for changing standards come on top of the (multiple) machine change expenses. Besides, if you did not train your operators properly in the use of a good standard in the first place, any equipment change has a high change of failing, and in the worst case it may even injure a worker or a customer. Standards and training are the prerequisites for using any equipment in manufacturing.

40.5 Product Design

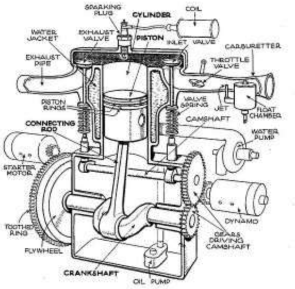


Figure 313: Engine drawing (Image Andy Dingley in public domain)

Finally, there is product design. Some improvements can be made and problems avoided through product design. You probably have heard of tools like Poka Yoke, or Design for Manufacturing and Assembly. A good product design can avoid a lot of problems. That's why it should be done when the product is designed. Doing it for an existing product may also work, but now it becomes more expensive. A changed product may require a change to the equipment. For example, if your injection-molded part is changed, you may need new molding tools. You may also need changes to specialized machinery. As we have learned above, changes to the machines may require changes to the standard. And a changed standard in turn requires re-training. All of this will cost money.

You should also not forget the additional paperwork. New parts require new part numbers, testing, and documentation. You have to phase out the old parts and introduce the new parts. Excess old stock may have to be scrapped. It can be quite an effort similar to the introduction of a new product.

40.6 Summary

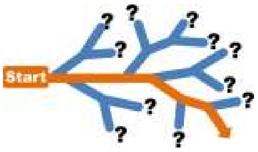


Figure 314: Too many Options (Image Roser)

Overall, when solving a problem or generally improving a system, see if you can do it through training. If not, see if you can do it by updating the standards or improving the layout. If not, see if you can improve the machines and tools. Only if all else fails should you consider changing the product.

Unfortunately, sometimes you need to go for the expensive options. Not all problems can be solved through training and standards. Sometimes you may also need a combination of actions to achieve the goal.

The above recommendation is also not a strict rule; it has quite a bit of leeway. There may be situations when changing the machine may be cheaper than changing the standard for the same results. An example may be a broken part of a machine, in which case you should of course fix it, which may not require a change to the standards. And sometimes, a change in the product design is just the best option. But please do not automatically change the machines or the product without first checking whether training or a change to the standards would have solved the problem. Now, **go out, solve your problems and organize your industry!**

41 Ten Years of Industry 4.0-Quo Vadis?

Christoph Roser, October 12, 2021 Original at
https://www.allaboutlean.com/ten-years-of-industry-4-0-quo-vadis/

Figure 315: Industry 4.0 (Image Fauziart89 with permission)

Pretty much ten years ago, in April 2011, Industry 4.0 was first presented to the audience at the Hannover Messe in Germany. Industry 4.0 made lots of promises about everything getting better and easier. But, <*surprise Pikachu*>, it did not. Let's have a look.

41.1 Introduction

Industry 4.0 is (supposedly) the fourth industrial revolution after the first (mechanization and steam power), the second (electricity and mass production), and the third (computer). Networking everything will (supposedly) solve a lot of problems. If you are a regular reader, you know that I am somewhat skeptical of a lot of these claims. See also my posts A Critical Look at Industry 4.0 and Industry 4.0 – What Works, What Doesn't.

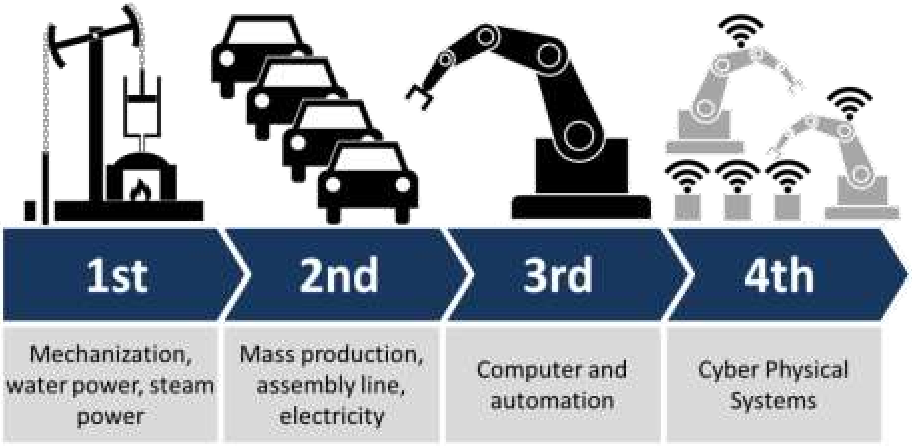


Figure 316: Industry 4.0 (Image Roser)

41.2 A Look at Productivity

In this post (inspired by a German article, source below) I am looking at the impact of Industry 4.0 on manufacturing. Usually, improvement in manufacturing is measured as labor productivity (i.e., how much goods a worker can produce in a given time). For countries this is usually measured as a monetary value per worker or per worker-hour. Luckily, these statistics are readily available.

The graph below shows the annual percentage change in manufacturing labor productivity in Germany (available data 1970–2020 Source) and the USA (available data 1987–2019 Source), including the ten-year moving averages (dotted lines). I also indicated the period when Industry 4.0 became a buzzword, which is from 2011 onward (albeit the topic is – frankly – not new).

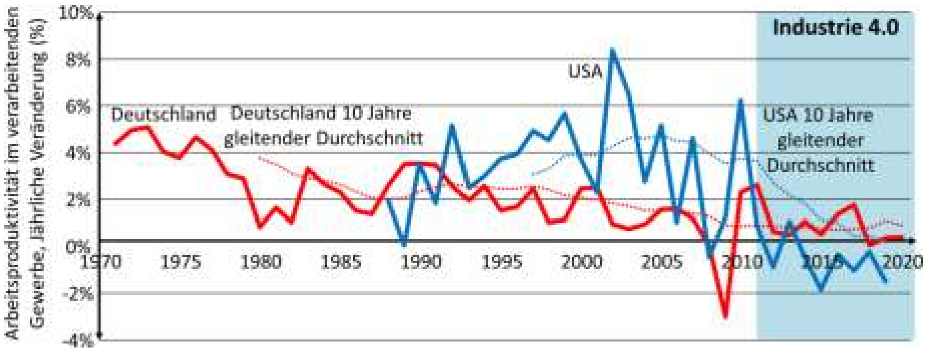


Figure 317: Manufacturing Labor Productivity 1970 to 2020 Moving Average (Image Roser)

If you are a strong believer in Industry 4.0, you may have expected a stronger growth due to the… well… revolution going on. In fact, the opposite is happening. Manufacturing productivity growth during the last ten years was definitely lower than in the decades before, and sometimes even negative. It almost looks like "the revolution" is slowing productivity.

Going a bit further back to the 1950s, the graph below shows you the overall labor productivity (not only manufacturing) for both Germany and the USA, again including the ten-year moving average as a dotted line and showing the period of Industry 4.0 (source).

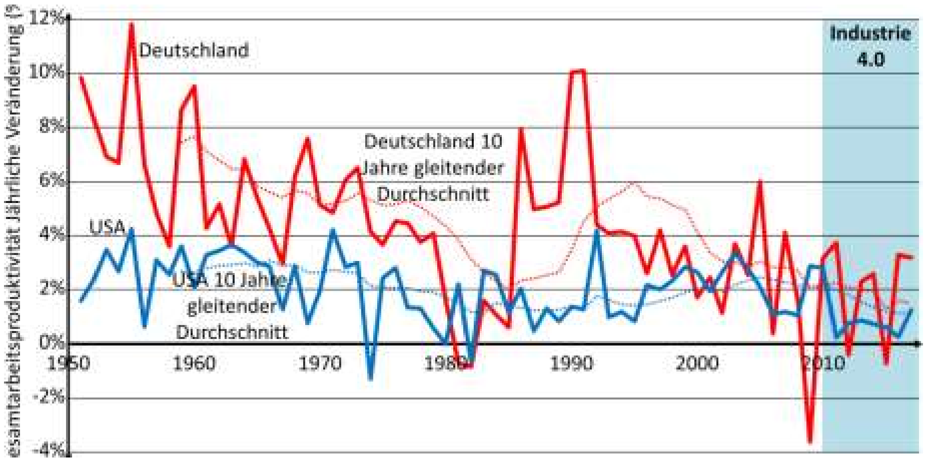


Figure 318: Labor Productivity 1950 to 2017 Moving Average (Image Roser)

Since this graph merges all productivity (besides manufacturing, also agricultural, services, mining, etc.), the effect is no longer as pronounced, but still there. Productivity growth in Germany is the lowest since World War II, and US productivity is not so hot either. But most decidedly there is not any uptick visible. What happened to the promised improvement from our new revolution? To be fair, there are lots of other factors that can affect productivity, from orange presidents to viral pandemics. But overall, the impact of Industry 4.0 on manufacturing is still disappointing.

41.3 Why Is There No Revolution?

Figure 319: Always! PDCA Circle (Image Roser)

Clearly, there is no revolution. If anything, productivity growth is less than before. In my previous posts I wrote a lot on caution when dealing with the Industry 4.0 hype. Some things work, but a lot of things don't. And you need to do thorough PDCA to make sure it does work. As well, it is much easier to sell the hype together with software, services, or consulting, than it is to actually provide bottom-line results.

Figure 320: Got the shovel, need the gold… (Image unknown author in public domain)

I believe Industry 4.0 is profitable for software vendors, service providers, and consultants, but only sometimes for the actual manufacturer. It is like a gold rush, were your best bet on making money is to sell shovels, and a possible way to lose money is to dig for gold. Some people DO get rich, but most don't.

It is the same in manufacturing. Some companies benefit immensely from Industry 4.0, but I believe the majority of companies are better off being followers than leaders. It also depends on how you interpret Industry 4.0 (*You're using email? Hey, you are a digitally networked cyber-physical Industry 4.0 company!* … or maybe not)

One of my colleagues, Steffen Kinkel, believes that companies put effort into digital systems but neglect to solve the fundamental problems on the shop floor. Putting a digital twin on an inefficient process does not magically make the process efficient. Data can help in making it efficient, but you still need to put in the effort to improve the underlying process. Unfortunately, many companies skip on this actual improvement part in favor of more digitization and more data … which they then don't use either.

Figure 321: (Image unknown author in public domain)

But there is still a lot of improvement potential. One German study, *Wertschöpfungspotenziale 4.0* (source below), finds still 95 billion Euro potential for improvement in the German industry by using lean manufacturing, or roughly 14%. Personally I think there will be more, but that is just a hunch. Unfortunately, investment in improvements and new equipment is reduced in favor of research and also digital toys… sorry… tools. But while painting a car makes it look nicer, it does not fix the broken engine.

Figure 322: Shoe Repair Japan (Image Kusakabe Kimbei in public domain)

Investing in research, of course, is valuable. But you also need to actually make the product. This is, I think, part of the German mentality. We love to engineer, design, and make blueprints. But the building of the product is more of a hassle that has to be done. (It is different in Japan, where the art of making things is part of the Japanese culture). It should be obvious that for a company to be successful, you need a combination of different factors. You need research, design, sales, AND manufacturing. The weakest link will limit your success. With all the glitzy digital companies from Google to Facebook, manufacturing does look old-fashioned and boring to some. But this is wrong. Both the Roman and the Chinese Empire fell far short of their potentials because manufacturing was left to the slaves and those not smart enough for politics or military (trust me, I wrote the book on this).

In sum, Industry 4.0 is NOT a shortcut to solve problems, but at best an aid. It does not magically solve problems and make you better. You still need to take care of all the little things on the shop floor. Overall, we continue to need manufacturing, and to invest and improve manufacturing, to be successful. Now, **go out, fix some problems on the shop floor, and organize your industry!**

41.4 Source

This blog post was inspired by an article from the German magazine Heise "Zehn Jahre Industrie 4.0: Null Produktivitätsfortschritt", written by Alexander Horn, which was pointed out to me by Dr. Tom Drews. Many thanks, Tom! This article is based on the (also German) report "Wertschöpfungspotenziale 4.0" by Steffen Kinkel, Sebastian Beiner, Arndt Schäfer, Heidi Heimberger, and Angela Jäger.

42 Military Leadership and Disobedience

Christoph Roser, October 19, 2021 Original at https://www.allaboutlean.com/military-leadership-and-disobedience/

Figure 323: US Combat Training in Germany (Image US Army in public domain)

In a recent LinkedIn discussion, there was a disagreement on leadership favoring a much more authoritarian leadership style and stating "A general who asks his soldiers if they will fight, he is not yet ready for war." I disagree with this view, both for military and especially for manufacturing. Yet, this discussion inspired me to write two posts on the difficult subject of leadership. This first post here looks in more detail at military leadership, and the occasional need of soldiers to refuse, ignore, or disobey an order. A second post will look at what this means for manufacturing.

42.1 Military Leadership in Theory

Figure 324: YES SIR, SERGEANT, SIR! (Image W. C. Prados in public domain)

Probably some of the strictest institutionalized decision making is found in the military. The officer in command gives an order, and the soldier executes the command without hesitation. In the military, this may often make sense. The common soldier usually does not have an overview of the overall strategy, and even if the soldier were allowed to know the master plan, there may be not enough time to discuss all the questions while the bullets are flying. Hence, usually it is a good approach that the soldier follows orders instead of questioning if the order is really good.

42.2 Military Mistakes

But, of course, this does not mean that the leader makes no mistakes. In fact, history is full of flawed military decisions, from small skirmishes to large-scale battles. The war in Iraq was started to find "weapons of mass destruction"… which were not there. British, Russians, and Americans invaded Afghanistan with some regularity, only to find that this was a costly mistake. The Vietnam War was maybe also not so hot, as far as decision making. And we Germans started the biggest war ever … twice! Bad decisions go all the way up to a country's leadership.

Come to think of it, most wars are probably a mistake …

42.3 Soldiers Can Disagree, Too

The soldier is supposed to just follow orders, but in reality most soldiers have quite an opinion on their work, especially if it is THEIR life on the line, and not the ones of the old guys (and sometimes girls) back home making the decisions. If soldiers disagree, while not legally, in reality they do have ways to act. The easiest one is dragging their feet. They follow the orders, but not with much enthusiasm or speed.

Figure 325: He did NOT end the world in 1983… (Image Queery-54 under the CC-BY-SA 4.0 license)

They may even refuse orders altogether. When NORAD did a test to see if soldiers would launch a nuclear missile (without knowing that it is only a test), quite a few soldiers disobeyed and did not want to start World War III. This may have actually saved the world, when Stanislav Petrov in 1983, on duty at the Russian early warning command, decided not to forward the information of a nuclear attack of the USA on Russia, believing (correctly) that this was a computer glitch.

Refusal can also become aggressive, and during the end of the Vietnam War quite a few soldiers voiced their disagreement by throwing a hand grenade at their superiors, which is known as "fragging." German soldiers, during the end of both World Wars, sometimes just shot their officers in the back.

Figure 326: DDR Steel Watchtower (Image DefenseImagery in public domain)

Or another example (again from Germany): While Germany was divided into East and West Germany (1949–1990), the East German border guards had strict orders to shoot to kill if a defector tried to flee East Germany to the much freer and democratic West Germany. (For PR reasons, this order was paused during public holidays.) This caused the death of at least 260 people. However, at least some guards turned out to be very lousy shots, missing the target even at short distances.

Figure 327: Still standing … (Image Yann Caradec under the CC-BY-SA 2.0 license)

Even officers refused orders. In 1944, when World War II was pretty much lost, Hitler ordered his commander of Paris to defend the city under all circumstances, no matter the cost of civilian lives or property, and to destroy the city if defense was impossible. The commander refused and simply surrendered to the Allied Forces.

Or, to give you a more recent example, the UN peacekeeping mission in Bosnia in the 1990s. Following the break up of Yugoslavia, the conflict in the Balkan escalated, including ethnic cleansing, mass-rape, genocide, and other war crimes. To de-escalate the conflict, UN peacekeepers were sent.

Now, I am not a military expert, but to me it seems like politicians like to send UN peacekeepers, but with orders not to hurt anybody or even shoot, because that would make the politicians look bad. It seems they hope that just putting some blue helmets nearby will impress the other factions… which it usually does not. Politicians also like to micromanage their troops. Many other forces were helpless, and the soldiers tasked with protecting Srebrenica were barely able to protect themselves during the Srebrenica massacre. They did follow their orders to the letter, though.

Figure 328: I am here to keep peace, AND I MEAN IT! (Image Bundeswehr-Fotos under the CC-BY 2.0 license)

Not so Ulf Henricsson, the Swedish commander of a Swedish-Danish-Norwegian battalion. Swedish soldiers are taught that the overall goal is more important than rules and orders. Hence, Ericsson ignored orders from the start. For example, he decided not to take only lightly armored vehicles and small arms, but brought Leopard battle tanks. When his forces took hostile fire, they simply shot back, regardless of the rules of engagement. When he was ordered to stand down, he pretended the radio did not work. The goal of his mission was to protect the civilian population, and he did what ever was necessary to protect them. While he was called trigger-happy at home, the opposing forces quickly learned not to mess with him, and the local civilians were much better off for it. (For a good write up see Trigger-Happy, Autonomous, and Disobedient: Nordbat 2 and Mission Command in Bosnia)

42.4 Soldiers Sometimes MUST Disagree!

In fact, most modern militaries have laws that a soldier must refuse an unlawful order, and soldiers following orders have been prosecuted for this (e.g., for the Mỹ Lai massacre). German military law, for example, says that a soldier must refuse an order if the order is unlawful or if it violates human rights and dignity (yes, we don't want to be responsible for World War III).

42.5 Sometimes Soldiers Are Intentionally Out of the Loop

Figure 329: Obama Getting News about Bin Laden (Image Pete Souza in public domain)

Military also has (often but not always) realized that micromanaging a soldier on the ground is not good. It delays decisions, decisions are made by someone faraway from the facts (the Gemba if you so will), and it creates a culture of distrust and leads to inferior results (which, for the military, often means death). When Seal Team Six killed Osama Bin Laden, President Obama and his team were watching the live video stream. Technically, it would have been easy for the leadership to also give orders to the soldiers in real time, but this was not done intentionally and the soldiers on the ground were making their own decisions to achieve the mission goal.

I am not a military expert (despite lots of experience playing Metal Gear Solid). But overall, the idea that a leader knows all the answers is a fallacy. Even the idea that the leader knows best is usually not true. Of course, the same is true for the followers. If time allows it, the combination of different views usually gives best results. Hence, even for the military, disagreement, independent thinking, and sometimes even disobedience is often good for the overall results (although the military is still unsure about how much disobedience it wants). In my next post I want to apply this learning from military leadership to the shop floor. Now, **go out, enable your people to make their own decisions, and organize your industry!**

43 The Boss Knows Best … or Does He?

Christoph Roser, October 26, 2021 Original at *https://www.allaboutlean.com/the-boss-knows-best-or-does-he/*

Figure 330: Businessman is pointing at himself (Image igorp17 with permission)

This post is on a topic you probably all have had experience with at one point or another (or even all the time) in your career. A superior makes a decision, and you are internally wincing because you know right away that it is a really bad idea. In this post I would like to talk about uncertainty and decision making, and how to make better suggestions. If you are a regular reader of my posts, you probably already know the answer: **Involve the employees!** This post is a continuation of my previous post on military leadership.

43.1 Introduction

Figure 331: US Combat Training in Germany (Image US Army in public domain)

In my previous post, I described that the military believes in a strong structure of command and control. The officer orders and the soldier follows the order… except, often they don't. There may be different levels of disobedience that actually may be beneficial. Using soldiers only to execute orders will fall far short of the possibilities.

43.2 Who Knows Best?

Figure 332: Valve Assembly Line (Image The Light Writer 33 with permission)

This is also true for manufacturing. Larger decisions should not be made by a single person. Plus, the people closest to the actual location (i.e., the Gemba) often know best. A lean improvement project on the shop floor touches the usually very complex production system, with lots of technical and organizational details. Mess any of them up, and the "improvement" may make it worse.

Even though the salary does not always reflect it, manufacturing does require skills. Every new employee will take some time to get up to speed, and even more time to become really good at their machine. If you don't believe it, go to your shop floor, pick a manual process, and try to do it. You may be able to do it, but much slower than any of the people doing it daily for the last five years.

The workers also have a good "feel" of the process. A good example is your car. If you use your car regularly, you will probably notice a minor quirk in the steering, or a slightly odd sound from the engine or transmission, quickly. In a rental car you wouldn't notice, because you do not know what a normal process sounds like. Similar in manufacturing, the operators know their process best.

43.3 Why to Involve Multiple People

Figure 333: Workers in Factory (Image Nopphon1987 with permission)

I am not saying that the shop floor workers have all the answers. Definitely not. In all likelihood, nobody knows all the details.

You have workers on the shop floor who know how the process will react to changes, and can often estimate the impact on their work (although some workers may have an overly pessimistic view). You have logistics people who can estimate the impact on the material flow. You have maintenance and programming who can determine if it is doable technically. And you have managers (yes, they do serve a purpose too!) who can determine whether the improvement is aligned with the overall goals of the company. Management is also needed to enable and support the improvement process in the first place.

Therefore, if you involve people from the different factions and stakeholders, you have a much better chance of getting all the relevant information. This helps not only to figure out what does not work, but can also give additional ideas for things that may work even better!

43.4 How to Involve Multiple People

Figure 334: Industrial engineer (Image ndoeljindoel with permission)

The simplest way to involve multiple people is to have a number of checkboxes or signatures, and everybody signs off on the project. But this is worthless, as due to time pressure very few will actually look at the documents in detail. Upper management, for example, signs dozens or hundreds of documents daily, hoping that the secretary did prepare the signature stack well and none of the signatures will blow up in their face. A simple signature checklist is a waste of time.

It is much better (albeit much more time consuming) to involve the people in the development of the improvement project. From the beginning with the analysis of the problem to the development of the solutions, selection and improvement of the solutions, to the implementation and finally the verification

(PDCA), representatives of the different stakeholders should be involved. This way they not only can find potential problems, but also potential solutions. Involving the operators also increases the buy-in and the likelihood of acceptance by the shop floor. I actually wrote an entire post on My Workshop Structure for Creative Problem Solving.

There may also be minor projects where a single person can do the work, but this is probably rare.

43.5 Why Leadership (Often) Does Not Like It

Figure 335: Frowning Manager (Image Sarah Cheriton-Jones with permission)

Involving the shop floor workers can significantly improve the outcome of the project, or make it possible in the first place. However, some managers have difficulties with this. There is of course the time pressure – involving multiple people takes more time than a single decision maker. But often, the expected behavior of the manager may clash with asking the workers. Let me go a little bit deeper on this.

Management is not easy. Everybody wants something from you (a raise, cheaper products, better quality, stock market performance, …), while the manager has limited time and has to make his decisions with often great uncertainty on the outcome (will the new product be a success or a flop?). No, definitely not easy.

Additionally, managers are often under constant scrutiny. Mess up, and it may impact your career. Look weak, and a more decisive fellow manager may get the promotion. And that is (often) the problem here. Managers usually can ill-afford to look weak. On top of this, managers often have a lot of insecurity due to the uncertainty, although usually well hidden (most sane managers constantly worry if the decision is the right one – it is the managers that do not worry who concern me).

Figure 336: Manager under pressure (Image AndreyPopov with permission)

As a result, managers feel they have to make decisions, even if it would be better if someone else makes the decision. Anyone questioning their decisions may make them look weak, and (some) managers use their power to oppress any critical questions or negative feedback, even if it is fully justified. You probably know such a manager who collects yes-men (and women) around them who support his decisions no matter what. In my view, the culture in the company selects its managers accordingly, and there are some companies where you need to look tough to advance, and others where it is more based on actual results (not only presented results, mind you).

Luckily, there are also managers who do a much better job of involving the employees, getting their input, and respecting their people. Hopefully you are such a manager, and/or working under such a manager. Now, **go out, involve your people, and organize your industry!**

44 Can You Plan Around Your Fluctuations?

Christoph Roser, November 2, 2021 Original at
https://www.allaboutlean.com/plan-around-fluctuations/

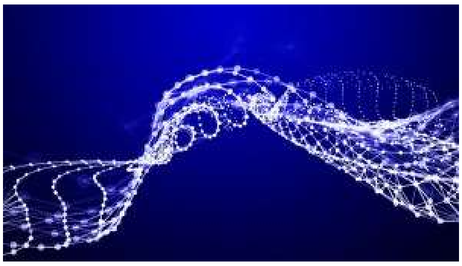


Figure 337: Abstract Wave Molecule (Image Drevynskyi Maksym with permission)

Balancing the need of high material availability with low inventory is tricky. Pull systems are a very good way to achieve this. But sometimes people argue with me that planning can be better if you use all the available information to create a production plan which then outperforms a pull system. In theory, this could work, but in practice it rarely does. After all, that is what conventional push systems are trying to achieve, usually with mediocre results. Let's have a look.

44.1 Introduction

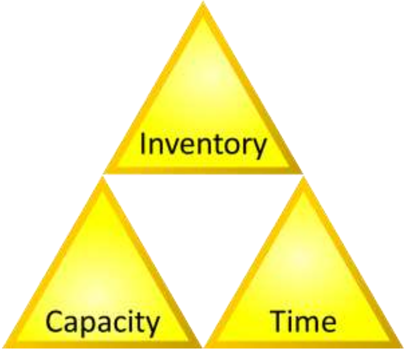


Figure 338: Inventory, capacity, and time can decouple fluctuations. (Image Roser)

The reason that we need inventory is primarily to decouple fluctuations. Other ways to decouple fluctuations are adjusting capacity (tough to do on short notice) and waiting (which always works, but often it is least desirable to let the customer wait). Often, inventory is simply the best choice to decouple short-term fluctuations. Of course, even better but much harder is to reduce fluctuations so you don't have to decouple them afterward.

Your production system is also a potential cause of fluctuations. Leveling aims to reduce these fluctuations. However, breakdowns and other disruptions increase fluctuations. A bad production program can also increase fluctuations. In theory, there is another option to handle fluctuations: You could just run your production system in sync with the fluctuations.

Figure 339: All synchronized? (Image Xavier Vergés under the CC-BY 2.0 license)

For example, if your customer requires more products, you would not need inventory if you just happened to produce more of these products. If your customer requires less, you would not increase inventory if you just happened to produce less of this product. If the output of your production system is perfectly synced with the demand, you would not need any inventory and would still achieve 100% material availability.

If you are in production, you probably already see a lot of holes with this plan. I agree on this. But, just for the sake of understanding, let's have a look at what would be necessary to make this perfectly synced production system a reality, and why it is not possible, or at least is possible only in a limited way.

44.2 The All-Knowing Production Planner

In theory you can imagine (or dream) of a perfectly synced production system, where each produced item would perfectly match the customer demand. One possibility would be a system where there are no fluctuations at all… which is a fallacy. In reality, every production system fluctuates, some more, some even more, and some even much more.

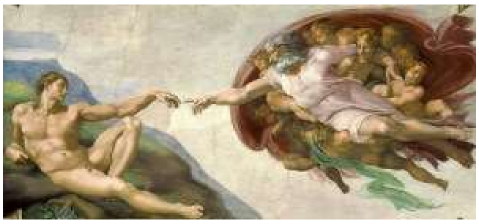


Figure 340: Michelangelo Creation of Adam (cropped) (Image Michelangelo in public domain)

Another purely theoretical option would be to know all fluctuations beforehand and plan around them. You would know for every part sold when the customer would order it, you would know all machine breakdowns, all supplier delays, and anything that will happen on your shop floor way before it happens.

In this case, you could include all fluctuations in the production plan, ensuring that a part is completed exactly when you need it, not earlier or later. Inventory would only exist to be worked on, or if you decide to go for larger batches (i.e., you would not order every screw separately, but a box of 500 when you need the first screw, or you may have larger lot sizes due to changeover times).

Obviously, knowing all fluctuations beforehand is impossible. You are not an all-knowing god on the shop floor, and some fluctuations you simply do not know beforehand.

44.3 Foreseeable and Unforeseeable Fluctuations

Figure 341: Some things you can see before they hit you… (Image Lt. Wayne Miller in public domain)

Some fluctuations you know beforehand, others only after they hit you, and some you may not even notice. With some effort you can predict maybe a few more fluctuations, but it is impossible to know them all. The question is: Can you use your knowledge of foreseeable fluctuations to reduce the inventory level and produce closer to the customer demand, even if it is not perfect?

This is possible, albeit with limitations. It is done frequently, with a common example being seasonality. Seasonality is often decoupled by increasing and decreasing capacity. You can also decouple seasonality by increasing and decreasing demand (e.g., if you are using pull systems, increase the inventory target or the number of kanbans before the season, and reduce afterward). If you are working in production, I am pretty sure you have done something like this. Similar build-ups of inventory are also common for larger maintenance shutdowns, replacement of machines, or other foreseeable and major fluctuations.

And this brings me to a key point: Besides being foreseeable, these fluctuations are major. What about doing the same thing for smaller fluctuations by adjusting the production plan and capacity to have inventory for these smaller fluctuations? Sounds too nice to be true, right?

Figure 342: Paperwork overload (Image isn5000 with permission)

It is too nice to be true. While it is possible in theory, it quickly becomes more and more work for the planning. Instead of doing this two (seasonality) or three times (maintenance) for a product or line per year, you would have to do this weekly or even daily. This would be a lot of effort. Few planning departments would be prepared for this enormous increase in workload. In the extreme case, every product would be make-to-order for the predicted customer demand. This would be an immense workload. And you still would have to deal with the unforeseeable fluctuations. At one point, the reduction in inventory would simply no longer be worth the effort to do so.

Many ERP push systems try to calculate the schedule on the best available data, but still need safety buffers (time or inventory) for unforeseen fluctuations. Despite all that, they usually perform worse than pull systems. If you would try it, you would end up with a push system, having lots of work, and the unforeseeable fluctuations would still mess things up significantly (especially for job shops, where small fluctuations can have an enormous impact on the lead time).

44.4 If You Do It, Do It with Pull

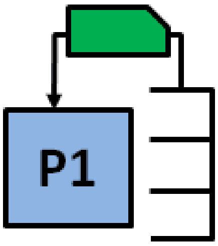


Figure 343: Simple kanban loop (Image Roser)

There is one way out of this, which could be a good compromise between workload and impact. You do it with a pull system. A make-to-stock pull system is an (almost) automatic system to refill your inventory to the target level. The only thing you adjust periodically is the inventory level.

Well… adjust more often. Foreseeable fluctuations can be handled by increasing and decreasing the inventory level in your pull system. Increase or decrease the number of kanban to match the expected fluctuations. But again, this is not easy. If your pull systems are quite new, then put your effort on improving the stability of the pull system. Adjust only infrequently (maybe every quarter, or only twice per year for seasonality), even if you may have a sliver more inventory than bare-bones necessary. Because frequent adjustments of the inventory level are still quite a bit of work, albeit probably easier and definitely more stable than scheduling every single product.

Figure 344: Source Make Deliver Fluctuations (Image Roser)

If you have the planning capacity for more frequent adjustments, you could adjust more frequently. Or, you could put the effort into reducing fluctuations! Rather than addressing the symptoms by planning with the fluctuations, you could address the root cause and reduce fluctuations! Overall, I am not always convinced that a higher planning effort is worth a small reduction in inventory, but of course it depends on the details of your industry.

44.5 Summary

Sometimes software tools are sold with the promise to plan around the fluctuations. I believe this is an enormous effort and nevertheless has a high risk of stock-outs. If you really want to adjust to fluctuations, don’t do it for every part, but for short periods by adjusting the inventory limit of your pull system. This will be much easier and much more stable. But if you can, put your effort into reducing the fluctuations rather than managing them. Now, **go out, reduce your fluctuations, or let your pull system take care of them if you are short on time, and organize your industry!**

45 How to Prioritize in Changeover Sequencing

Christoph Roser, November 9, 2021 Original at https://www.allaboutlean.com/prioritize-changeover-sequencing/

Figure 345: Mom and daughter eating ice cream (Image oksix with permission)

Changeovers take away time from production, and often require larger lot sizes as well. The best response would be of course to reduce changeover times, but this is a lot of work and may not always be possible. Another frequent option is to sequence the changeovers to reduce the overall changeover time. This post looks at a way to sequence production while also being able to prioritize production.

45.1 Introduction

First of all, changeover sequence is only useful if the changeover duration (or maybe the cost) depends on the product group. If all changeovers have the same duration regardless of the product, a changeover sequence is useless. It would actually be worse than useless, since you delay the information flow and hence increase the replenishment time, without getting any benefit out of it.

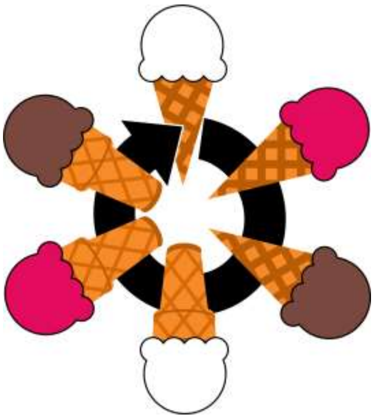


Figure 346: Ice Cream Change Over Wheel Three Flavors Two Cups (Image Roser)

However, changeover sequencing may be helpful if some changeovers are faster than others. By optimizing the sequence, you can reduce the overall changeover time – but at the cost of an increased lead time and hence either longer delays for make-to-order jobs or higher inventory (or stock-outs) for make-to-stock items. I already discussed non-prioritized changeover in two previous posts on changeover sequencing part 1 and part 2. The example I used was ice cream, where changing from a lighter color to a darker color requires less cleaning, as well as larger tool changes for using different types of waffles, than the other way round. The result was a changeover wheel (i.e., a sequence in which to produce the different types of ice cream, as shown here).

45.2 What to Prioritize

Figure 347: Older Couple Eating Ice Cream (Image manpeppe with permission)

Sometimes, you may have jobs that are of higher priority or urgency than others. These you may want to put to the front of the queue for production to reduce waiting time and to accelerate the lead time. Often, these could be **make-to-order jobs in a system that does mostly make-to-stock production**. If you can accelerate the make-to-order products, your customer has to wait less. If your workload is no more than 20-30% make-to-order, the corresponding increase in inventory is minimal.

Another example is **make-to-stock items that you are in danger of running out of**. Rather than simply waiting until the next production is planned according to the changeover sequence and running out of stock, you may want to escalate and prioritize the critical items to the front of the queue.

Figure 348: Ice Cream (Image Jenifoto with permission)

Much less recommended but also possible is to **prioritize low-quantity make-to-stock parts**. The demand fluctuates proportionally higher for low-volume parts than for high-volume parts. You could reduce the low-volume make-to-stock inventory by prioritizing these parts over the high-volume make-to-stock items. However, the prioritization is a lot of work, and I would hesitate to put in the effort just to reduce the total inventory by 3%.

If your system produces only make-to-order, the prioritization is already part of the sequencing process, and you may not need an additional prioritization for the changeover sequence.

In this blog post I will continue the example of **different ice cream flavors and two types of waffles** from my previous posts. However, besides the high-demand and high-volume make-to-stock ice cream flavors **chocolate**, **raspberry**, and **milk**, there will be additional make-to-order ice cream in the much less popular flavors like **natto** (Japanese fermented soy beans… where the word fermented is used euphemistically), **haggis** (Scottish chopped sheep offal stuffed into unchopped sheep offal), and **surströmming** (Swedish bioweapon disguised as food). I actually do like haggis, and I have eaten natto and am sure that I don't like it, but I am not man enough to open a can of surströmming, let alone eat it. And yes, all of these three ice cream flavors do exist somewhere in the world!

Figure 349: The less popular custom-order ice cream flavors of Natto, Haggis, and Surströmming Natto, Haggis, Surströmming (Image Kinchan1 and Beck under the CC-BY 2.0 license as well as Lapplaender under the CC-BY-SA 3.0 Germany license)

45.3 A Very Fast But Inefficient Way to Prioritize

The easiest but potentially most inefficient way to prioritize is to simply put the prioritized item at the very front of the production jobs. When the current job is done, you change over to the priority job. Afterward, you change back to the next job in the regular sequence. This would be the fastest, but also potentially very cumbersome, as you may need a longer changeover, twice!

Let's take again the example of the ice cream. You have your sequence of going from light- to dark-colored ice cream, repeating this twice for the much more cumbersome exchange of the waffle tool. However, the king of Sweden makes a rush order for surströmming in a cup just after you did the raspberry in a cone. Now you not only have to change the flavor (you have to do that anyway for surströmming no matter when you do it), but you also have to spend a lot of time changing the waffle tool from a cone to a cup, only to change it right back to a cone after you did the surströmming, only to change it again to a cup after you complete the chocolate flavor. Overall you need three waffle tool changeovers instead of one. That is quite a lot of changeover effort just for a single rush order.

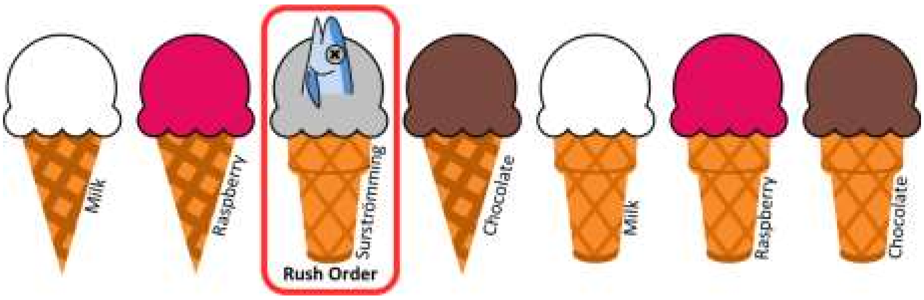


Figure 350: Ice cream Sequence Rush Surströmming (Image Roser)

45.4 Find a Good Spot to Prioritize

If the rush order could wait just for one more flavor, then you could first complete the chocolate-flavor cone. Only after that do you switch the waffle tool to the surströmming cup, including the cleaning for the new flavor. The advantage is that now instead of three waffle tool changeovers above, you need only a single waffle tool changeover below (but you still have to clean the machine for the new flavors).

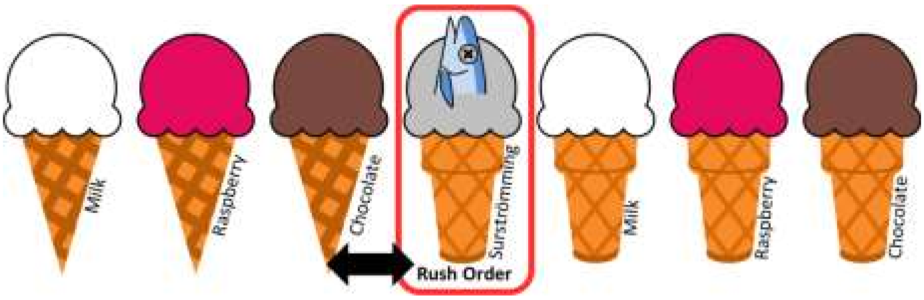


Figure 351: Ice cream Sequence Delayed Rush Surströmming (Image Roser)

You could have optimized it even more, and did the surströmming cup after the milk-flavored ice cream cup, and saved a bit of cleaning effort when changing from white milk to gray surströmming. However, the saved changeover time would be very short, and depending on the urgency of the rush order you may still prefer to do the surströmming as the first cup. (Although, in my opinion, after producing surströmming ice cream, the machine should not be cleaned but instead should be set on fire and thrown out… but that's just my opinion).

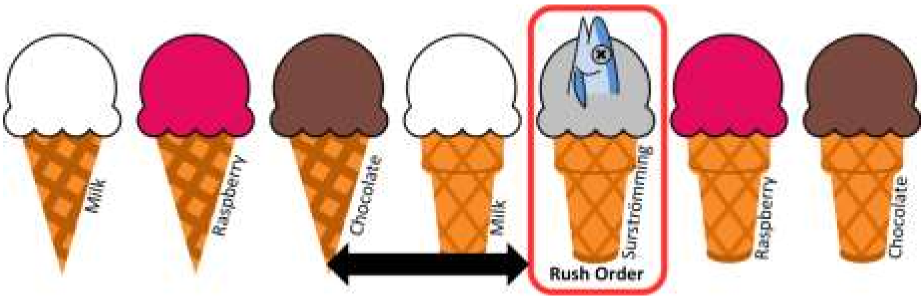


Figure 352: Ice cream Sequence Twice Delayed Rush Surströmming (Image Roser)

In more general terms, it is a tradeoff between a delay of the rush order or prioritized order on one hand, and the increased changeover effort on the other hand. If you would accept a slight delay, you could find a better slot for the rush orders that require less changeover effort. There may be even situations where an even better spot would open up with an even longer delay. How long do you want to hold the prioritized order for which benefit. The details of course also depend on your system, what kind of changeovers you have, and how long they will take.

If you have more frequent custom orders, you may even consider having slots in the changeover sequence explicitly for those custom orders. If there are no orders, this slot is skipped (as it would be for any other product where there are no orders). In any case, I hope this post was helpful for you. Now, **go out, for the love of God stay away from surströmming, and organize your industry!**

46 Replenishment Time Stability for Changeover Sequencing

Christoph Roser, November 16, 2021 Original at https://www.allaboutlean.com/replenishment-time-stability-for-changeover-sequencing/

Figure 353: Older Couple Eating Ice Cream (Image manpeppe with permission)

Changeover sequencing is simply creating a production sequence that reduces the changeover effort. For example, in injection molding, colors are often changed from light to dark to reduce the cleaning effort. However, like all production sequencing (like leveling, lot sizing, prioritization,….), it adds to the replenishment time. Especially if you are using pull production, a consistent replenishment time reduces fluctuations, whereas an inconsistent replenishment time increases fluctuations and hence waste. But how can we get a more consistent replenishment time?

46.1 Introduction

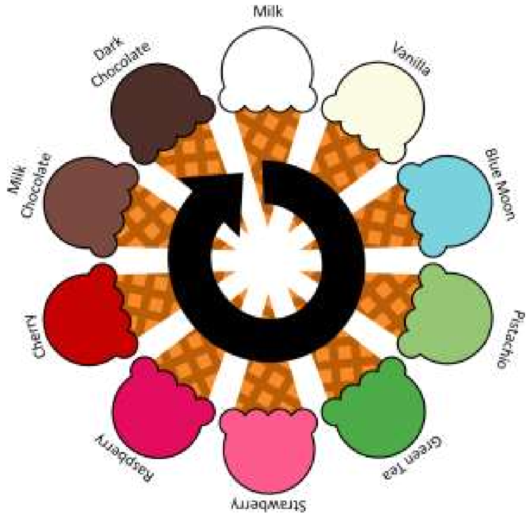


Figure 354: Ice cream changeover wheel – 10 flavors Ice Cream Change Over Wheel 10 Flavors (Image Roser)

As I have explained in previous posts (here, here, and here), a changeover sequencing is a production sequence aimed to reduce the changeover effort. For example, injection molding processes like to sequence from lighter colors to darker colors to reduce the cleaning effort, since a speck of white plastic in a black part will be much less noticeable than a speck of black plastic in a white part. Changing tools takes longer than cleaning; hence, a good sequence may do all colors of one shape (i.e., tool) first before switching to the next shape. If there is no need for certain products; the product is simply skipped and the next product in the sequence is produced.

Figure 355: Inventory (Image Axisadman under the CC-BY-SA 3.0 license)

Creating the sequence is not that hard, but the challenge is in making the total sequence a consistent duration before the same item is produced again. Since each product is (usually) produced only once during the changeover sequence cycle, the inventory of this product needs to satisfy the demand until the next production run. The longer the sequence, the more inventory you need to cover the time until it is reproduced again. And, we all don't really want a large inventory due to all the costs associated with it. This is true for all make-to-stock items, regardless whether it is push or pull, but in pull the problem will be more visible.

However, not only the average duration of a changeover sequence cycle, but also the fluctuations. Your inventory not only needs to cover the average duration of a changeover cycle, but the (reasonably) worst-case fluctuation of such a cycle. Hence, you should not only try to reduce the average duration of a sequence (hint: smaller lot sizes!), but also the fluctuation of the sequence. In pull, the sequencing (including the changeover sequencing) is one of the elements that go into the replenishment time, which determines the inventory limit, as shown below.

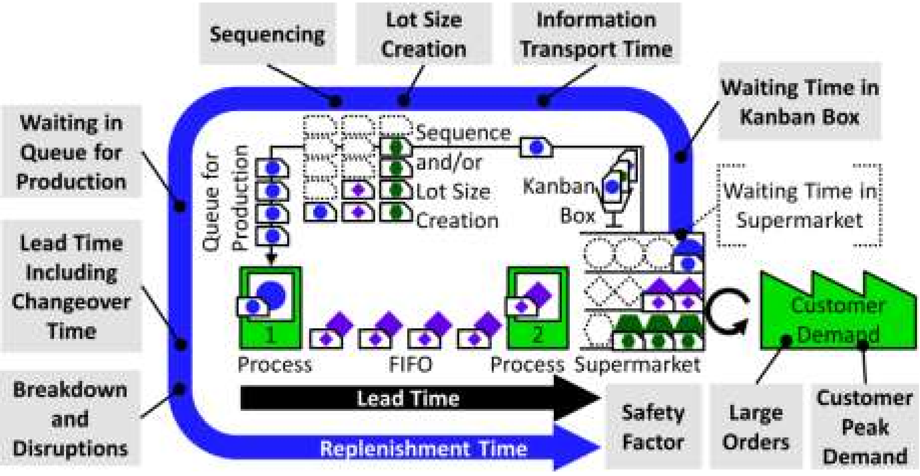


Figure 356: All About Pull Production – Kanban Components (Image Roser)

The problem is slightly less relevant for make-to-order production. The average duration is still relevant. Having a long and detailed changeover sequence will increase the lead time for the customer proportionally, besides the inevitable rush job that messes up your sequence anyway. The fluctuations, however, are usually taken care of by prioritizing the jobs due to the due date anyway.

46.2 A Highly Fluctuating Way for Changeover Sequencing

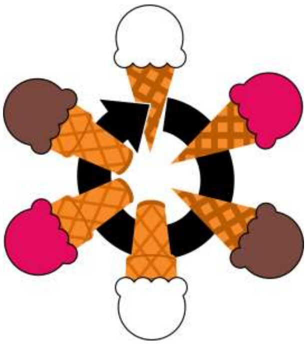


Figure 357: Ice Cream Change Over Wheel Three Flavors Two Cups (Image Roser)

Let's use again the example of ice cream from previous posts, shown here. We have three flavors and two different types of cups. We go from light color (milk) to medium (raspberry) to dark (chocolate) before changing the waffle tool and repeating the flavors. Hence, we have a total of six different product types. The graph below shows the sequence, and also the total possible production orders, where each cone or cup represents one hour of production. We could produce six hours worth of milk ice cream cones, two hours worth of raspberry ice cream cones, seven hours worth of chocolate cones, and so on.

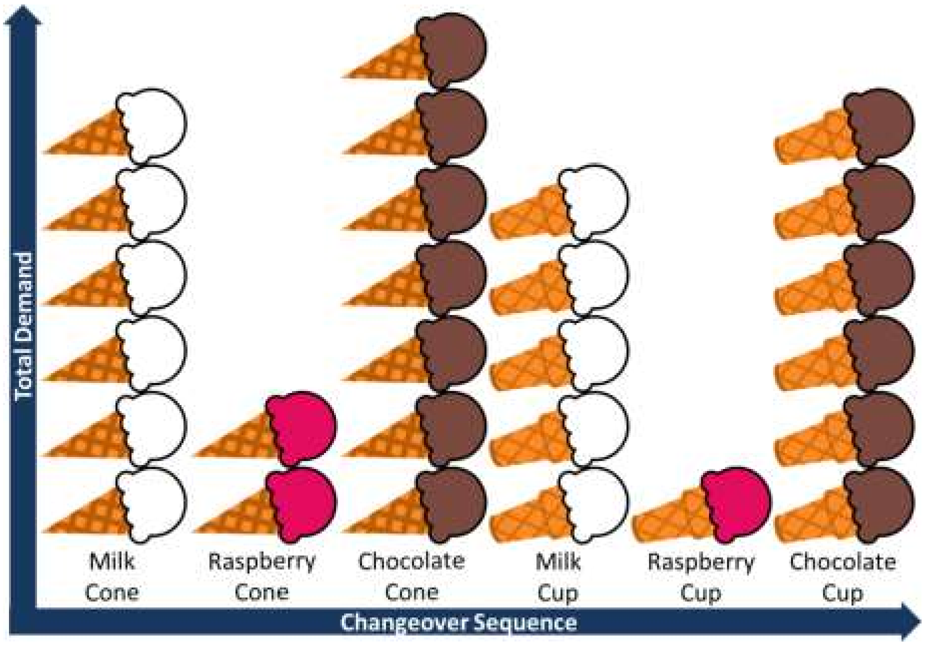


Figure 358: Ice Cream Demand Changeover No Restrictions (Image Roser)

If a manufacturing person sees this, the common reaction would be to just make as much as possible to reduce the changeover effort. In this case, make all six hours worth of milk cones in one go. However, some of these production orders may not be needed anytime soon, and by simply doing everything, we increase our average changeover cycle. The fluctuations also depend simply on what possible orders or kanbans are available for the system; hence, we will have a very long and fluctuating changeover cycle, which in turn will increase the needed inventory.

46.3 Fixed Capacity Changeover Sequencing

A much better way would be to limit the capacity for each changeover sequencing slot. Assume, for example, you want the entire sequence to be 18 production hours, or 18 icons in the diagram. The easiest approach is simply dividing the hours on the products. Hence, for our example we would have three hours for each product type as shown below, where the capacity for each product is highlighted in blue.

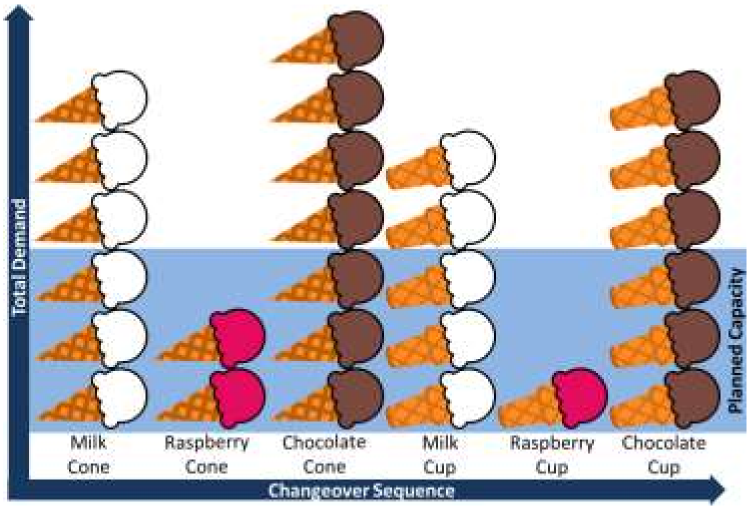


Figure 359: Ice Cream Demand Changeover All Same Capacity (Image Roser)

However, it is also very easy to see that having the same capacity for each would be not good. The less popular products (i.e., raspberry) would be produced faster than necessary, or even have unused production capacity. The more popular products (chocolate, of course) would have to wait more even though there is a high demand. Overall, a fixed capacity for all would be quite obviously not so good. It would be much better to have the capacity match the proportional demand (i.e., high runners get more capacity, low runners get less). The graph below still has a total of 18 hours of capacity in the production sequence, but now the high runners get more capacity than the exotics.

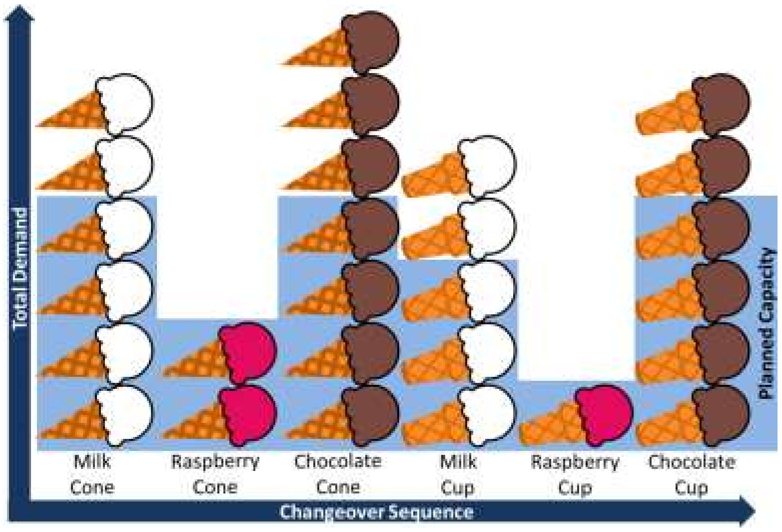


Figure 360: Ice Cream Demand Changeover Variable Capacity (Image Roser)

This is much better, but still has some inflexibility. Assume, for example, that Beyonce said that milk ice cream gave her hickeys, but raspberry ice cream is the new “it” ice cream flavor. Suddenly your demand for milk ice cream breaks down, but your demand for raspberry goes through the roof. At a minimum you should adjust the capacity for each product type regularly. Overall, this approach is feasible, but there is something that offers better performance – at the cost of more planning.

46.4 Flexible Changeover Sequencing

A more flexible approach would be to prioritize the changeover sequence every iteration, or even every slot. You can fill the available capacity in the changeover sequence with the most important jobs after every cycle.

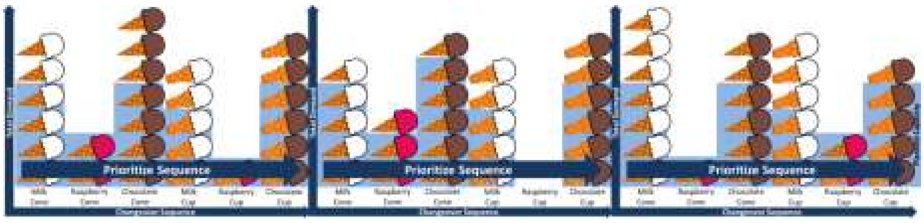


Figure 361: Ice Cream Demand Changeover Prioritize Every Iteration (Image Roser)

Even more flexible – but also much more work – is to adjust the priority before every changeover. Which jobs do you want to do during the next changeover cycle? There may be not much change from the previous priority (except for the priorities of the just completed part type, which is now at the end of the current changeover prioritization). However, if there is a change to the demand, you may have small adjustments.

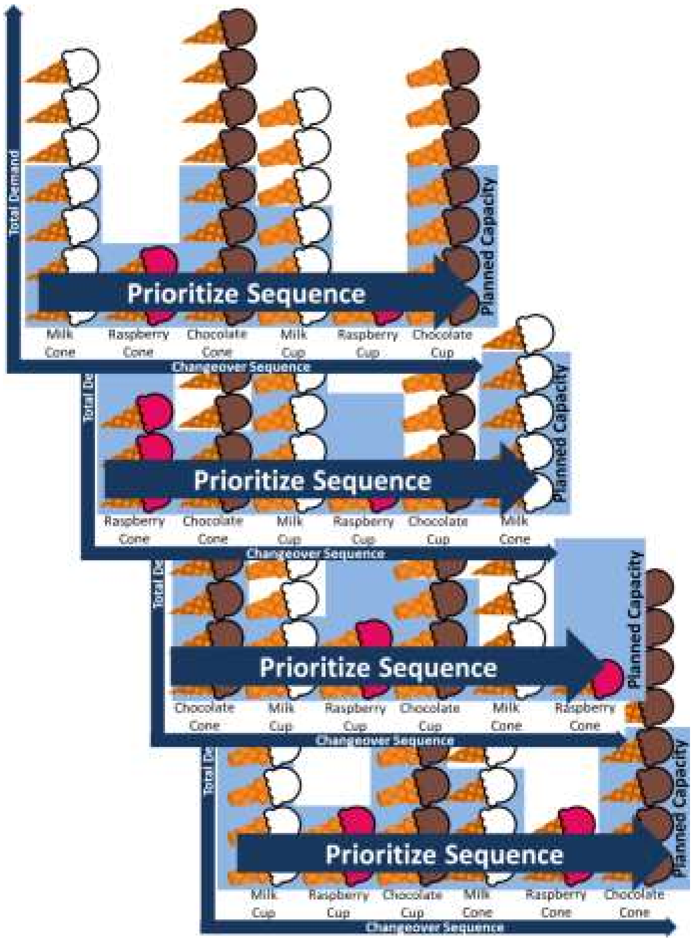


Figure 362: Ice Cream Demand Changeover Prioritize Every Slot (Image Roser)

46.5 Summary

Overall, you could use a fixed slot size, which is the easiest. You could also re-prioritize every iteration of the changeover sequence, or even before every changeover, although this takes more management effort. If your demand changes not so much between changeover cycles, you may just go for the easy approach. On the other hand, if your demand wildly fluctuates you may adjust the quantities for the changeover cycle more frequently. Of course, every plant claims that their customer fluctuations are terrible, but the real question here is do you want additional management overhead effort for frequent adjustments, or can you live with a slightly larger inventory but less organizational work. And, please note that these fluctuations also heavily depend on the length of your cycle, hence (again) I encourage you to use smaller lot sizes to make the entire changeover cycle smaller. Now, **go out, stabilize your changeovers, and organize your industry!**

47 When to Produce Make-to-Order, When Make-to-Stock?

Christoph Roser, November 23, 2021 Original at https://www.allaboutlean.com/mto-vs-mts-1/

Figure 363: Waitress re-stocking Buffet (Image kadmy with permission)

One of the questions for any production system is if the product is produced on stock before the customer order (make-to-stock, MTS), or only on demand after the customer order (make-to-order, MTO). In many cases this is an easy decision. Custom-made items are always make-to-order, since you cannot start before you know what the product will be. Everything else does have exceptions. Let me dig deeper into the decision tree on deciding which items to produce on order, and which ones for stock. This is a short series of blog posts, and the first one looks at the key aspect (but not the only one) in deciding between make-to-order and make-to-stock.

47.1 Introduction

Figure 364: Make-to-order (Image desertsolitaire with permission)

In make-to-order, production starts only after a customer order. The customer always has to wait on the completed product. In make-to-stock, production starts before a customer orders the item, in the hope that the customer will actually order such an item later on. In this case, the customer (ideally) does not have to wait for the product. Overall, customers never want to wait for products. If they have to, they would like to wait as little as possible. However, it is not always possible to produce make-to-stock, and even if it is, it may not be economically sensible.

This leads to an often overlooked but important distinction between make-to-order and make-to-stock: how you optimize the production system. With make-to-order, the customer must wait, but wants to wait as little as possible. Hence, the customer is interested in a short lead time between the order and the delivery. This can be achieved by having lots of capacity available, but the manufacturer does not want his machines and workers to sit around idle waiting for an order. Hence, **for make-to-order the production system is optimized for a trade-off between the lead time and the utilization.**

Figure 365: Make-to-Stock (Image Masahiko OHKUBO under the CC-BY 2.0 license)

With make-to-stock, the customer wants its item right away, and hence is interested in a high material availability or delivery performance. This can be achieved by having lots of inventory, but the manufacturer does not want lots of expensive inventory waiting around for a customer. Hence, **for make-to-stock the production system is optimized for a trade-off between the material availability and the inventory quantity.** These are quite different goals, but it is quite possible to combine this in the same production system. Especially if the make-to-order jobs are no more than 30% of the workload, you can prioritize the make-to-order jobs over the make-to-stock products, and achieve a faster lead time for make-to-order at the cost of an only slightly larger inventory of the make-to-stock parts. I have written quite a bit on this in my book All About Pull Production.

Figure 366: Thinking Man (Image MicroOne with permission)

Overall, you have to decide for all of your products if you want them to be produced make-to-order or make-to-stock. This applies not only to the final products, but also to the subcomponents and materials. Do you produce your subcomponents make-to-order or make-to-stock? Even when purchasing your own supplies, you can similarly decide between purchase-to-order (PTO) where you buy material only after you need it for a product ordered by a customer, or purchase-to-stock (PTS) where you buy material beforehand, hoping that you can sell it later as part of a customer order. Overall, this is a question of cost-benefit. Make-to-stock has higher inventory-related costs, but make-to-order may miss sales, customers, or even have penalty payments for being late.

On a side note, it is common to create custom products using (at least some, usually mostly) make-to-order parts. Your end product may be produced only based on a customer order, but you produce it by building variants using the many parts you have on stock. Any custom-ordered supplies will extend the lead time significantly.

47.2 Quantity?

Figure 367: Tomato Harvest Armenia (Image Narek75 under the CC-BY-SA 4.0 license)

The first criteria everybody thinks of when deciding between make-to-order and make-to-stock is the quantity produced. The more of an item is required, the easier it is to produce it to stock. This is often a good approach, but not flawless. Let me give you a counterexample.

A company produces coffee cups. Cup A sells around 10,000 items per year. Cup B sells around 5000 per year, and Cup C sells much less with 1000 items per year. At a first glance, Cup A would be a very good candidate for make-to-stock. Often, this is correct. However, if Cup A happens to be, for example, a one-off order by a single corporate customer that wants to give all of his employees a motivational cup for an anniversary, then this will be a one-off order that can be produced only after the customer orders the cups and finalizes the design. Hence, even though Cup A has a larger quantity, it would have to be produced make-to-order.

Figure 368: Three Cup Examples (Image Roser)

Cup B could be a Christmas-themed cup, which sells only between Halloween (when Christmas traditionally starts in retail) and actual Christmas. The total quantity is smaller, but it is make-to-stock, since it is sold to individual customers that just happen to desire a Christmas-themed cup. However, the demand does have quite some fluctuation, and outside of the Christmas season it will not sell at all. Hence, it is probably best to produce the item to stock before Christmas, but not to produce it at all or maybe produce it only make-to-order if someone really wants a Christmas mug in March.

Finally, Cup C may be a long-selling cup that is popular as a birthday gift for people when you don't really know what to give (i.e., "Best Dad Ever"). This product has a quite stable demand. Hence, Cup C may be make-to-stock.

47.3 Quantity & Fluctuations!

Figure 369: Abstract Wave Molecule (Image Drevynskyi Maksym with permission)

Overall, while the quantity is relevant, on its own it is not enough information. A stable and high demand is the best candidate for make-to-stock. A small and highly fluctuating demand may be more of a candidate for make-to-order. In its extreme, a product that is produced only once ever (i.e., a custom-made item) is the prime candidate for make-to-order. Overall, a combination of the quantity and the fluctuations are the most important parameters for deciding if you produce make-to-order or make-to-stock. However, it is not the only parameter, and there are additional factors that influence your decision. But before I go into additional parameters, I first want to look at how to measure quantity and variation in my next post. Now, **go out, look at your production volume and fluctuation, and organize your industry.**

48 Make-to-Order vs Make-to-Stock: The ABC XYZ Analysis

Christoph Roser, November 30, 2021 Original at
https://www.allaboutlean.com/mto-vs-mts-2/

Figure 370: Waiter with food (Image pxfuel in public domain)

In my last post I started to look at when to produce make-to-stock and when to produce make-to-order. There are quite a few factors that influence this decision (more on this in my next post), but the most important ones are the total sales or production volume as well as the fluctuations thereof. To understand these, you could use a Pareto analysis, an ABC analysis, or an ABC-XYZ analysis. I do like to include not only quantity but also fluctuations, but usually I need to divide this into only two groups, and the three groups of ABC or nine groups of ABC-XYZ is, in my view, a bit of an overkill. Anyway, let's have a look:

48.1 Pareto Diagram

As discussed in my last post, the quantity as well as the fluctuations of the demand are relevant to decide if you produce make-to-order or make-to-stock. Sorting your products by quantity is easy; this is the Pareto diagram. For many data sets, you will also find that 80% of the volume is 20% of the products. Below is a similar example, where I plotted the world's population by country, both in million people and as a cumulative percentage. Roughly 20% of the countries make up 80% of the world population, starting with China, India, and the USA. Correspondingly, 80% of the countries make up 20% of the population, ending with Nauru, Tuvalu, and the Vatican City.

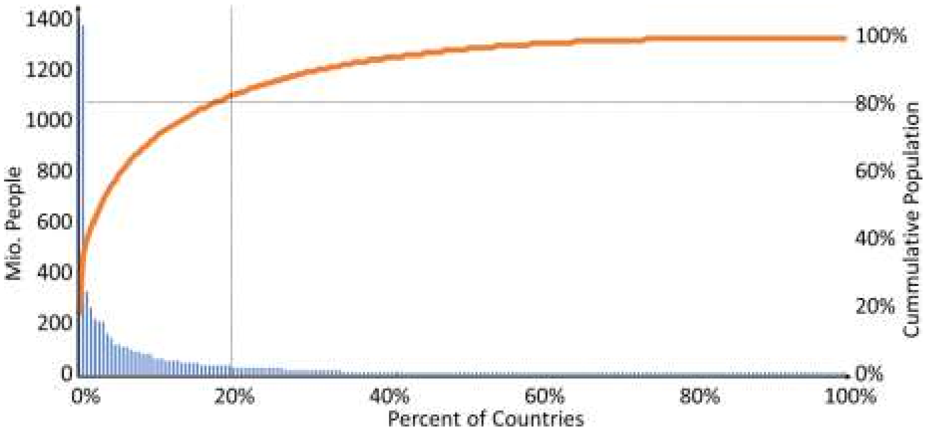


Figure 371: World Population by Country Pareto (Image Roser)

48.2 ABC Analysis

Figure 372: ABC blocks (Image Yuliya Shustik with permission)

The ABC analysis is nothing more than a Pareto analysis grouped into three levels. A's are the most common items, B's the middle group, and C's the least common ones. However, there is no consensus as to what percentage is A, B, and C. Often a ratio of 20% A, 30% B, and 50% C is used, but there are also others that use 10% A, 20% B, and 70% C. There are probably many more, but the point I want to make is that **this grouping is somewhat arbitrary and depends on your needs**. Besides, you may not need three groups anyway; often two groups are just what you need.

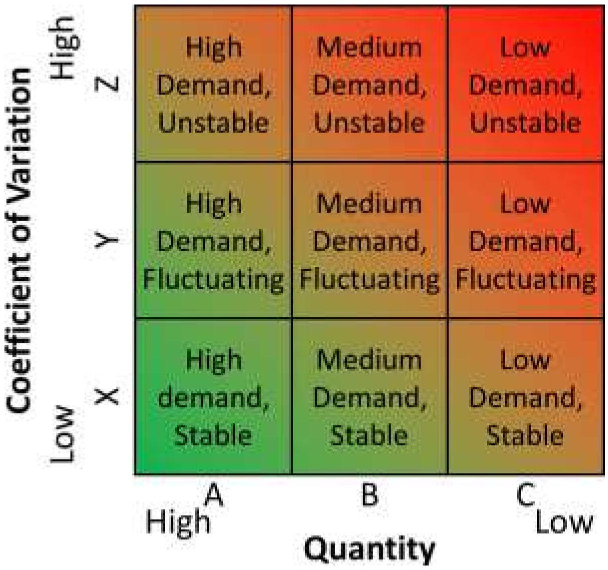
ABC	A	B	C
Variant 1	5%	15%	80%
Variant 2	10%	20%	70%
Variant 3	20%	20%	60%
Variant 4	20%	30%	50%
Variant 5	75%	15%	10%
Variant 6	80%	15%	5%

Even if the quantity alone would decide between make-to-order (Probably C's?) and make-to-stock (maybe A's), you cannot just use a fixed percentage value to decide. Instead you would have to look along the axis and decide at what point it is no longer worth having the items in inventory. Depending on your business, you could end up with 100% make-to-stock items. A completely different business may end up with 100% make-to-order items. But don't just use a percentage. In any case, the fluctuations also matter, which brings us to the ABC-XYZ analysis.

48.3 ABC-XYZ Analysis

Figure 373: ABC XYZ Children Blocks (Image Frank L Jr with permission)

The ABC-XYZ analysis now includes the fluctuations. The ABC parts is still a simple Pareto of the quantity, grouped into three groups. Sometimes it is alternatively the product value if you want to give more expensive products a higher priority than cheap products, but this would be not so good for the decision between make-to-order or make-to-stock.



	A	B	C
Z	High Demand, Unstable	Medium Demand, Unstable	Low Demand, Unstable
Y	High Demand, Fluctuating	Medium Demand, Fluctuating	Low Demand, Fluctuating
X	High demand, Stable	Medium Demand, Stable	Low Demand, Stable

Figure 374: ABC XYZ Analysis (Image Roser)

The XYZ part now captures the fluctuations, also grouped into three groups. You can also think of it as capturing the uncertainty or the stability. X-items fluctuate very little, Y-items somewhat more, and Z-items quite a bit. Technically, the fluctuations would be the standard deviations of the demand (i.e., the standard deviation of how much products you sell per day or per week). However, since you are comparing products of different absolute quantities, the **coefficient of variation** (the standard deviation divided by the mean) is better. This is a good measure, and it is sometimes used.

Figure 375: Christmas Cup (Image Roser)

Another possible measure is the **number of orders** (e.g., orders per year). A high number of orders is seen as a stable demand, whereas a low number of orders is seen as an unstable demand. This is easier to measure, but is not as accurate as the coefficient of variation. For example, the Christmas cup from my last blog post may have a lot of individual orders where a customer orders one cup. However, these orders are all clustered around the Christmas season, and you still have a lot of fluctuations. The coefficient of variation may here be a better option. But for seasonal fluctuations you may have to switch between make-to-stock (in season) and make-to-order (out of season) anyway. Overall, what you are trying to measure is how stable the demand is.

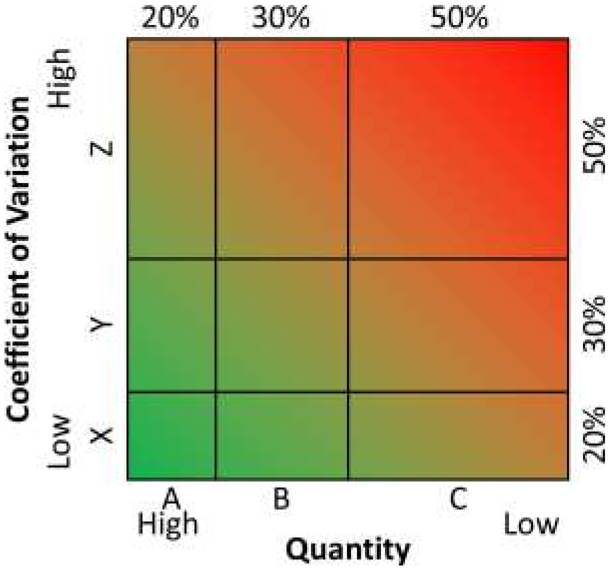


Figure 376: ABC XYZ Analysis 20-30-50 (Image Roser)

Do not confuse the ABC-XYZ analysis with a plot, where the axes are simply the values (although you can do that too). For ABC-XYZ, the axes are merely the products in sequence as sorted by its KPI value, not the absolute value. In other words, both axes markers would have merely 1, 2, 3… n for your n products.

Overall, the AX parts are your high volume and stable products (often the easy money-makers), and your CZ parts is the small fry that is ordered very irregularly (often the troublemakers with little money).

Most examples online simply show nine equal-sized boxes as the image farther above. You can also split the areas using a different percentage, the image here has a 20%-30%-50% split. But in my view, it is not necessary to use 9 boxes, or even more for the ABCD-WXYZ analysis with 16 boxes (same thing but more divisions), or even more with the (luckily uncommon) Kubus-analysis with 27 boxes (they add a third axis to make it a cube, all axes sliced into 3 parts).

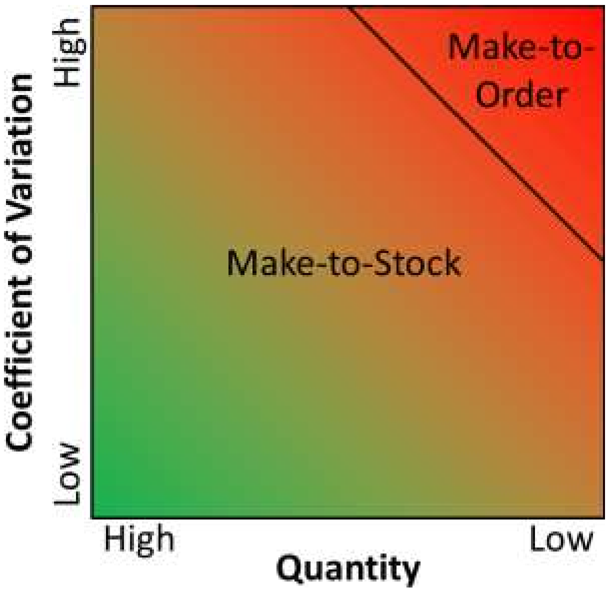


Figure 377: ABC XYZ Analysis Two groups Only MTS MTO (Image Roser)

But for me, all of this is overkill. You basically want to split your products into 2 groups, those that are make-to-stock, and those that are make-to-order. Hence, usually **you need only 2 groups**, not 9, 16, or 27, unless you want to impress someone else with fancy graphs and diagrams. Keep in mind that an *AB-YZ* analysis would not sound as nice and also would not sell as well for consultants. For 2 groups, however, some sort of diagonal line is all you need, as shown here.

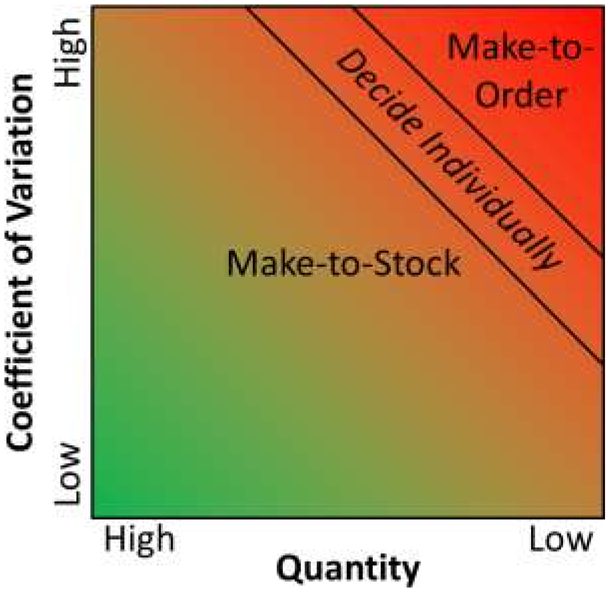


Figure 378: ABC XYZ Analysis Decide Individually MTS MTO (Image Roser)

You may also look a bit closer at products that are close to the line, and may decide individually which group you want them to be. The question is where to put this line, and what to consider if you want to change a product from make-to-order to make-to-stock or the other way round (more on this in the next post).

By the way, the products are usually not spread evenly across the chart. You probably have a few products with high quantity and low variability (AX), a lot of products with a low quantity and a high variability (CZ), and some in-between (BY). High quantity AND high variability (AZ) as well as low quantity AND low variability (CX) are less common.

In my next post I will look at where to split, and what else can influence this decision. Until then, stay tuned, and **go out and organize your industry!**

49 Make-to-Order vs Make-to-Stock: Additional Decision Factors

Christoph Roser, December 7, 2021 Original at https://www.allaboutlean.com/mto-vs-mts-3/

Figure 379: Waitress with two plates of food (Image HighwayStarz with permission)

For all your products, you have to decide between make-to-order and make-to-stock. A similar decision is needed for components or raw materials that you produce or purchase. As described in my precious posts, the key criteria is the quantity and the fluctuation. In this last post in this small series I will look at where to make the cut, and what other factory play a secondary role for your production system.

49.1 Where to Put the Split

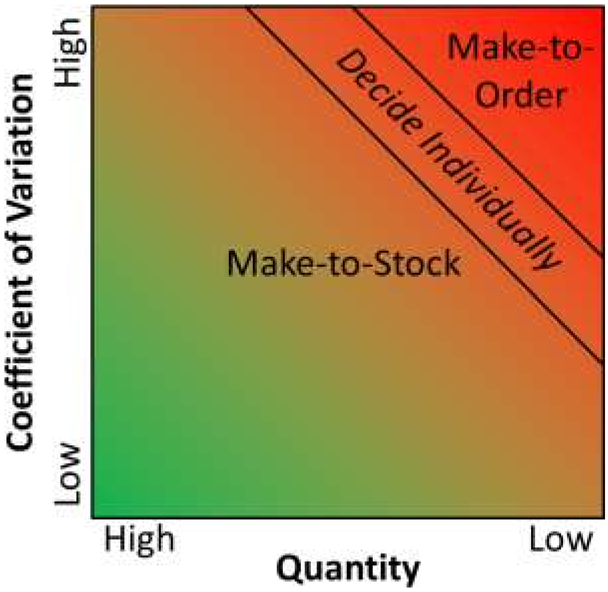


Figure 380: ABC XYZ Analysis Decide Individually MTS MTO (Image Roser)

As described in the last post, make-to-order and make-to-stock depends on the quantity and the fluctuations of the item sold. For all your items you could make an ABC-XYZ analysis (although you don’t have to bother about how much for A, B, etc., but only make a plot), or a similar plot of the fluctuations over the quantity.

For the question on where to split between make-to-order and make-to-stock, I would approach this from both sides. I would look at the extremes with the lowest quantity and the highest fluctuations, and would consider them make-to-order products. Especially if you have products that are heavily customized and produced or even developed only if a customer orders the item.

On the other end, you have the high-quantity products with the least fluctuations. These are often prime candidates for make-to-stock. From those extremes I would move toward the middle and decide for each item between make-to-stock and make-to-order. If you are still in the corners, then the decision is probably easy. However, the smaller the gap between the two groups, the more you may want to think about the decision. Below I have a few additional criteria that can help you to decided. Depending on your business, you may end up with 100% make-to-stock or 100% make-to-order, but most businesses have a mix in between.

Make-to-stock has higher inventory costs, but some customers cannot or will not wait for a make-to-order production. At the end of the day, you want to use the approach that gives you and your company the best benefit for the effort.

Also, it may be best to look at individual products rather than product groups. A product group may be mostly make-to-order or make-to-stock, but they still may have a few products for the other category. Best to look at each product separately.

49.2 Additional Factors

49.2.1 Impact of a Stock-Out

Probably the next most important criteria after the quantity and fluctuations is the problems you will have if you have a stock-out. There are multiple possible scenarios. The easiest one is if you have a monopoly and power over the customer. If you don't have the item available the customer is forced to wait, but will buy it from you anyway. In this case, there is no additional pressure to produce make-to-stock, as the only risk is a slightly damaged reputation. Another scenario is not a monopoly, in which case the customer buys from the competition. A missed part merely means a missed sale and maybe also a lost customer.

Figure 381: A stop costs $1 million per day… (Image Siyuwj under the CC-BY-SA 3.0 license)

The critical situation is if the customer has power over you, and will cause you a lot of trouble if there is a missing product. To be more precise, this is a situation where the customer cannot accept a waiting time longer than the replenishment time. Assume, for example, you produce for a car maker. Even though the product is needed only in small quantity and with high fluctuations, a delay in delivery may lead to the final assembly line at the major car maker being stopped. This will cost the car maker around $1 million per day, and they quickly make your life uncomfortable with late penalties and forwarding the cost to you. These products may be better produced as make-to-stock, unless the contract permits make-to-order production.

Figure 382: Milking snakes for antivenom. (Image Barry Rogge under the CC-BY 2.0 license)

Another example would be infrequently used medicine. Let's take as an example a snake-bite antivenom. This may not be needed very often, but once you need it, you don't want to start milking snakes to produce it. Hence, despite its low and highly fluctuating demand, it is an item that should be produced make-to-stock. Luckily, the customers are willing to pay for this item to be produced to stock.

49.2.2 Product Shelf Life

Figure 383: Juice bottles in a retail supermarket (Image Roser)

Another smaller factor may be the shelf life of the product. If the product has a long shelf life, it has no impact on the decision between make-to-order and make-to-stock. However, if it is a product which expires quickly (e.g., fresh food), there is a risk that it will expire before it is sold, in which case you have to cover the loss. This makes make-to-stock production more expensive, and may nudge you toward make-to-order production. That does not mean that all short shelf life products are make-to-order, but it is one factor in the decision.

49.2.3 Quality Issues

Figure 384: Defective brick (Image Sergey Chuyko with permission)

Another smaller aspect is if the product has frequent quality issues. If not, then this is not a factor. But if it has quality issues, a make-to-order production can give you faster feedback between production and finding the problem. This faster feedback can help in finding the cause of the issue and resolving the problem. Again, it is not a key factor, but if you have a product where it is difficult to decide, this may nudge you toward make-to-order.

49.2.4 Cost and Size of the Product

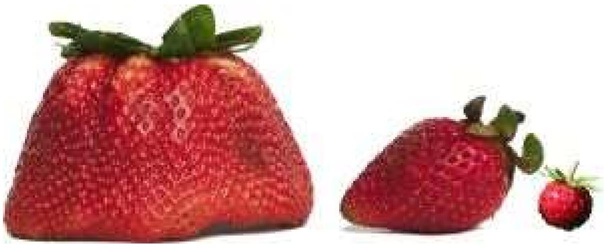


Figure 385: Size matters… (Image Dllu under the CC-BY-SA 4.0 license)

Another minor aspect is the cost and/or the size of the product. The decision between make-to-order and make-to-stock is basically the question of which option is more profitable. All other things being equal, an expensive product ties up more capital than a cheap product. Similarly, a large product has more storage cost than a small product. Other less common situations may be a product that needs to be stored at -70°C vs. a similar product that can be stored at room temperature. Again, it is not a big factor, but it may influence your decision for the products where you are not yet certain.

49.2.5 Fluctuations in Purchasing or Production

Figure 386: Source Make Deliver fluctuations (Image Roser)

The fluctuations we looked at so far were demand fluctuations. However there may also be supply fluctuations. If your supplier does not have a reliable delivery turnaround, you may also be inclined more toward make- (or purchase-) to-stock, especially for raw materials and purchased components.

49.3 Limitations

Figure 387: Out of space… (Image Christin Michaud in public domain)

There may also be limitations, mostly for make-to-stock items. The more you produce make-to-stock, the more storage space you need and the more capital you have sitting idle on your shelves. Storage that you have available is cheaper than storage that you need to get or rent. Hence, once your inventory is full with make-to-stock items, you may be a bit more hesitant to include even more products as make-to-stock. You cannot always avoid it, but the available storage space and capital may also be a (smaller) influence on your decision. Also, keep in mind that you should not fill up your storage space to 100%, as you will then no longer have room for the inevitable fluctuations.

This concludes my short series on the decision between make-to-order and make-to-stock. I hope it was helpful for you. Now, **go out, ponder the decision between make-to-order and make-to-stock, and organize your industry!**

50 The Benefits of Mass Production

Christoph Roser, December 14, 2021 Original at
https://www.allaboutlean.com/mass-production-benefit/

Figure 388: Lotus Final Assembly line (Image Brian Snelson under the CC-BY 2.0 license)

Mass production makes items faster, better, and cheaper. The larger your production volume, the lower your cost and, subsequently, your product prices. This is common knowledge, but what is not well known is the magnitude of this effect. In this post I would like to show you a few comparable products, albeit with vastly different production volumes, and hence different prices.

50.1 Introduction

Mass production makes things cheaper. The larger the quantity, the cheaper the product, while at the same time the product also has better quality and is produced faster. Production quantity has a huge impact on cost. Increasing volume has a particular impact for small production numbers, albeit the relation is not linear. Increasing your production volume from 10 000 to 20 000 (Δ 10 000) will result in a significant cost savings, whereas going from 1 000 000 to 1 010 000 items (also Δ 10 000) will reduce the price only marginally. At some point, there may even be a diseconomy of scale, where further increases in volume may increase overall cost.

Please note, I am talking about total production quantity (e.g., items per year), not lot size. A smaller lot size has lots of benefits for production, as it reduces fluctuations. But here we look only at the total quantity. Also, we do not look at one product variant only, but at a product group where many somewhat similar items are produced. This would be mass-customization.

50.2 The Products

Figure 389: 2018 Toyota Corolla (Image EurovisionNim under the CC-BY-SA 4.0 license)

I am looking at a few different products with a comparable complexity. The first one is a normal car, namely the **Toyota Corolla**, which was the bestselling car of 2020. It sold over one million vehicles in 2020. The model was first introduced in 1966, and the current model is now in its 12th generation. In 1997 it overtook the VW Beetle as the best-selling car ever, having sold 50 million cars at that point.

Figure 390: Porsche 911 Carrera (Image Damian B Oh under the CC-BY-SA 4.0 license)

Continuing with cars, the best-selling luxury sports car is the **Porsche 911**. It sold 28 000 vehicles in 2020. Since its first sale in 1964, it has sold over 1 million vehicles in total. That is quite a lot, but still much fewer than the Toyota Corolla.

Figure 391: 2005 Sea Ray 220 (Image McChizzle in public domain)

The next product is a boat. I am looking in particular at the best-selling pleasure boat, the **Sea Ray**. The manufacturer with the same name is part of the Brunswick Boat Group. The boats come in quite different sizes, ranging from 6-meter to 20-meter yachts, and hence also have quite different prices. The Brunswick Boat Group does not publish sales numbers, but they sell more than 2000 boats annually, with the shorter (and hence cheaper) boats being more popular. There are also different models: for example, the Sundancer, Sun Sport, and many more. To make it comparable, I will be looking at smaller boats with outboard engines.

Figure 392: Cessna 172 Skyhawk in the air (Image Anna Zvereva under the CC-BY-SA 2.0 license)

The last product is a private propellor plane. The best selling propellor plane in 2020 was the **Cessna 172 Skyhawk**, with 214 items sold. This model had its first flight in 1955, and by sales is probably the most successful aircraft with almost 50 000 sold so far. It is a very popular private plane, affordable to middle class if you really insist on having one. The upper crust, of course, prefers private jet planes.

50.3 Comparison

My argument is that these products are all somewhat comparable, except for the production volume. I am fully aware that this comparison is imprecise, but for a rough estimate it is good enough. All of these products are designed to move people around, and hence fit comfortably around their passengers. The Corolla usually has 5 seats, the Porsche 4 (although admittedly the back seats are better suited for children and other tiny humans), the smaller Sea Rays fit 8 people or more (although this quickly gets crowded), and the Cessna has again 4 seats.

Next let’s look at the weight. Both cars are almost exactly 1400 kg (varying slightly also by the exact features). A 7-meter Sea Ray boat is somewhat heavier, with a weight between 1500 and 2200kg. Unsurprisingly, the Cessna is designed to be lightweight, and it weighs only 762kg (empty and without pilot). The dimensions are also similar, with the Corolla usually being 4.5 x 1.79 x 1.45 m in length x width x height. This is almost the same size as a Porsche with 4.5 x 1.9 x 1.3 m. The boat is obviously bigger, with the exact size depending on the model, but somewhere around 7 x 2.6 (the height varies with the awning). The plane is obviously the biggest of the bunch at 8.28 x 11 x 2.72 m, where a larger wingspan is needed for it to function.

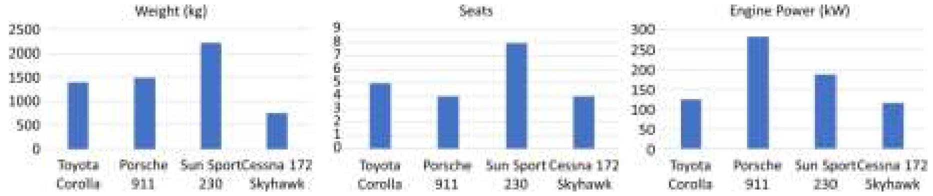


Figure 393: Weight Seats Engine Power Mass production Comparison (Image Roser)

All products have a combustion engine, where some hybrid cars may have an additional electric engine. These engines also have similar power. The Corolla is usually between 122 and 184 hp (90-135kW). The Porsche obviously sticks out with 385-650 hp (283-478 kW). The boats are often between 150 and 250 hp (110-183 kW), and the plane has 160 hp (117 kW).

Figure 394: Engine failure, no casualties. (Image John Chroston under the CC-BY-SA 2.0 license)

So again, my argument is that these products are roughly comparable. If anything, the cars are more complex. The boat is probably the least complex product, having neither wheels nor suspensions, and not even brakes. Even the gearbox is much simpler than a car’s. It is in effect a fancy bathtub with an engine, where a standard engine is often attached to different boat models. The plane does need wheels, but the suspension is much easier. On the other hand, a higher level of quality and safety is needed. A car that breaks down simply stops. A plane than breaks down still moves … straight down into the ground…

50.4 Quantity vs Price

The comparison of the specifications above all yielded pretty similar values. Maybe sometimes one product has half the weight or is twice as powerful, but there are no enormous differences. However, both the quantity and the price differ enormously. For every Porsche 911 there are 40 Corollas. For every Cessna there are over 1000 Corollas produced. At the same time, you get 4 Corollas for a Porsche, and almost 20 Corollas for a Cessna.

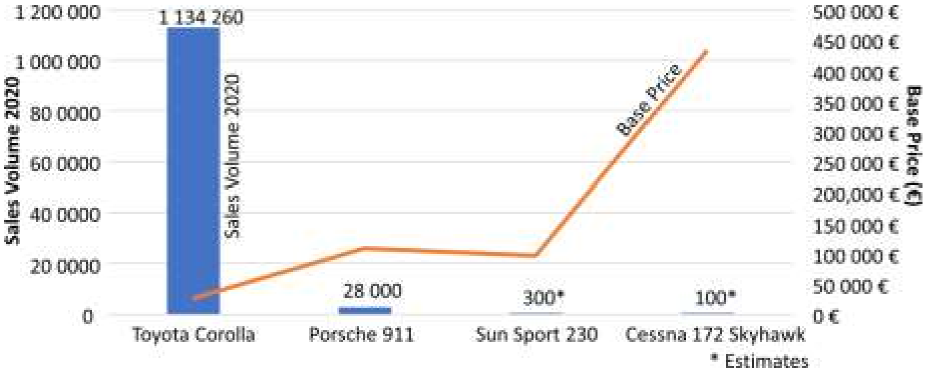


Figure 395: Sales Volume vs Price Selected products (Image Roser)

It is not that a Porsche is 4 times better than a Corolla, or a Cessna 20 times better than a Corolla. While of course there are differences in quality and craftsmanship, the main difference is the production volume, or – if you so will – how exclusive the product is. The smaller your sales volume, the fewer customers have to share a bigger part each of the fixed costs like development, tooling, and so on. If the world would buy a million Cessna's every year, then you probably could get one for the price of a Corolla. Quality would improve too, since if you have a million products, you have so many more opportunities to detect and fix problems.

If you sell a million Porsche 911s per year, the price would go down too, although it probably will still be more expensive than a normal car, even though Porsche benefits heavily from the development of engines and other components that are later produced in larger quantities at Volkswagen also for other products. While we all know that the fixed cost has to be distributed among the customer base, I am over and over again surprised how large this effect is (even though in theory I know it well). Anyway, I hope this little musing on volume and cost was interesting to you. Now **go out, dream of having a Porsche if everybody else would also buy one, then realize that this would also now no longer impress the girls (or boys), and organize your industry!**

51 Changeover Sequencing under Duress: Problems with Source

Christoph Roser, December 21, 2021 Original at https://www.allaboutlean.com/changeover-sequencing-problems-source/

Figure 396: Dropped Ice Cream Cone (Image Christin Lola with permission)

Changeover sequencing helps you to produce more efficiently with smaller lot sizes, less inventory, and/or less changeovers. But despite a good changeover sequence, sometimes things blow up in your face. Your supplier does not deliver, your customer wants more than you planned, or your main process went belly-up and is waiting for repairs. In any case, something is forcing your hand and messing up your changeover sequence, or more generally your entire production sequence. What do you do? Well, depending on what happened, you may have options to mitigate the damage. This first post will look at mishaps originating from your supplier, and the next post will look at difficulties originating from your customer or even from your own system.

51.1 Introduction

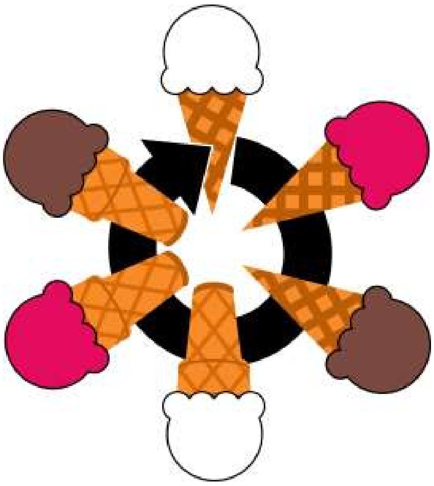


Figure 397: Ice Cream Change Over Wheel Three Flavors Two Cups (Image Roser)

I have written a lot on changeover sequencing, usually using ice cream as an example. I explained the basics in Changeover Sequencing Part 1 and Part 2, talked about prioritization, and also discussed fluctuations, in addition to many posts on how to do changeovers or reduce changeover duration. In this post I will look at what to do if something goes wrong. I loosely structured this using source-make-deliver (i.e., problems with your supplier, in your own process, and with your customers).

51.2 Problems with Source

Figure 398: Ever Given stuck in Suez Canal (Image NASA in public domain)

Let’s have a look at the first example: you have problems with your source of materials (i.e., your suppliers). In most cases this means that you are not getting what you need, or at least not in a timely fashion. This could be due to problems at the supplier, delays during shipping, your supplier going bankrupt, and many other things. It could also happen due to reasons on your side, like you don’t have the money to pay, you messed up or forgot your own orders, or you pissed off the supplier enough that he no longer wants to deal with you.

Figure 399: Truck Accident (Image RJA1988 in public domain)

In any case, you miss some of the material and parts you need, or you can foresee that you will not get them on time. Even if it is only a cheap part missing, it has the power to stop your entire production. If you lack an O-ring worth less than 1 cent, you cannot produce, ship, deliver, and get paid for an entire product worth potentially millions. One obvious step is now to escalate to try to get parts earlier. Pay a premium, try to get other suppliers, do air freight instead of the much cheaper ocean shipping (that is supposedly how airlines make most of their money), and many more. In foresight you may have already established a two-supplier system for all your parts instead of having a single source. But this is not the focus of this blog post.

Figure 400: Bicycle hub Parts (Image Keithonearth under the CC-BY-SA 3.0 license)

Because there is another thing you can do: namely, fine-tune your production sequence. This won’t give you more parts, but it will help you to use the remaining parts you have for the best outcome. You need to figure out what products need the parts that are in short supply, and then prioritize by end products. Figure out which products and how many of them are most important with the parts you have. The priority is usually related to profit, but includes such hard-to-guess costs of declining customer relations if they do not get the part. Often, companies opt to keep their larger customer happy and are willing to drop the small-fry customers first.

Figure 401: An empty standard EUR pallet with a bit of plastic on top, transparent background. (Image Roser)

For changeover sequencing, you can still optimize the sequence of the prioritized products to reduce changeover time and effort. You do not have to produce your products strictly in order of their priority, but can switch these prioritized products to reduce the changeover effort. Just don't schedule any non-prioritized products in the sequence just because it fits nicely. Your limitation is not the capacity but the materials!

Figure 402: Rena Container Ship (Image NZ Defence Force under the CC-BY 2.0 license)

It may also matter how many materials a part needs. Assume you have two products, one that gives you a profit of $10 000, the other one a profit of $3000. Both of them are short of the same type of O-ring. At first glance, the $10 000 product would be more important than the $3000 product. However, if the $10 000 product needs ten O-rings, and the $3000 product needs only one, then you could make a profit of $30 000 by making ten of the $3000 products instead of profiting $10 000 by producing only only one of the $10 000 product. Overall you **try to maximize the profit and minimize the losses** with the available materials.

In some extreme cases, you could also take already completed products apart to extract the critical parts for other, more-important end products. However, this makes everything more expensive and damages your other, less-important product. I once was at a manufacturer of large industrial pumps, where the completed pumps included a small plastic bag with a kit of O-rings and screws for the installation. This kit was often short on supply, and they regularly treated their finished goods as a part supply, ripping open the packaging to extract this plastic bag. These pumps were stored outside in (formerly) waterproof packaging, and as a result, these products got wet and started to rust. Hence, every product had to be checked for rust, missing parts, and repackaged before shipping. What a pain, and all for a small bag worth less than $5 for a pump worth thousands. If you take apart existing products to make other products, then the cure may be worse than the disease. Use this approach only as a last resort.

Figure 403: Cargo truck cash bricks (Image unknown author in public domain)

Just for completeness' sake, there are very rare cases when the problem is not too few parts from the supplier, but too many. This could be due to ordering too much by accident, or a supplier that can force parts on you. In any case, this should not change your sequencing much, as you merely have a larger inventory that you have to manage and slowly reduce by trying to get less until you are back to a regular inventory. Quite an unpleasant fluctuation.

Hence, there are quite a few things to consider when you have supply problems, besides obviously fixing your supply problems. In my next post I will look at problems with make (your own production) and deliver (your customer orders too little or – gosh – too much). Until then, stay tuned, and **go out and organize your industry!**

52 Changeover Sequencing under Duress: Problems with Make and Deliver

Christoph Roser, December 28, 2021 Original at https://www.allaboutlean.com/changeover-sequencing-problems-make-deliver/

Figure 404: Dropped Ice Cream Cone By Feet (Image Christin Lola with permission)

In my last post I looked at strategies to manage changeover sequencing if your supplier gives you trouble. Basically, you can sometimes reduce the damage by fine-tuning the prioritization (i.e., by using the limited raw materials to make the most important parts). This second post in this series looks at similar situations if your customer acts up, or if your own system makes problems. In other words, after discussing "source" in the last article, we now look at the "make" and "deliver" part. Admittedly, some of the approaches are similar to the problems with "source."

52.1 Problems with Make

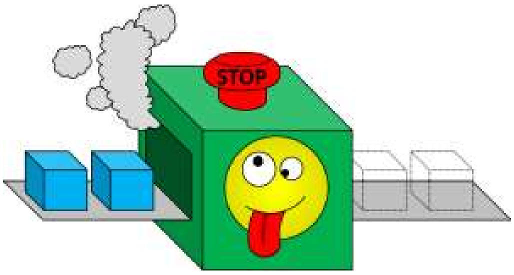


Figure 405: Broken Machine in Jidoka (Image Roser)

Sometimes you may have problems with "make" (i.e., your own production). This usually means something went belly-up, a machine broke, workers are on strike, your key specialist quit and now works for the competition, or other reasons. Here, too, you should of course work on fixing the system to get up to speed again. A huge topic, but again not the focus of this blog post.

The question is which of the remaining products to ship to which customer. This problem is somewhat similar to the problem with source above. Prioritize the remaining completed stock to get the maximum benefit (or the minimum loss) from your customers. Here, too, you may take apart completed products to make other products, again with the high risk of the cure being worse than the disease.

52.2 Problems with Deliver

Figure 406: Black Friday Shopping (Image tshein under the CC-BY 2.0 license)

Finally, there are problems with deliver, where your customer orders too much or too quickly, or alternatively orders too little. While this looks like a customer problem, it is in fact usually a problem of your capacity – you are unable to match your supply to the customer demand. Of course, one major action here is to adjust your capacity. Add or remove extra shifts or generally working hours, get a new machine, make a machine faster, and so on. But again, the focus here is on sequencing, which is another option to mitigate the problem until you have brought capacity online (or offline).

Figure 407: Crowded Supermarket in Nagoya (Image Roser)

First, let's look at the more beneficial situation where the customer wants more products. Here, we have to distinguish between a peak demand for a single product or an increased demand across the entire board. Assume you have 20 products, with roughly 500 each per month. Assume you make one batch of 500, with a different product every day (and yes, this is still a pretty big batch, but it makes an easy example). For some reasons you get an order for one of these products of 3000, while all other products drop slightly so that the total demand is unchanged at 10 000 products next month. Manufacturing happily makes one big batch of 3000 products, reducing their changeover time. However, this could be really bad. If you normally make 500 of each product every twenty days, then those 500 are the inventory to cover the remaining nineteen days until you make the product again. If you now make six days of one product, you may run out of inventory for the other products. It may be better to split this large order of 3000 products in smaller batches for production of maybe six batches of 500 each. What this could look like at your plant depends heavily on your situation, but please do try to **level demand peaks into smaller batches** so as not to run out of stock for other products or raw materials for the peak product.

If your demand goes up across the board, then besides adding capacity you also have to prioritize your limited capacity. This is again similar to the limited supply example above. What products and customers are most important, where can you generate the largest benefit and the smallest loss. Prioritize your remaining capacity accordingly. Produce the most urgent parts.

Figure 408: Japan queuing in line at shops (Image Roser)

For changeover sequencing, you can still optimize the sequence of the prioritized parts to reduce changeover time and effort. For problems with the supplier, the capacity was not the constraint when deciding on the changeover sequence. However, now it is the constraint, and you should not waste precious capacity for a wasteful changeover sequence. Hence, figure out all the parts you want to make, and then create a good changeover sequence. You also have to consider whether you want to use larger lot sizes, which means less changeovers but more fluctuations and a higher likelihood of running out of stock. Yet, even then I would still prefer the smaller lot sizes; otherwise there is a risk of running out of stock of the parts that you may need the most.

Figure 409: Empty Store (Image whoohoo120 under the CC-BY 2.0 license)

A problem could also be that your customer does not order enough products. You have more capacity than you need. Here, too, there are some things to consider for your production plan while you reduce your capacity. Often, the feeling on the shop floor is to use the available capacity and simply produce even though there are no orders. Do not produce more than your inventory limit! Do not create more inventory than you need just because you have the capacity! This is overproduction (which is the worst of the seven types of waste), which leads to inventory (which is the second-worst type of waste). This excess inventory can cost you more than the labor to make it. I would be very careful not to increase inventory beyond the target unless I am highly confident that a proportional increase in demand is just around the corner. And even then, if you use a pull system, adjust your target inventory rather than producing in excess of your inventory limit!

Sometimes, changes in the customer demand come unpredictable, but sometimes you know these changes beforehand. Seasonality especially does not surprise seasoned planners. Adjust your capacity beforehand, or even switch parts temporarily from make-to-order to make-to-stock for your season.

Of course, ideally you should be able to prevent any such problems from happening. In reality, however, despite best efforts sometimes your demand does not match your supply, or your machine breaks, or your supplier fails you. Besides fixing the root cause of the problem, you can sometimes use prioritization and changeover sequencing to mitigate the damage. Basically, make what is most important with the constraints you have, and do not overproduce. Now, **go out, improve your production sequence, and organize your industry!**

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54 Author

Figure 410: Christoph Roser (Image Roser)

Prof. Dr. Christoph Roser is an expert for lean production and a professor for production management at the University of Applied Sciences in Karlsruhe, Germany. He studied automation engineering at the University of Applied Sciences in Ulm, Germany, and completed his Ph.D. in mechanical engineering at the University of Massachusetts, researching flexible design methodologies. Afterward he worked for five years at the Toyota Central Research and Development Laboratories in Nagoya, Japan, studying the Toyota Production System and developing bottleneck detection and buffer allocation methods. Following Toyota, he joined McKinsey & Company in Munich, Germany, specializing in lean manufacturing and driving numerous projects in all segments of industry. Before becoming a professor, he worked for the Robert Bosch GmbH, Germany, first as a lean expert for research and training, then using his expertise as a production logistics manager in the Bosch Thermotechnik Division. In 2013, he was appointed professor for production management at the University of Applied Sciences in Karlsruhe to continue his research and teaching on lean manufacturing.

Throughout his career Dr. Roser has worked on lean projects in almost two hundred different plants, including automotive, machine construction, solar cells, chip manufacturing, gas turbine industry, paper making, logistics, power tools, heating, packaging, food processing, white goods, security technology, finance, and many more. He is an award-winning author of over fifty academic publications. Besides research, teaching, and consulting on lean manufacturing, he is very interested in different approaches to manufacturing organization, both historical and current. He blogs about his experiences and research on AllAboutLean.com. He also published his first book, “Faster, Better, Cheaper,” on the history of manufacturing and his second book “All About Pull Production” on implementing pull production as well as this series of collected blog posts.