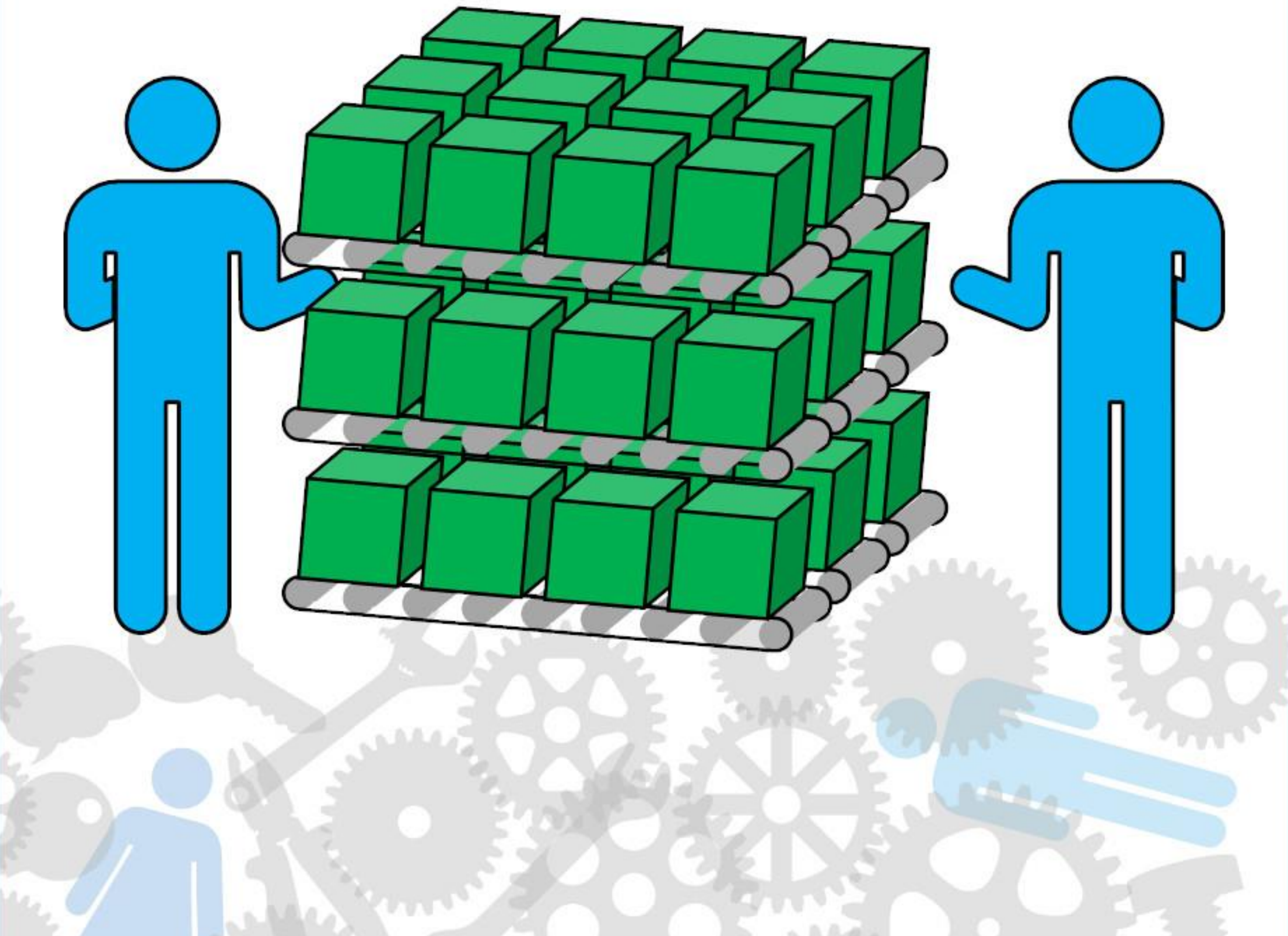
Collected Blog Posts of

AllAboutLean.com

2020

Christoph Roser



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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

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

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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 pubication database in 2020, as well as the seven books that contained them (plus some other conference and journal articles). Wih 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.

Not knowing my large lists of publications, there were also discussions at my university about giving time credit to authors of publications. I estimated that according to their ideas, my output in 2020 would result in a time credit equivalent of two years of full-time work. Hence, I politely inquired when I can take two years off to write even more. I haven't heard back from them yet, nor anything about that proposal anymore… 😕. Hence, as expected, I get all the honor, but little other benefit.

Anyway, I still enjoy writing, and I hope my works, both online and offline, will help you in your daily work on lean. Now, **go out, and organize your industry!**

Table of Content

1 225th Anniversary of the Death of Josiah Wedgwood – Father of Science in Manufacturing

Christoph Roser, January 3, 2020 Original at
https://www.allaboutlean.com/225th-anniversary-josiah-wedgwood/

Figure 1: Josiah Wedgwood (Image George Stubbs in public domain)

The British potter Josiah Wedgwood (12 July 1730 – 3 January 1795) was not only a ceramic artist, but also on the forefront of the Industrial Revolution. Wedgwood brought science into the manufacturing process. He also introduced work standards, time sheets, and many other methods that are common in the modern-day workplace.

While experiments to gain knowledge were already well known in science, craftsmen still followed the old traditions and rarely improved their craft. Josiah Wedgwood was one of the first industrialists who used this scientific method of experimenting and collecting data to propel his wares to an never-before-seen level of quality. Combining this with his keen business sense, he and his firm prospered, and the works of his firm are still highly regarded even today.

1.1 Personal Life

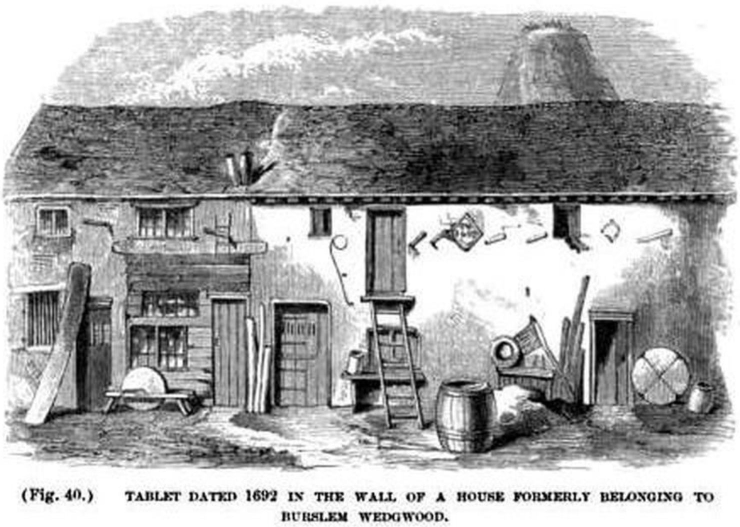


Figure 2: The Wedgwood House (Image Eliza Meteyard in public domain)

Wedgwood was born in 1730 in Burslem, Staffordshire, as the eleventh (!) child of Thomas and Mary Wedgwood. He was the fourth generation of a series of potters. While he was initially a skilled potter, smallpox almost killed him and permanently crippled him. He no longer could use one of his knees and needed crutches. Hence he also could no longer operate a potter’s wheel. Later in his life, his right leg even had to be amputated, in 1768, due to smallpox. (Please note that general anesthesia was invented only eighty years later, although his friend Priestley [see below] experimented with NO2 … but with results only seven years after Wedgwood's leg was chopped off with a bone saw). Hence Wedgewood focused more on sculpting and design rather than making traditional pottery.

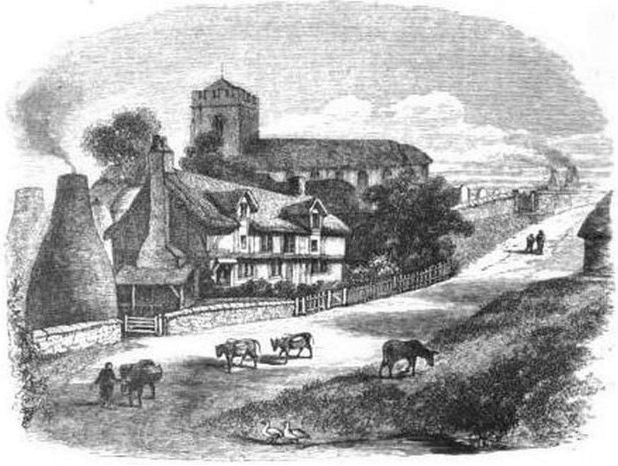


Figure 3: The Thomas Wedgwood Churchyard Works (Image Eliza Meteyard in public domain)

In school he was skilled at math, and was lucky to have a teacher who was skilled in the scientific method and taught him the value of experiments and data. He worked first with his older brother Thomas Wedgwood, and thereafter with Thomas Whieldon (1719 – 1795), who soon became his partner. Whieldon was a creative thinker and liked to experiment and to try things out, significantly influencing Wedgwood.

Figure 4: Etruria in 1865 (Image Llewellynn Frederick William Jewitt in public domain)

Eventually Wedgwood established his own workshop in Ivy Works in the town of Burslem in 1759 at the age of 29. He moved his expanding operations to a larger factory, Bell Works, in 1762 in Burslem, and started his famous Etruria Works in Stoke-on-Trent, Staffordshire, England, in 1769. He married his third cousin in 1764 and had eight children. One of his grandchildren was Charles Darwin. He died at home in 1795, aged 64, probably due to cancer.

Figure 5: Etruria (Image Eliza Meteyard in public domain)

1.2 Work Organization

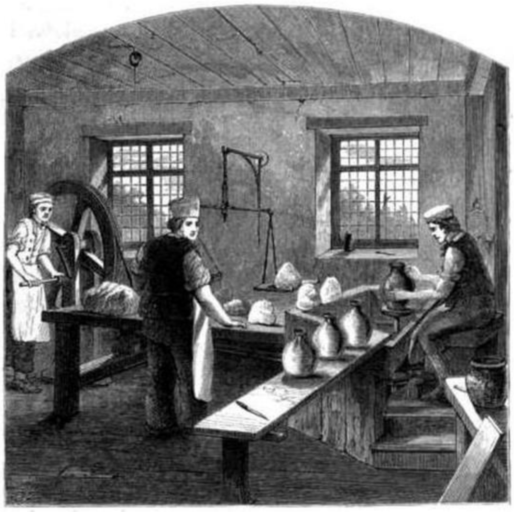


Figure 6: The throwing room in Etruria (Image Eliza Meteyard in public domain)

First of all, inspired by Matthew Bolton's Soho factory, he organized his workshops in the flow of the material. His workshop had five major departments, and they were arranged so that the clay traveled from the docks at the river in a circle back to the docks again as finished products. Contrary to modern-day lean manufacturing, however, he was not controlling the inventory but produced as much as possible and had quite large inventories.

Wedgwood strongly believed that a division of labor and subsequently using many different separate process steps is much more efficient and profitable than the previous generalist potter. Hence he organized his workshops in many small tasks, and his workers were assigned specific workplaces. They were not permitted to "wander around" between different tasks, as had been common before. He even had separate entrances for separate processes within the same building.

Figure 7: The modeling room in Etruria (Image Eliza Meteyard in public domain)

The speed of each task was also matched to the overall speed of the system (a takt time, if you will). Subsequently the workers became specialists, and therefore also much better and faster at their specialty than the generalist potters before. Out of 278 workers in 1790, only five were "odd men" without a specific assignment. He also created written work instructions for each task, the precursor of modern work standards. Hence he, in his own words, managed "*to make Artists… (of)… mere men,*" to "*make such machines of the Men as cannot err.*"

He also found that training older workers was much more difficult, and they tended to resist his new ways. Subsequently he preferred to train young employees to shape them to his vision. Overall, 25% of his workers were apprentices. He also employed women and girls, but also paid them less than the men and boys.

Figure 8: Bell Works in 1865 (Image Llewellynn Frederick William Jewitt in public domain)

Workers had to show up on time, and Wedgwood introduced the first system to track time using a bell in 1762 in his correspondingly named Bell Works factory. The bell was rung at 5:45AM, an hour before work to wake people up, at 8:30 for breakfast, at 9:00 for the end of breakfast, and so on. He used pieces of paper with the names of the employees to track time and attendance, the precursor of the modern timesheet. This was very much disliked by the older, traditional employees, but they liked his ban on drinking even less. Still, Wedgwood was never able to fully control the work times (many modern-day shop floor managers surely understand. If not, go to the shop floor five minutes before the break and observe the “work”). Potters regularly took whole days of leave, e.g. for funerals or festivals.

Figure 9: Wedgwood Portland Vase, ca. 1785 (Image unknown artist in public domain)

To keep discipline, Wedgwood was very stern and often feared by his employees. When a riot happened in 1783, he summoned the military and had one of the men hanged. Keeping this discipline was also difficult, as he had to travel often to other cities on business, and his written rules were usually ignored. He was one of the first who experimented with introducing middle managers, but had difficulties finding suitable people. Experienced workers in a supervisor role continued to ignore the rules. Eventually a nephew of his, Thomas Byerley (1747 –1810), was able to take over, but even then Wedgwood’s absence was bad for production. During his two-week honeymoon, for example, production stopped completely. Nevertheless, he was probably one of the first to introduce the foreman to production.

Figure 10: Wedgwood saucer around 1779. (Image unknown artist in public domain)

His workshops were also meticulously clean. Even though the effect of lead poisoning was still not well understood (and few industrialists cared), Wedgwood had more-stringent rules for the lead-glazing room. Workers had to keep the room even cleaner than the rest of the factory, were not allowed to eat in the room, used protective clothing, and used a wet sponge instead of a brush for applying the coat to reduce dust. Similar measures were taken at the grinding of flint, the dust of which could damage the lungs.

Despite his stern rule, working for him was popular, pay was good, housing was clean, and he took care of the health of his people. While he still ruled like a king (like most industrialists of his time), he was a comparatively good employer. Hence, few people left (despite numerous tries by the competition to hire his workers in order to duplicate his success). In his own words, he turned "*dilatory drunken, idle, worthless workmen*" in 1765 into "*a very good sett of hands*" by 1775.

1.3 Accounting

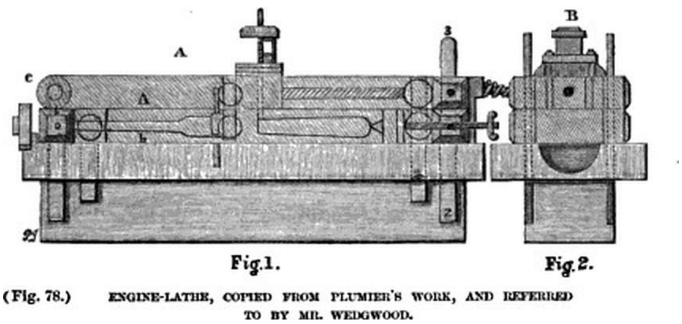


Figure 11: Lathe used in the Wedgwood Factory (Image Eliza Meteyard in public domain)

Wedgwood also kept track of expenses and profits. Highly unusual for the time, he had an accounting system rather than just working and hoping that the profit would materialize. He knew the cost of every step of his value stream. He experimented with a pay-by-piece remuneration, but found the resulting quality insufficient. He understood the difference between fixed assets and variable costs, and increased mechanization of production. For example, Wedgwood was the first to use a lathe in pottery production.

1.4 Scientific Approach

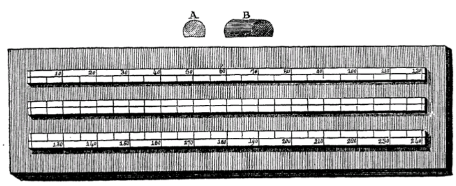


Figure 12: The Wedgwood scale (Image unknown author in public domain)

Influenced by his school teacher and his first partner, Whieldon, Wedgwood was familiar with the scientific method, using experiments and measurements to further knowledge in his field. He performed countless experiments, measuring weights and ingredients, tracking the position in the kiln, and recording the results of the pottery. To measure the temperature, he invented a high-temperature thermometer – a pyrometer, or now called *Wedgwood scale* – where the temperature is measured based on the expansion of clay.

Figure 13: Wedgwood Jasper Trials (Image Daderot in public domain)

His notebook was filled with huge amounts of data. He even made models predicting the outcome of his experiments. He studied chemistry and materials, and sampled and experimented with different clays and other minerals both for the pottery and for the glaze. Due to his research, he was able to maintain a consistent quality and color. At that time, if you broke one of your dishes within a larger set from another potter, you could of course order a replacement. But there was no guarantee at all that it would have the same shade of color. In the worst case, you ended up with one of your plates looking different.

He also exchanged ideas with Joseph Priestley (1733 – 1804, discoverer of oxygen), and met and interacted with Benjamin Franklin (1706 – 1790, one of the US Founding Fathers). He bought a lathe from Mathew Boulton (1728 – 1809) and became a close friend to him. They cooperated to create metal implements in ceramic vases. He was also familiar with Erasmus Darwin, grandfather of Charles Darwin; canal-builder James Brindley; industrialist Richard Arkwright; and many more of the who's-who of eighteenth-century science and industry.

Figure 14: Wedgwood Cream Trials (Image Daderot in public domain)

He was one of the principal members of the Lunar Society of Birmingham, so named since they met during a full moon – whose extra light made it easier to walk home late at night. These meetings aimed to exchange and discuss ideas, and the society existed for around fifty years. Many of these irregular members are still well known today, including James Watt (steam engine), Matthew Boulton (Watt's partner), Erasmus Darwin (grandfather of Charles Darwin), Joseph Priestley (discoverer of oxygen), John Wilkinson (famous ironmonger), Joseph Black (discoverer of magnesium), Benjamin Franklin (US Founding Father), and many more.

Figure 15: Richard Arkwright, Matthew Boulton, James Brindley, Erasmus Darwin, Benjamin Franklin, Joseph Priestley, James Watt, John Wilkinson (Various authors, in public domain)

1.5 Economic Success

Figure 16: Thomas Bentley on Wedgwood Pottery (Image Josiah Wedgwood in public domain)

In 1769, Wedgwood partnered with Thomas Bentley (1731 – 1780), a local merchant. Soon Bentley handled the sales in London, and Wedgwood the production in Etruria.

In 1763, Queen Charlotte ordered Wedgwood pottery, which he then marketed as "Queens Ware." Anything made for the queen was exhibited for advertising beforehand.

They created two different lines of pottery, high-quality hand-crafted and hand-painted "*ornamental ware*" for the elite, and lower-quality "*useful ware*" made using simple molds for the middle class. The ornamental ware was made in Etruria, and the useful ware in the Bell Works.

Figure 17: Wedgwood Queens Ware, ca. 1770 (Image Daderot in public domain)

The high-end products were not always profitable. First, he gave away thousands of items for free to nobility. Second, even if it was a sale, how do you force a king to pay a bill? Nevertheless, it was excellent advertising and helped sell his other products to the middle class.

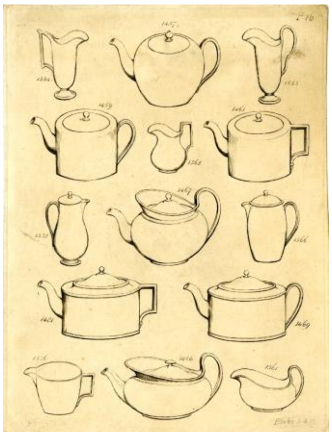


Figure 18: Wedgwood Catalogue (Image British Museum in public domain)

He also advertised in newspapers, and even spread false rumors of upcoming shortages to increase sales. He printed his first catalog in 1773. Due to the quality and popularity of his goods, he was even able to sell his goods to China (usually it was the other way round).

1.6 Legacy

Figure 19: Wedgwood Signature (Image Eliza Meteyard in public domain)

Wedgwood is known for two things: First, for the artistic quality of his wares. His company still exists, and is still positioned in the premium segment for ceramics. Second, and the focus of this post, his scientific approach to manufacturing. As Winslow Taylor is the father of scientific management, so is Wedgwood the father of scientific manufacturing. His approach to measure, experiment, and improve quality, as well as his rigorous organization of his factories, was centuries ahead of others. He was probably the first to use controlled experiments in manufacturing. Hence, I am happy to have the opportunity to commemorate him in this blog post, which turned out much longer than usual. Now **go out, understand your processes, and organize your industry!**

P.S.: If you want to learn more, I can recommend The Wedgwood Museum in Stoke-on-Trent, Staffordshire, England.

2 What Is Kaizen?

Christoph Roser, January 7, 2020 Original at https://www.allaboutlean.com/what-is-kaizen/

Figure 20: Kaizen Word Bubble (Image PixelsAway with permission)

If you are in lean, you surely have heard of kaizen, and its English translation, *continuous improvement process* (CIP). It is one of the fundamental parts of lean. Kaizen generally means to improve, and in lean in particular, it means to continue improving forever. Pretty much all companies that haven't gone bankrupt do this, often without using the word *kaizen*. You need to continuously improve in order to survive the harsh realities of competition.

2.1 Linguistics

Figure 21: Kaizen in Japanese (Image Majo statt Senf under the CC-BY-SA 4.0 license)

Kaizen is Japanese for "improvement" or "betterment." The word itself does not say anything about this being a continuous or repeating process, and in normal Japanese it could be only a single improvement. However, in Japanese business ethics, the repetitive process is pretty much always implied. The word *kaizen* consists of two Japanese characters: 改善. The first one 改 means "reformation, change, inspection, search." The second means "virtuous or good." Overall, it is improvement.

2.2 The Basic Idea

You are probably familiar with the basic idea of kaizen: Keep on improving. If you do not continuously work on getting better, you will fall behind. Or, as it is commonly said in English, you have to run just to stand still.

2.3 Different Types of Improvements

You can distinguish improvement into different types if you want. There is troubleshooting and problem solving, and then there is actual improvements. The boundary between these two is actually fluid, but it helps to keep in mind that there is more to kaizen than just firefighting, even though many shop floors are mostly occupied with solving problems that pop up.

2.3.1 Troubleshooting

Figure 22: Man on Crutches (Image Tony Alter under the CC-BY 2.0 license)

Even a very well set-up production system will degrade over time. Machines and tools age, and their performance may suffer if there is no maintenance. Things will break. Sometimes you notice right away because the breakdown causes a lot of problems, and this forces you to fix it immediately. Other times the issue will be more subtle, and you may not even know that you have a technical defect, except that your quality or performance is slipping. The system also changes due to external factors. New products are developed, and what may have worked well for the old products may not work well for the new ones. The customer wants more (or fewer) products than before. You get a new supplier, maybe because the old one is out of business. All of this forces you to change your production system just to keep your company from going under.

However, fixing problems and troubleshooting is only one part of the different improvement efforts. Another part is prevention of problems through preventive maintenance and similar activities. I leave it up to you to decide if you consider this an actual "improvement" (i.e., kaizen) or not, since it only maintains the status quo, but you should not neglect it.

2.3.2 Actual Improvement

Figure 23: Marathon Runner (Image Katie Chan under the CC-BY-SA 4.0 license)

Besides fixing and preventing problems, there is actual improvement. The system runs, and there are no major issues like machine breakdowns, but it could run even better. What can you do to improve the system performance? Could you establish a pull system? Should you improve work standards? What about improving the shop floor layout to improve performance?

Most companies are almost completely preoccupied with firefighting. Only very lean and well-organized companies spend a lot of their efforts on actual improvement. If you are not sure which type your company is, then it is probably the former. Some truly lean companies like Toyota actually spend a lot of effort merely to find out where they still could improve.

As I said above, these two groups actually overlap quite a bit, and this classification is not a tool to distinguish projects, but more of a philosophical aid to show you that there is more to improvement than what blows up in your face.

2.4 Where to Start?

Figure 24: True North (Image Hike The Monicas under the CC-BY-SA 4.0 license)

This brings up the question on where to start your kaizen efforts. This is not an easy question. You should know your true north. What are the overarching goals of your company? At least some of your improvement efforts should be geared toward this true north. If you are using Hoshin Kanri, it may help to give you a better understanding of the direction the company should be moving. Especially for larger projects, Hoshin Kanri or a similar overarching direction is very helpful.

There are also the firefighting projects. These often take priority. It is of no use to develop a beautiful pull system if your tools are broken and you do not produce anything.

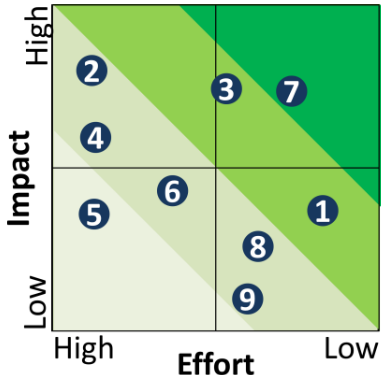


Figure 25: Impact Effort Matrix (Image Roser)

An impact effort matrix can help you prioritize projects. You try to get the biggest bang for the buck. See more on prioritization in my post How to Manage Your Lean Projects – Prioritize. Some of your kaizen projects may be large, take time, and include multiple people. Do not underestimate the many things that can go wrong in large projects. Smaller steps are often easier.

Other kaizen projects may be very small, include only one or two people, and can be implemented quickly using duct tape and some string. Often, if it looks useful and can be done quickly, then you should just do it. Even starting an impact effort matrix may be more effort than doing the quick improvement in the first place. Such quick kaizen efforts are often particularly good to raise morale.

2.5 How to Proceed

So now you know where you want to do kaizen. But there are still many things that can go wrong. For me, there are a few key points that are more important than others:

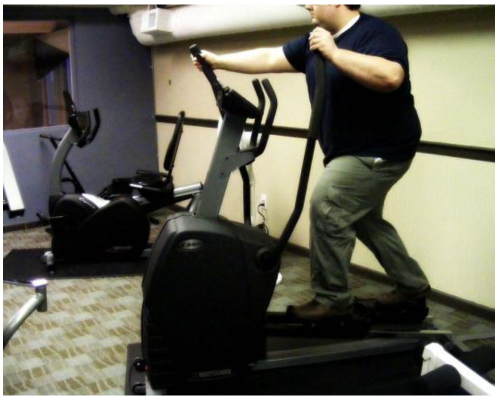


Figure 26: Exercising Weight (Image Robert Anthony Provost under the CC-BY 2.0 license)

Management Support: Any kind of successful project needs support from management. And by this I do not only mean that management allows it, or even wants it; they need to put their weight behind it. If you want to become lean, it is not enough that you want to lose weight; you actually need to do a lot of exercise to become lean. This may even require additional manpower or time to do the actual improvement. At Toyota, they have an amazingly large number of people to help with the kaizen effort, whereas in many other companies the task is merely slapped on top of already-overworked people.

Worker Involvement: It really helps if the improvement is done together with the people whose area is affected. Do not change a machine without talking with the workers first. They may not command your salary, but they usually know the shop floor better than anyone else does.

PDCA: Plan–Do–Check–Act are crucial for any kind of project. For me, this is one of the most important philosophies to achieve success. Many people want to achieve a lot in little time and do Plan-Do-Plan-Do-Plan-Do… but end up achieving nothing. The Check and Act are essential to ensure that your improvement is actual an improvement (kaizen 改善), and not a changing for the worse (kaiaku 改悪).

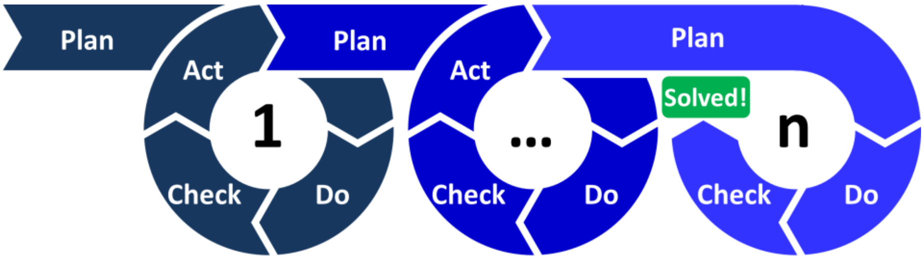


Figure 27: PDCA (Image Roser)

So this is the brief overview on how to do kaizen. While tools like SMED have a clear approach in seven steps (or similar), kaizen is much more fuzzy and harder to nail down. I hope this was useful to you, and gives you a little bit of guidance in the "softer" parts of lean manufacturing. Now **go out, improve your system, and organize your industry, and keep on doing this forever!**

3 Flexible Manpower Lines 1 – Introduction

Christoph Roser, January 14, 2020 Original at *https://www.allaboutlean.com/flexible-manpower-lines-1/*

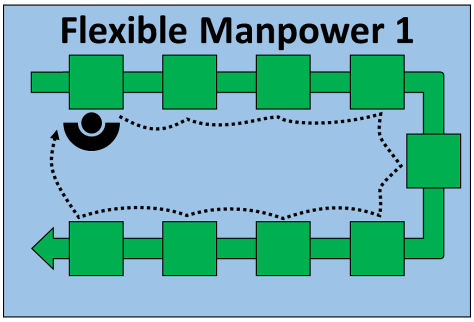


Figure 28: Flexible Manpower Line 1 Operator (Image Roser)

Production lines with manual labor often have the possibility of adjusting manpower due to demand. Such flexible manpower lines can work with different staff numbers, and can adjust the production output to the customer demand. At Toyota, such lines are also called ***Shoujinka*** (少人化, literally "few people production"). A gender neutral term would be "flexible staffing line". This blog post will go into the details on how to set up such a line.

3.1 When to Use

Figure 29: Source Make Deliver Fluctuations (Image Roser)

Flexible manpower lines can be used when customer demand is changing over time. Hence the customer demand fluctuates. As I explained in a previous post, there are three fundamental ways to decouple fluctuations: You can buffer through inventory, you can let your customer wait, or you can adjust capacity. The flexible manpower line adjusts capacity. By adding and reducing the number of workers in the line, you can increase or decrease the production output. This is best used if the customer demand changes for a longer duration. Short-term changes may be decoupled simply by using inventory buffers.

3.2 Requirements

A flexible manpower line is not always possible. There are a couple of requirements for this to work.

Approach is for a flow shop: Such a flexible manpower line makes sense only if you have a flow shop. If you have a job shop or project shop instead, then of course you can also adjust the manpower in these production systems. However, the method is different and often requires less fine-tuning. In job shops, people often move between stations due to the needs of the system, and the structure for assigning people to stations is usually able to handle different numbers of workers anyway. Furthermore, each process in a job shop is usually a single process and the number of operators for a single process cannot be changed easily. A project shop is usually also able to handle different numbers of workers. Hence, it is usually easier for job shops and project shops to add or remove workers to adjust capacity than it is for a flow shop. Yet, flow shops are usually vastly more efficient and produce higher quality at lower cost than comparable job shops or project shops.

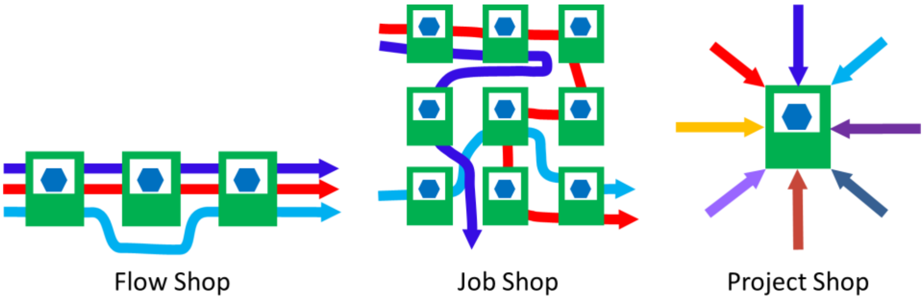


Figure 30: Flow Shop Job Shop Project Shop (Image Roser)


Figure 31: Worker Assembly (Image naxaso with permission)

It must include manual work: Only with manual work can an operator move between stations and handle more than one station at a time. If you have a fully automatic system, then it is not possible to increase or decrease output during the same work time. Okay, technically you could change your machines to a slower setting, but there is no benefit in this. The machines would work slower, but you would not have any benefits from it. Rather, you risk running into quality issues because the slower speed settings may require additional fine-tuning.

It must be more than one manual process: This is also a must-have. If your system has only one manual process, then you cannot add workers into it (of course, you could remove the single worker, but then you would not produce anything).

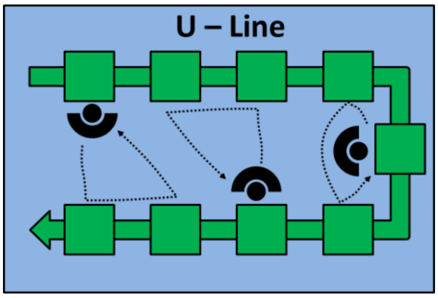


Figure 32: U-line-workers (Image Roser)

Manual stations should be close to each other: Strictly speaking, this is not an absolute must-have, but it is highly recommended. Since a worker may be covering multiple workstations, he must walk between these stations. This walking requires time, which is of course paid work time. If there are excessive walking distances, then the additional labor cost for walking is prohibitive. Often, the line layout is optimized for such flexible manpower, as for example in an U-Line or a S-Line.

Labor must be flexible: If you sometimes need more workers and sometimes less, then you need to be able to adjust the number of workers. Hence, you need some flexibility with your workforce. You may be able to distribute excess workers to different flexible manpower lines with higher demand, or draw workers from flexible manpower lines with lower demand. You may be able to have more people take a day off, or ask them to come in. In sum, this approach makes sense only if you can decrease or increase the number of hours of your workforce – but please do this in a way aligned with the workers, the unions, and the local laws.

3.3 Advantages and Disadvantages

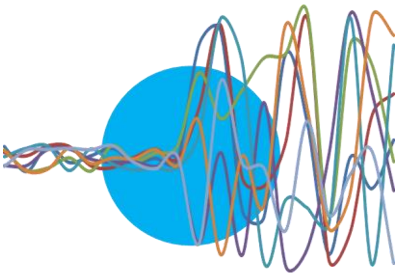


Figure 33: Leveling (Image Roser)

Many people believe that a flexible manpower line exists to reduce labor cost. This is not true. You could also simply reduce labor cost by reducing work time. If you have eight people working one hour or one person working eight makes no difference for your labor cost.

The big advantage of flexible manpower lines is leveling! While the total working time is roughly the same, the big advantage is a more continuous and steady production. This applies to the supply, to the demand, and also to the workers.

Let's start with the workers since this is most obvious. Mathematically, it makes no difference if one worker works eight hours or eight workers each work one hour. However, for the worker it makes a lot of difference if they come to work for a normal eight-hour day or if they are called in for one hour and then sent home. The workers would be quite unhappy to commute to work only to find out that they are sent home after an hour. In any civilized country, the unions would be really upset, and rightfully so. The worker would probably prefer to take a day off rather than coming in for one hour. Hence, such a flexible manpower line is easier on the working hours of the operators.

Similarly for the supply and demand. A continuous and steady demand of parts from preceding processes is better than a line that runs at full capacity for two hours and is then switched off for the rest of the day. The same applies to the customer side – which may be the end customer or only the next production system in the value stream. No matter if suppliers or customers, if the line goes from full capacity to zero and back, you need inventory to buffer these fluctuations, and hence you need space to store it, tie up capital, increase your lead time, increase material handling, and many, many other negative aspects associated with inventory. See my post on the The Hidden and Not-So-Hidden Costs of Inventory for more. So, in sum, **the advantage of a flexible manpower line is that it levels your production and keeps your inventory down, as well as allowing easier work times for the operators**.

Figure 34:More work for me? (Image STUDIO GRAND OUEST with permission)

All of this does not come free, however. There are also quite a few downsides. A flexible manpower line is more **management overhead**. Management needs to create and maintain multiple work standards for a line with different numbers of operators. Management needs to think about which person does what if there are two, three, four, or more operators in the line.

This is additional work in setting up the line. Additionally, there is the task of assigning workers to the line, other lines, or keeping them at home, although you may have similar scheduling work if you decide to run the line at full capacity with less hours instead.

The workers also have **more walking distance**. Since they now cover multiple stations, they have to walk between these stations. This walking distance takes time, and hence costs the company money. In some cases, the worker may be able to do a job while walking and holding a part, but this is rare.

Figure 35: Training in progress (Image auremar with permission)

Finally, if you reduce the number of workers, a worker needs to cover more stations. Hence, your **workers need to be trained in more stations**. It is actually good to have workers trained in multiple stations, and maybe you have qualified your workers already. However, if you have not yet, then this is one additional task on your to-do list.

This is the first post in a four-post series on flexible manpower lines. In the next post I have a bit more introduction before I present an example line that will be adapted for different numbers of operates using the standard work sheets from Toyota. Until then, stay tuned, and **go out and organize your industry!**

4 Flexible Manpower Lines 2 – Alternatives and Example

Christoph Roser, January 21, 2020 Original at https://www.allaboutlean.com/flexible-manpower-lines-2/

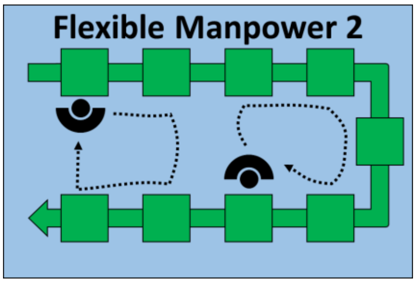


Figure 36: Flexible Manpower Line 2 Operators (Image Roser)

Having a flexible manpower line is a good way to adjust the production capacity to changing demand while still keeping your system leveled. In this second post in my series on flexible manpower lines, I give you some alternatives before going into more details of an example line that we will set up for different numbers of operators in the next few posts.

4.1 Alternative Options

Figure 37: Nordic Walking (Image Malcolm jarvis under the CC-BY-SA 3.0 license)

A flexible manpower line is one answer to fluctuating customer demand (or, technically speaking, fluctuating supply too … but this is a whole different problem). However, it is not the only possible answer. The most desirable solution is to **reduce or eliminate the customer fluctuation** and force your customer to just take as much as you produce … but this is rarely an option. You may be able to influence your customer a bit, however, like the ski pole company that promoted Nordic Walking, or through promotions and special discounts.

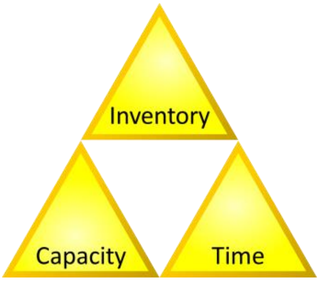


Figure 38: Triforce Inventory Capacity Time (Image Roser)

Other than that, there are three fundamental ways to decouple fluctuations: Inventory, capacity, and time. The flexible manpower line adjusts capacity while running full time. You can also adjust capacity by **reducing or increasing the working time of your line**. This comes with the challenge of where to put the workers. Ideally, you have other tasks that need to be done, and can assign these workers to these other tasks. Sending people home earlier or later may also be possible, but this has to align with the workers and unions and labor laws. In most countries, some flexibility is possible, especially if it is announced beforehand.

If you run your line for shorter durations, you need to buffer the fluctuations through inventory, which causes more handling, storage, tied-up capital, and other costs. For shorter-term customer fluctuations, you can use **inventory buffers** to decouple the customer fluctuations. Finally, if all else fails, you can **let the customer wait** (i.e., sell less). This is usually not a desired solution but the automatic default if you were unable to resolve the issue in another way.

4.2 Customer Takt and Line Takt

Figure 39: Metronome (Image Vladimir Voronin with permission)

The goal of a flexible manpower line is to match the customer takt with the line takt while keeping the line working during usual working hours rather than stopping the line. Quick recap: the takt is the average time between parts, and can be calculated for the customer (average time between the demand for one part) and the production (average time between the production of one part). Ideally, these two numbers are very close to each other. Please do not confuse the takt time with the cycle time. The cycle time has no problems or losses and is an ideal state. The takt time includes all losses like machine breakdowns, missing parts, defect parts, and so on. If you divide the cycle time by the takt time, you get the OEE. For more, see my post on the Different Ways to Measure Production Speed.

4.3 Manpower Options and Limitations

Figure 40: A two-man job! (Image New Africa with permission)

Next you have to think about the different manpower options. For many lines this is simple. At most you can have one person per station. The smallest number would be one person for the entire line. However, in some cases there may be additional considerations. For example, some processes may need two (or even more) people to work. If you have to install a large and heavy item, the station may require two (or even more) people to lift the item into place and assemble it.

Similarly, there may be situations where having a worker at every station may be overkill. For example, assume there are two adjacent stations where a worker has to put a part in the machine, press a button, and then wait for fifty seconds for the machine to finish the process. In this case, it would be overkill to have one worker at each station spending most of its work time waiting, while one worker could easily do both jobs without any reduction in productivity.

4.4 Flexible Manpower Example

Figure 41: Nokia 3310 Mobile Phone (Image Multicherry under the CC-BY-SA 4.0 license)

In the following, I will use a simple example of a fictional mobile phone final assembly line. There are a total of seven steps as shown below. All of them are manual work except step 6, the electronic quality check. The worker merely inserts the phone into the machine and lets the machine work on its own.

- Glue foam parts
- Install display in top housing
- Install keyboard in top housing
- Install & connect PCB in top housing
- Close housing with bottom housing
- Electronic quality check
- Packaging of phone and accessories

4.5 Standard Work Sheet

Creating a flexible manpower line is an excellent use of the standard work sheet from Toyota. Hence here we will use the standard work sheets as used by Toyota. I have written a whole series of posts on this, please check out Toyota Standard Work Part 1: Production Capacity, Part 2: Standard Work Combination Table, and Part 3: Standard Work Layout.

As you may remember, there are three parts to the standard work sheet. The first one is production capacity. Without going through all the details, here is the production capacity sheet for our example. We can see that all steps take around thirty seconds, except the step 6 quality check, where the manual labor is only five seconds and the machine takes twenty-five seconds.

Production Capacity Sheet

Part Name: Final Assembly | Part Nr.: 224-08/17 | Date: 14.01.2020 | Manager: 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 42: Flexible Manpower Example Production Capacity Sheet (Image Roser)

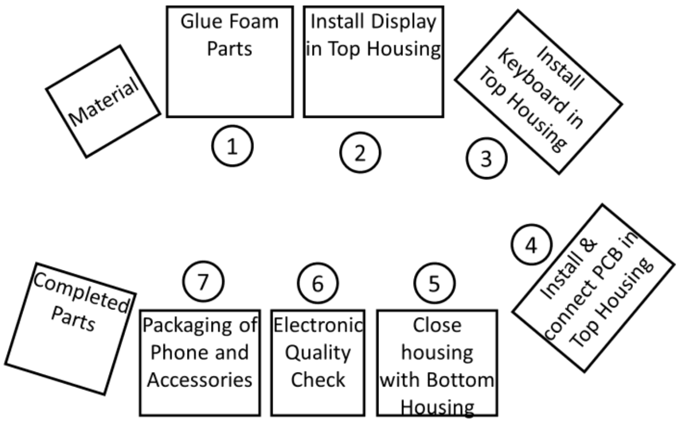


Figure 43: Flexible Manpower Example Layout Blank (Image Roser)

Another part of the standard work sheet is the layout. Since we assume that we already have a line that we want to adapt for flexible manpower, we assume that we already have a layout. Usually, even though the number of workers in the line changes, the layout does not. Moving around the machines would take too much effort, and hence is usually not done. However, I also have seen lines where the machines were all on wheels and with flexible pneumatic, electric, and electronic connectors, and they could be moved around easily. Yet, for this example we stick to a fixed layout so as not to make things too complicated. You can find all the machines there again, and the major material supplies. This is not yet a finished layout, as we are missing the walking distances.

Finally we have the standard work combination table. In this table we will check the work content (including walking and waiting) for the operators. Below is an incomplete table. It lists only the tasks and the manual and machine times. The walking times are not included, and neither is the graph for the operation time (since both depend on the number of operators).

Standard Work Combination Table

Part Name: Mobile Phone 22117 | Part Nr. 224-08/16 | Date 16.01.2020 | Process: Final Assembly | Takt Time: | Demand/Shift:

#	Work Content	Time: Manual	Time: Machine	Time: Walk	Operation Time (10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190)
1	Glue Foam Parts	31	0		
2	Install Display in Top Housing	29	0		
3	Install Keyboard in Top Housing	30	0		
4	Install & connect PCB in Top Housing	29	0		
5	Close housing with Bottom Housing	32	0		
6	Electronic Quality Check	5	25		
7	Packaging of Phone and Accessories	24	0		
8					

Figure 44: Flexible Manpower Example Standard Work Table Blank (Image Roser)

Just as a reminder, below is the legend for the operation time that we will fill out in a bit. Black boxes are working times for operators, squiggly lines represents walking, dashed lines are the working time of machines without operators. Empty boxes represent waiting time and at the end is a vertical line representing the takt.

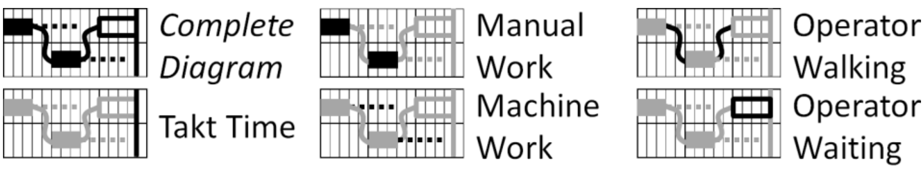


Figure 45: Toyota Standard Work Combination Legend (Image Roser)

In my next post we will actually plan this line for different numbers of operators. We will do all options between a single operator and a sensible maximum of six operators. However, not all of these options make sense. Until then, stay tuned, and **go out and organize your industry!**

5 Flexible Manpower Lines 3 – Example Line

Christoph Roser, January 28, 2020 Original at [*https://www.allaboutlean.com/flexible-manpower-lines-3/*](https://www.allaboutlean.com/flexible-manpower-lines-3/)

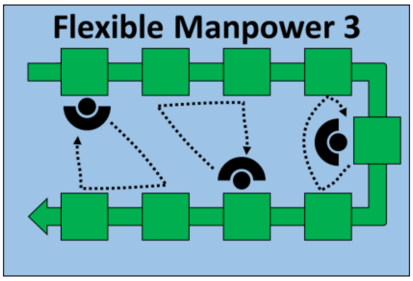
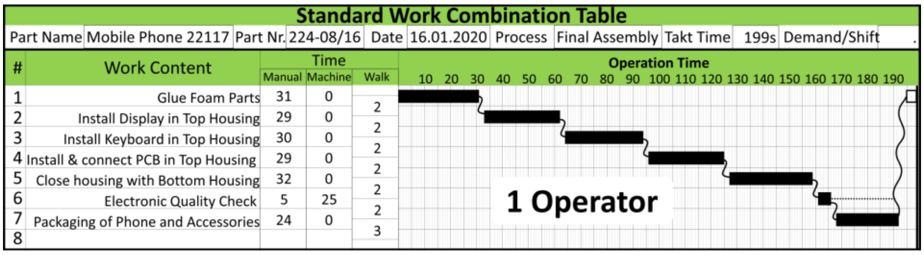


Figure 46: Flexible Manpower Line 3 Operators (Image Roser)

This third post in the series continues with the example on flexible manpower lines. Now we will investigate different options for these flexible manpower lines (also called *Shoujinka* 少人化). I will show you the details on all options between a single operator and the (sensible) maximum of six operators, and why for our example it does not make sense to use four or five operators.

5.1.1 Single Operator

Continuing our example, let's start with a single operator. One operator does all processes in sequence, with always 2 seconds walking time in between, except for waking back to the first station, which takes 3 seconds. The standard work combination table could look as shown below. All steps are in sequence, and the worker arrives back at the first station after 195 seconds. However, this would be the cycle time. For the takt time we would need to add a bit of buffer to protect against unforeseen events. In this example, I added 3 seconds waiting time for a total takt of 199 seconds.



Standard Work Combination Table

Part Name: Mobile Phone 22117 | Part Nr. 224-08/16 | Date 16.01.2020 | Process: Final Assembly | Takt Time: 199s | Demand/Shift

#	Work Content	Time Manual	Time Machine	Walk
1	Glue Foam Parts	31	0	2
2	Install Display in Top Housing	29	0	2
3	Install Keyboard in Top Housing	30	0	2
4	Install & connect PCB in Top Housing	29	0	2
5	Close housing with Bottom Housing	32	0	2
6	Electronic Quality Check	5	25	2
7	Packaging of Phone and Accessories	24	0	3
8				

Figure 47: Flexible Manpower Example Standard Work Table 1 Operator (Image Roser)

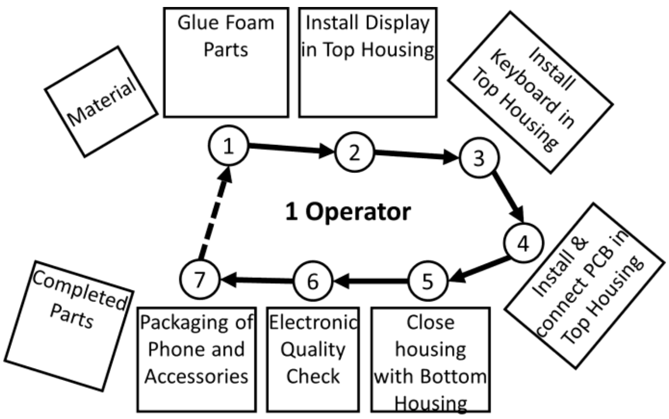
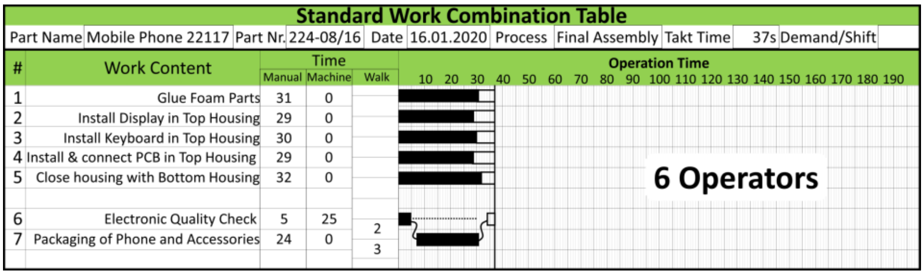


Figure 48: Flexible Manpower Example Layout 1 Operator (Image Roser)

This would be an OEE of 97%, which looks high. However, human workers usually have fewer problems and breakdowns than machines, and human workers can and do catch up if there is a problem. Hence, with one worker we would be able to fulfill a customer takt of 199 seconds or slower. This is also the minimum sensible output of the line. If you need less time, you would have to reduce the working time of the line. The layout could look like the image shown here. The single worker circles all stations before returning to the first station.

5.1.2 Maximum Number of Operators

Next let's look at the other end with the maximum number of operators. We do have seven workstations, which would allow a maximum of seven workers in the system. However, step 6 quality check is mostly machine work, and a worker can complete step 7 while step 6 is in automatic mode. While you could place seven workers in the system, there would be little benefit, and a system with six workers performs equally well. Since all but the last worker have no walking distance, the standard work combination table would look like this. Stations 1 to 5 are manned by one worker each, and stations 6 and 7 have a single worker for both stations.



Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	37s	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	
2	Install Display in Top Housing	29	0	
3	Install Keyboard in Top Housing	30	0	
4	Install & connect PCB in Top Housing	29	0	
5	Close housing with Bottom Housing	32	0	
6	Electronic Quality Check	5	25	2
7	Packaging of Phone and Accessories	24	0	3

Figure 49: Flexible Manpower Example Standard Work Table 6 Operators (Image Roser)

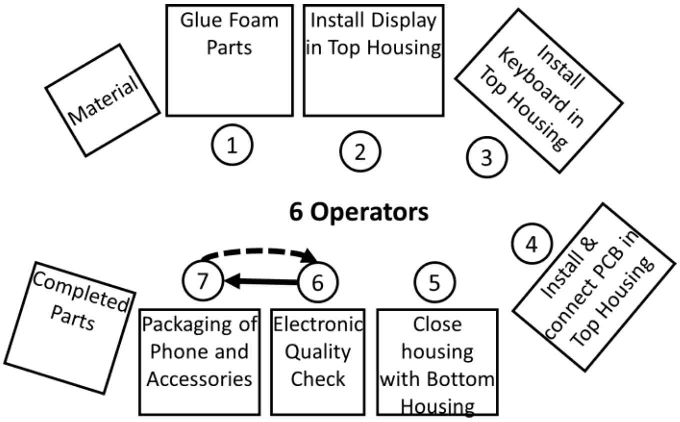


Figure 50: Flexible Manpower Example Layout 6 Operators (Image Roser)

The worker with the largest work content (for stations 6 and 7) would complete his round in 34 seconds. Allowing again for a bit of safety, we arrive at a takt time of 37 seconds. Hence, this line would be able to satisfy a customer demand of 37 seconds or slower if there are six workers in the system. This would also be the maximum output the system can handle. If you need more, you would need to increase working time on the line (e.g., additional shifts), improve performance, or add another line. The corresponding layout could look like this. All stations have one worker each, except one worker for station 6 and 7.

5.1.3 Two Operators

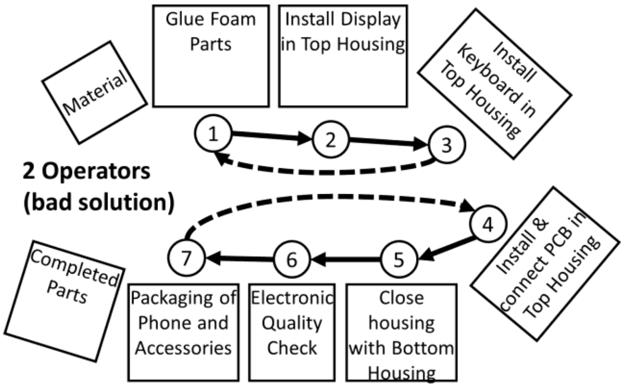


Figure 51: Bad Flexible Manpower Example Layout 2 Operators (Image Roser)

There is also the possibility of running the line with two operators. Just to illustrate a point, the first layout here on the right is NOT a good layout, since there are lots of walking distances for the workers. The second layout below would be much better, since the distance traveled by the worker and the time required for walking would be less.

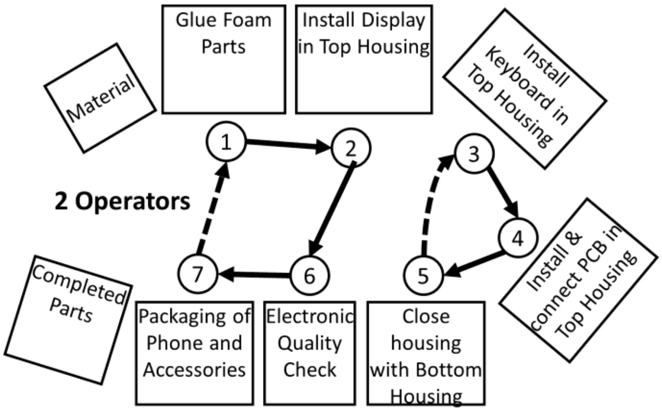
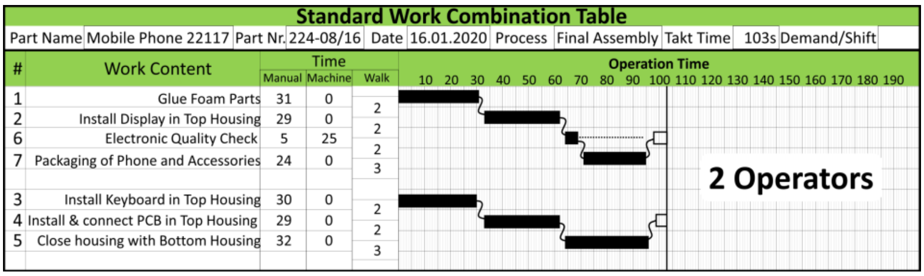


Figure 52: Flexible Manpower Example Layout 2 Operators (Image Roser)

A possible standard work combination table could look like the one below. Worker 1 handles stations 1, 2, 6, and 7; while worker 2 handles stations 3, 4, and 5. The worker with the largest work content, worker 2, would be done in 99 seconds. Adding some safety, we get a line takt of 103 seconds. Hence, this setup could handle customer takts of 103 seconds or slower.



Standard Work Combination Table

Part Name: Mobile Phone 22117 | Part Nr. 224-08/16 | Date 16.01.2020 | Process Final Assembly | Takt Time 103s | Demand/Shift

#	Work Content	Manual	Machine	Walk
1	Glue Foam Parts	31	0	2
2	Install Display in Top Housing	29	0	2
6	Electronic Quality Check	5	25	2
7	Packaging of Phone and Accessories	24	0	3
3	Install Keyboard in Top Housing	30	0	2
4	Install & connect PCB in Top Housing	29	0	2
5	Close housing with Bottom Housing	32	0	3

Figure 53: Flexible Manpower Example Standard Work Table 2 Operators (Image Roser)

5.1.4 Three Operators

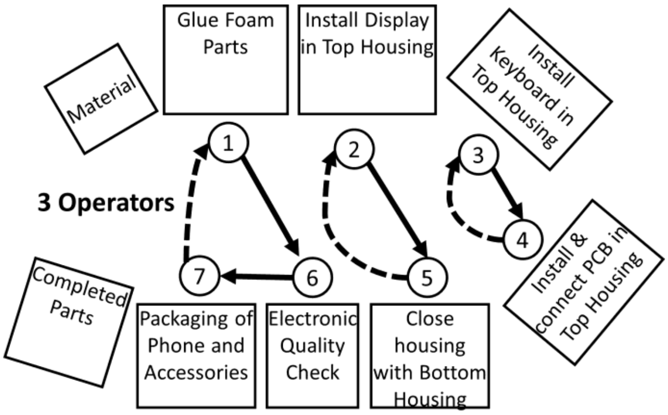
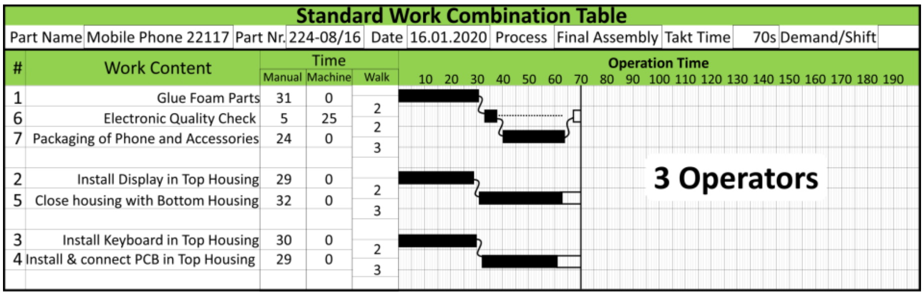


Figure 54: Flexible Manpower Example Layout 3 Operators (Image Roser)

Finally, we have the setup with three operators. Here, too, we would have multiple possible combinations. Below is the layout and the standard work combination table. The worker with the largest work content, worker 1 would complete his tasks in 62 seconds. Adding some safety this setup with three workers could satisfy a customer takt of 70 seconds or slower. Please note that feasible other solutions exist.



Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	70s	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	
				2
6	Electronic Quality Check	5	25	
				2
7	Packaging of Phone and Accessories	24	0	
				3
2	Install Display in Top Housing	29	0	
				2
5	Close housing with Bottom Housing	32	0	
				3
3	Install Keyboard in Top Housing	30	0	
				2
4	Install & connect PCB in Top Housing	29	0	
				3

Figure 55: Flexible Manpower Example Standard Work Table 3 Operators (Image Roser)

5.1.5 What About Four and Five Operators?

Having seven workstations with at most six operators, we made standard work sheets for one, two, three, and six operators. What about four and five operators? Well, while this is theoretically possible, it would not make sense for our line. Our example line is reasonably well balanced, and each task has about 30 seconds (and tasks 6 and 7 together also around 30 seconds). No way how you divide it, if you add additional workers, you just add more waiting time. Let me show you.

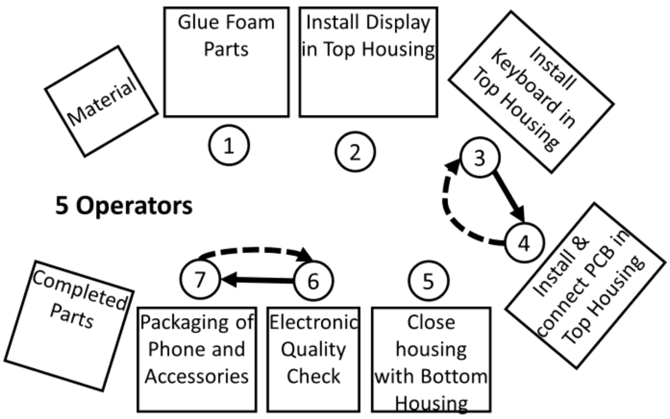
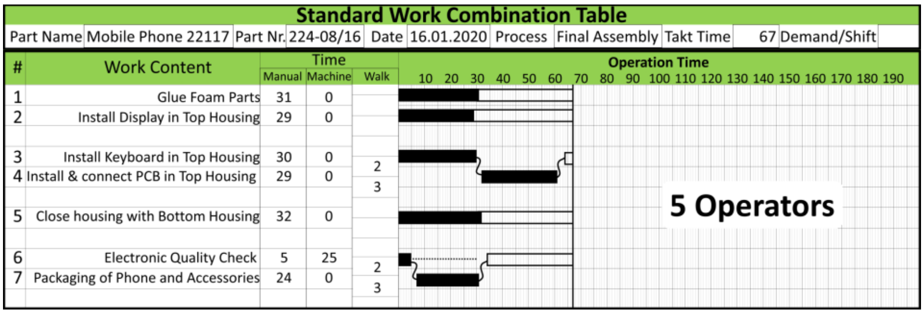


Figure 56: Flexible Manpower Example Layout 5 Operators (Image Roser)

Let’s make a system with five operators. We have one operator cover stations 3 and 4 as shown in the layout below besides the operator for stations 6 and 7. All other stations (1, 2, and 5) have only one operator. Below is the standard work combination table.



Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	67	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	
2	Install Display in Top Housing	29	0	
3	Install Keyboard in Top Housing	30	0	2
4	Install & connect PCB in Top Housing	29	0	3
5	Close housing with Bottom Housing	32	0	
6	Electronic Quality Check	5	25	2
7	Packaging of Phone and Accessories	24	0	3

Figure 57: Flexible Manpower Example Standard Work Table 5 Operators (Image Roser)

The outcome would be pretty bad. The operator for stations 3 and 4 has now twice the workload of all other operators, and completes his tasks in 61 seconds. Since the line cannot move faster than the operator with the most work content can, our line also cannot move faster, and, including some safety, we get a line takt of 67 seconds. With three workers we had a takt of 70 seconds, and after adding two more workers we get a measly two-second improvement in the takt time?! This is not worth it; instead of improving the output, we merely increased the waiting time of the other workers.

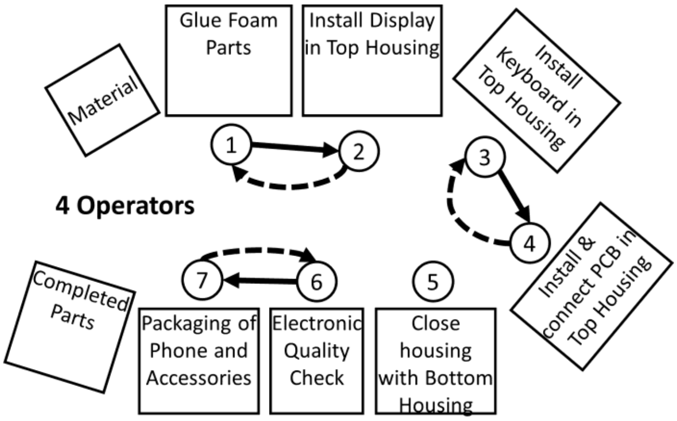
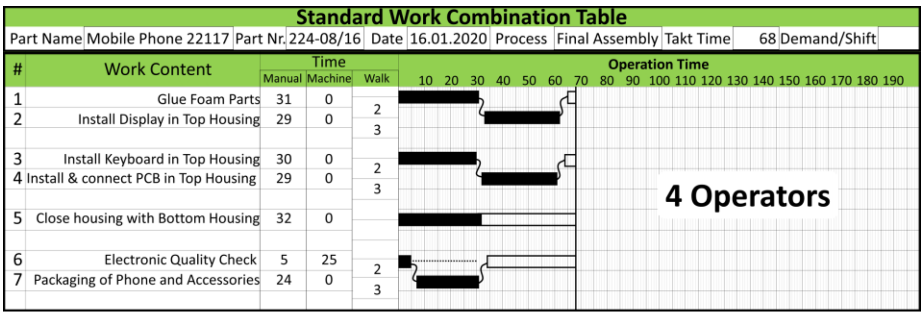


Figure 58: Flexible Manpower Example Layout 4 Operators (Image Roser)

A similar result would have happened with four operators. The work content in the different stations just can’t be distributed well, and you cannot make a well-balanced line with four or five workers. Here is the layout and the standard work combination table for four operators. Other solutions exist, but they are not better than this one. The worker with the largest work content (for stations 1 and 2) finishes his round in 65 seconds. With some safety you get a line takt of 68 seconds. You add one extra operator and all you get out of it is a reduction in takt time from 70 seconds with three workers to 68 seconds with four workers. These measly two seconds are also definitely not worth the extra worker, which just causes a lot of waiting time in two of the four workers.



Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	68	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	2
2	Install Display in Top Housing	29	0	3
3	Install Keyboard in Top Housing	30	0	2
4	Install & connect PCB in Top Housing	29	0	3
5	Close housing with Bottom Housing	32	0	
6	Electronic Quality Check	5	25	2
7	Packaging of Phone and Accessories	24	0	3

Figure 59: Flexible Manpower Example Standard Work Table 4 Operators (Image Roser)

5.1.6 Comparison Overview

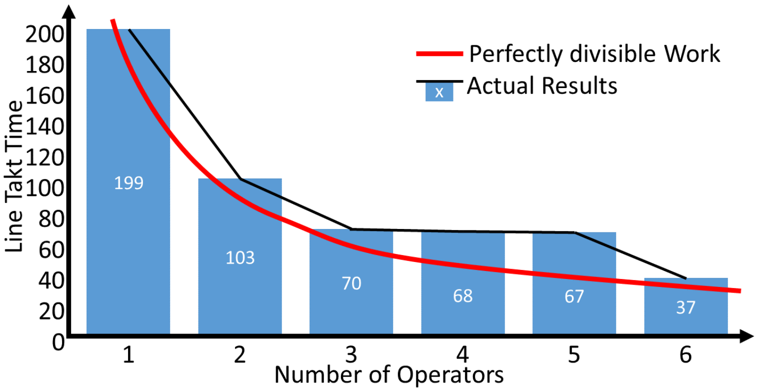


Figure 60: Flexible Manpower Example Results Overview (Image Roser)

The graph below shows you the line takt times for different numbers of operators. The blue bars are the actual takt time (connected with black lines). The red curve would be a theoretical optimum if the work at the station would be infinitely divisible without any walking time. This theoretical line is simply the work content of 180 seconds divided by the number of operators. Unless you optimize the actual work, you will not have a takt time below this line.

With every increase in the number of workers, there is a corresponding decrease in the takt time – except for with four and five workers. For four and five workers there is almost no change in the takt time, hence these two options would be not really good solutions. Therefore, for the example above, good solutions of flexible manpower lines exist for one, two, three, and six operators, but there is no good solution for four and five operators.

In my next and last post on this series on flexible manpower lines, I give you a brief how-to on flexible manpower lines to explicitly show you the basic steps. I will also give you some easier but not quite as efficient alternative options like the bucket brigade or the rabbit chase. Now, go out, make your lines flexible by adjusting the number of operators, and **organize your industry!**

6 Flexible Manpower Lines 4 – How-To do Flexible Manpower Lines

Christoph Roser, February 4, 2020 Original at https://www.allaboutlean.com/flexible-manpower-lines-4/

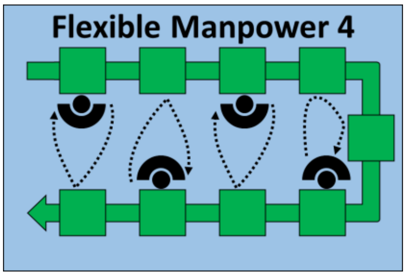


Figure 61: Flexible Manpower Line 4 Operators (Image Roser)

This is the final post in this series on flexible manpower lines. Since we completed the example line in the last post, I will give you a brief theoretical run-down on how to divide the work among multiple people. I will also show you some easier-to-manage but maybe not-quite-as-efficient alternative options, the bucket brigade and the rabbit chase.

6.1 How-To: Flexible Manpower Line

Now we have seen the organization of a flexible manpower line for an example with anywhere between one and six workers. Let me summarize the main points:

6.1.1 Use Standard Work Sheets

Production Capacity Sheet												
Part Name	Final Assembly	Part Nr.	224-08/17		Date	14.01.2020		Manager	John Doe			Section
Sequence	Process Name	Machine Nr.	Manual Time Min.	Manual Time Sec.	Machine Time Min.	Machine Time Sec.	Total Time Min.	Total Time Sec.	Lot Size	Change Over Time Min.	Change Over Time Sec.	Process Capacity 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 62: Flexible Manpower Example Production Capacity Sheet (Image Roser)

Prepare a **standard work production capacity** sheet, **create a layout** (without adding the workers yet), and create a **production capacity sheet** (without the operation time chart yet). If these are unclear, check my series of posts starting with Toyota Standard Work Part 1: Production Capacity.

To get a rough estimate of the possible takt times, take the total manual work content and divide it by the number of workers. Your takt time cannot be faster than this theoretical limit, and in all likelihood will be 10% to 20% slower than the theoretical limit due to walking time and uneven distribution of work.

6.1.2 Try Out Different Numbers of Operators

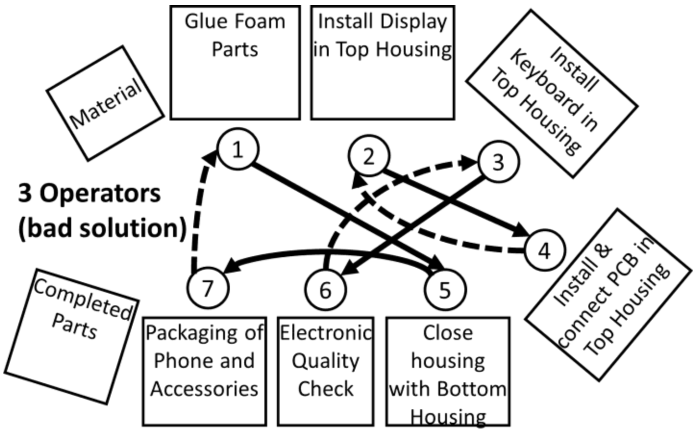


Figure 63: This is really bad! (Image Roser)

Pick the number of operators you want to investigate. Usually this may include a maximum number of operators, a minimum number of operators, and anything in between. Now try to divide the manual work in the stations equally among the workers, while **keeping walking distances short**. At the same time, make sure that the **path of the workers does not overlap**, and that the **stations are in sequence with the material flow**. If the paths of the workers overlap (as shown here in this terrible example), then you will have workers bumping into each other, and it will be very confusing. The walking distances will also increase. This may involve a bit of trial and error, testing different solutions.

If you have a nicely balanced line where every station has roughly the same work content, then you could make a quick check for possible solutions by checking the divisibility of the number of stations. If you have six equal stations, then your options are probably one, two, three, and six, since six can be divided by these numbers. On the other hand, if you have seven equal stations, it is more difficult, since seven is a prime number. It can be only divided by itself and by one. Hence your options are lines with seven people and with one person.

It helps if you have some stations at less than the line takt, where even in a fully manned line an operator is handling more than one process. These stations with small workloads help you make different numbers of manpower lines even if the number of stations is not easily divisible. Below is an example where a fully manned line would have five operators, a prime number. However, since some of these operators handle multiple stations, it is possible to run the line also with three workers efficiently (I ignored walking times for simplicity in the example below). Of course, there is also the option to have only one worker.

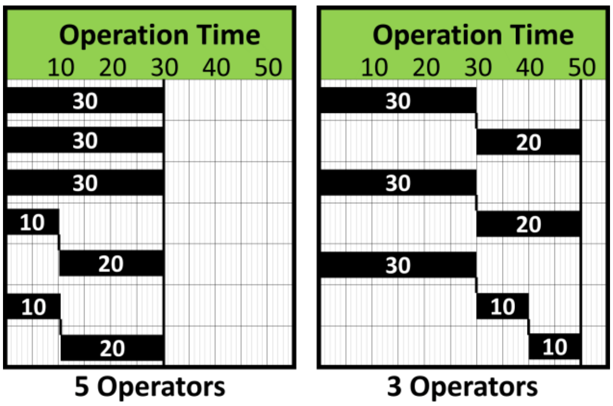
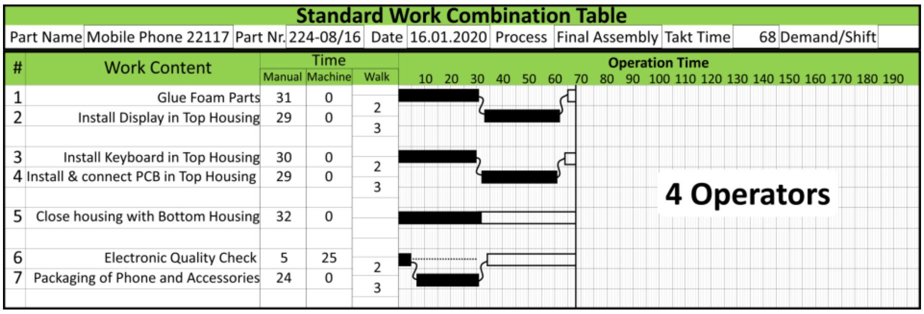


Figure 64: Flexible Manpower Prime Division (Image Roser)

6.1.3 Optimize

Also, **never hesitate to optimize**. As in the previous example shown once more below, if you happened to start a system with four workers, you would quickly find out that two of the workers have a lot of idle time. This would be a good point to improve the balancing and reduce one more worker. Similarly, if one worker has an excessive workload, it may make more sense to add one more worker. A flexible manpower line never works for all possible numbers of workers equally well. I highly recommend not wasting the time of your workers through waiting just to achieve a takt time target!

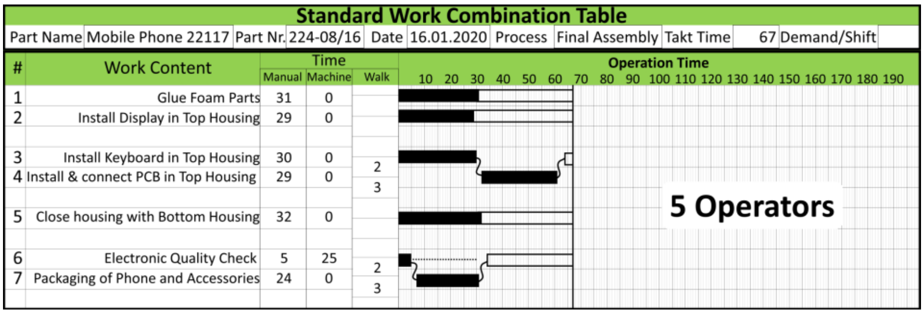


Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	68	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	
2	Install Display in Top Housing	29	0	2
				3
3	Install Keyboard in Top Housing	30	0	
4	Install & connect PCB in Top Housing	29	0	2
				3
5	Close housing with Bottom Housing	32	0	
6	Electronic Quality Check	5	25	
7	Packaging of Phone and Accessories	24	0	2
				3

Figure 65: Flexible Manpower Example Standard Work Table 4 Operators (Image Roser)



Standard Work Combination Table

Part Name	Mobile Phone 22117	Part Nr.	224-08/16	Date	16.01.2020	Process	Final Assembly	Takt Time	67	Demand/Shift

#	Work Content	Time: Manual	Time: Machine	Time: Walk
1	Glue Foam Parts	31	0	
2	Install Display in Top Housing	29	0	
3	Install Keyboard in Top Housing	30	0	
4	Install & connect PCB in Top Housing	29	0	2
				3
5	Close housing with Bottom Housing	32	0	
6	Electronic Quality Check	5	25	
7	Packaging of Phone and Accessories	24	0	2
				3

Figure 66: Flexible Manpower Example Standard Work Table 5 Operators (Image Roser)

In any case, you hopefully end up with different setups that give you different takt times without wasting too much of your workers' time by waiting. If your customer demand changes, then you can select the appropriate number of operators to get close to the customer takt. However, it is unlikely to match exactly. There will be probably some remaining differences which you may have to sort out through slightly increased or reduced work time, but this change in work time should be much less than without a flexible manpower line. After all, **the benefit of a flexible manpower line is leveling!**

6.2 Alternative Organizational Options

There are also a couple of other alternatives that have less management overhead, but can be slightly more confusing for the workers. These are:

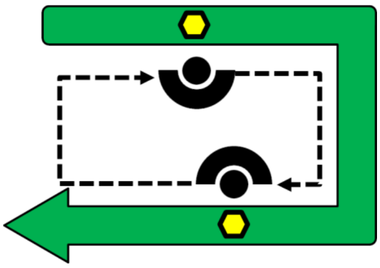


Figure 67: Animated lean rabbit chase. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

The **Rabbit Chase**: Two or more workers always move in a circle and handle all processes in sequence. For details see my post The Lean Rabbit Chase in a U-Line.

The **Bucket Brigade**: Two or more workers move forward in the line, working on all processes until they meet the next worker (or the end of the line). In this case, they walk back without processing until they meet the previous worker (or the end of the line). In this case, they turn around and work their way forward again on all processes until they meet the next worker again. For details see my series of posts starting with The Lean Bucket Brigade, and also its variant One Up One Down.

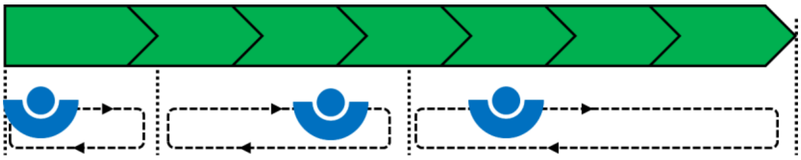


Figure 68: Animated bucket brigade. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

For general advice on how to set up a line with workers handling multiple stations, especially on how to set up the workstations, check my post on The Chaku Chaku Line.

6.3 Notes on Implementation

Figure 69: PDCA Circle (Image Roser)

Finally, a few notes on implementation. If you set up a flexible manufacturing line, make sure to include one or more workers from this line in the process. They do know the line best, and can alert you to problems that you would have never thought of but which can create major problems during actual use. Be prepared, however, to overcome some resistance against change in general. Also, as always, follow the PDCA, and check after implementation if it actually works.

This concludes this small series on flexible manpower lines. Again, the main benefit here is the leveling of your production system. Now go out, level your production by adjusting the manpower to have your line takt match your customer takt, and **organize your industry!**

7 Storage Strategies – Stacking Options

Christoph Roser, February 11, 2020 Original at https://www.allaboutlean.com/storage-strategies-stacking-options/

Figure 70: Warehouse worker checking the inventory (Image WavebreakMediaMicro with permission)

If you are in production, you have material. You probably have too much, except for the one thing that's missing. In this blog post I will give an overview of the options for storing material. Hopefully this will give some inspiration. Please note that this is not on how to manage the material, merely on how to store it. This is the start of a small series on how to store material.

7.1 Floor Storage

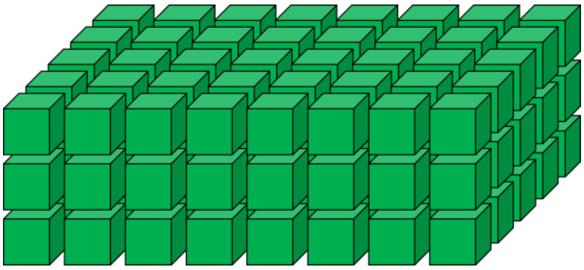


Figure 71: Floor Storage Full (Image Roser)

Probably the easiest approach is floor storage. You just stack your boxes, pallets, and pallet cages on the floor. This can make the best use of your space but requires stackable packaging. It also requires the lowest upfront investment as you do not need any shelves or similar stuff. However, it can be a pain to organize, it is difficult to find your things again, and depending on which item you require, you may need quite a bit of time to dig it out. It is only used if space is at a premium and there is not much shifting around. A prime example is a container ship. Usually you need at least some empty space in storage to shift things around in order to get out material from farther back. Please keep in mind that no matter how good your system is, sometimes you will spend a lot of time searching for material that you believe you have.

Figure 72: Container Ship (Image Paul Brennan in public domain)

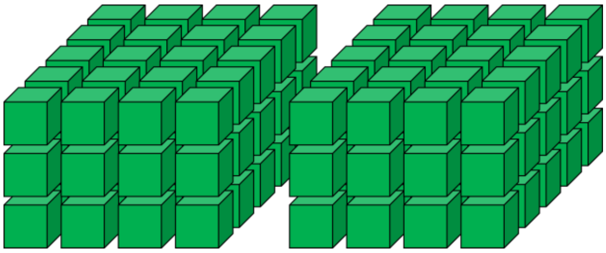


Figure 73: Floor Storage Rows (Image Roser)

A variant of this leaves at least some rows free. This makes access somewhat easier, but you may still have to shift material around to access your parts. This is frequently used at container terminals, although they do have some special equipment to move their containers around. Both approaches are usually not used in lean manufacturing, since lean generally needs easy and frequent access to the material.

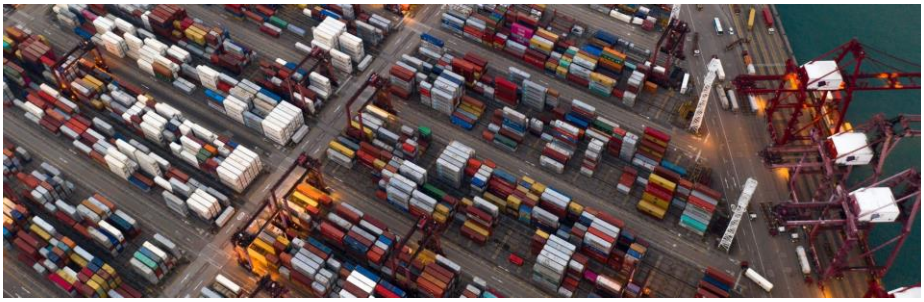


Figure 74: Container Terminal (Image Bellergy in public domain)

7.2 Shelf Storage

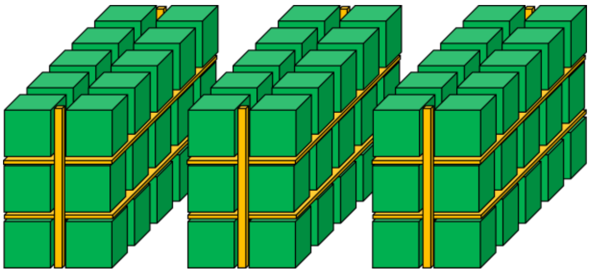


Figure 75: Shelf Storage (Image Roser)

Figure 76: Shelf Storage (Image Heinrich Taxis GmbH under the CC-BY-SA 4.0 license)

Another option is shelf storage. Now you need to invest in shelves, hence your up-front cost is higher. You also need to keep access lanes for forklifts, people, or automated retrieval systems. However, now you can efficiently store material that is not stackable, and you can access every item right away (unless you run out of space and your forklift drivers place their items in the corridors anyway … but that of course has never happened in your place …).

Figure 77: Automated Storage Retrieval Shelf System (Image Lance Cheung in public domain)

This type of storage is common in industry. Please keep in mind, however, that you have a management overhead, and your system needs to remember which part is where. If you have multiple identical items, you also need to remember which one should be used first.

Naturally it is possible to combine shelves with a dedicated automated storage and retrieval system. The robot shown here stores and removes trays with data tapes for the US military.

7.3 Mobile Shelving

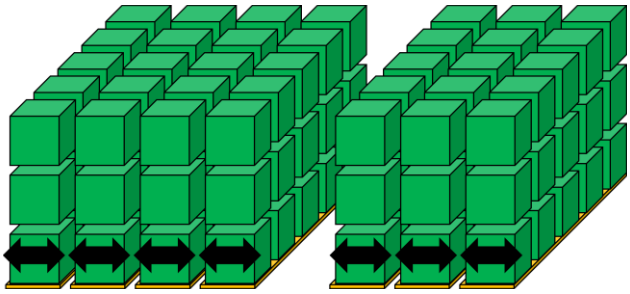


Figure 78: Mobile Shelve (Image Roser)

Mobile shelving is shelves that can be shifted sideways. Often they are found in libraries, but there are also industrial applications. This can utilize space better than a normal shelf, as you do not need space for access between every shelf. On the other hand, you need to move the shelves around in order to access certain locations. Hence it is better suited for storage with less-frequently-needed access. This shelving can be powered by hand or motorized. The more slots between shelves you have for access, the less you have to move the shelves around to get to what you need.

Figure 79: Mobile Shelving Library (Image Andreas Praefcke under the CC-BY 3.0 license)

7.4 Rotating Shelf Storage

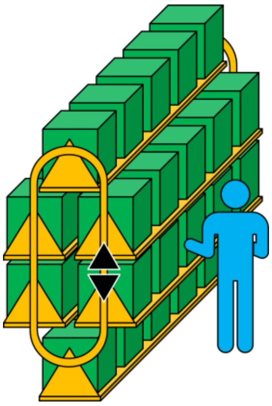


Figure 80: Rotating Shelf (Image Roser)

A variant of shelf storage is storage shelves that can rotate or revolve. Most often this is for small-part storage, and is used quite frequently with electronics and other smaller products. The set-up is a bit more expensive than a normal shelf, but it gives easier access. Some of these towers are quite high, but the smallest such systems can be put on your desk for your stationery. Still, a system would need to track which part is where.

7.5 Rolling Rack

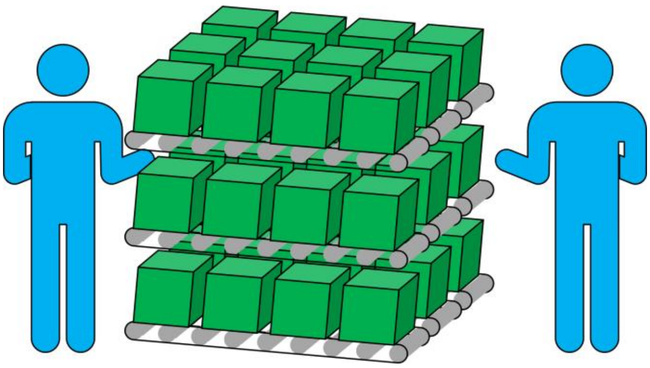


Figure 81: Rolling Rack (Image Roser)

The rolling rack system uses … well … rolling racks. The material is added on one side, and (usually gravity) has the items roll to the other side for consumption. The out side usually has a stopper of some sort. Hence this system has a clearly defined in and out side. Most importantly, this system maintains FIFO. This is very commonly used in lean manufacturing. If you have reusable containers, then this system often includes return lanes for these containers.

Figure 82: Warehouse rolling rack (Image praethip with permission)

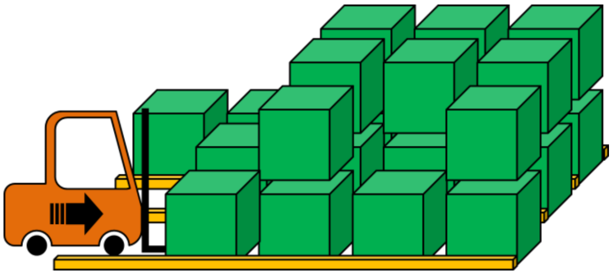


Figure 83: Forklift Sliding Rack (Image Roser)

There is also a cheaper variant of the rolling rack for pallets. Instead of actual expensive rollers, they merely attach some rails to the floor. The forklift puts pallets or pallet cages into one side, and removes them from the other side. Since on an even floor there is no gravity moving the pallets along, the forklift simply pushes the whole row forward until the end of the slide. The forklift driver must take care that he doesn't overshoot the target; otherwise the pallets will stick out too far on the other end. Sometimes there is a stopper on the other end, although in this case the receiving end needs to lift the pallet over this stopper, which may be a problem for small hand-operated pallet carriers.

7.6 Amazon Kiva Storage System

Of course, there are also more-exotic options to store your goods. Amazon uses small Kiva robots to move material from storage to picking (see my series on The Inner Workings of Amazon Fulfillment Centers). This small robot lifts a shelf and transports it to picking. The image below shows such a shelf storage. You can clearly see that the shelves are packed in 4×4 or 4×7 groups, with one-way access ways in between. While it takes a bit more time to maneuver a shelf from the inside of a group, it allows for a much higher storage density. I believe that this system has quite a bit of potential, both for high storage density and low labor cost retrieval, and I know of at least two Chinese knock-offs using such a method.

Figure 84: Amazon Kiva Floor Overview (Image Amazon with permission)

This has been a brief overview of the different ways to store inventory. If I missed one, please let me know. For bulk material you also have other options like making a pile or storing it in silos or tanks. Depending on which storage you have, there are also different ways to manage such inventories (see for example my post series on milk runs). I also have a whole series with twelve ways to create space around your assembly. In my next post I will look at where exactly to store your items. Now **go out, set up your storage, and organize your industry!**

8 Storage Strategies – Even More Stacking Options

Christoph Roser, February 18, 2020 Original at
https://www.allaboutlean.com/storage-strategies-stacking-options-2/

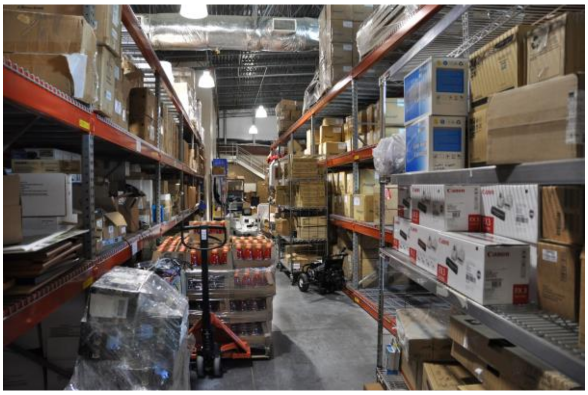


Figure 85: Messy Warehouse (Image Christin Michaud in public domain)

There are even more storage options. Continuing from my last post, I will show you some more options to store your material. This post is with much thanks to Juan Carlos Viela for the detailed suggestions!

8.1 Vertical Lift

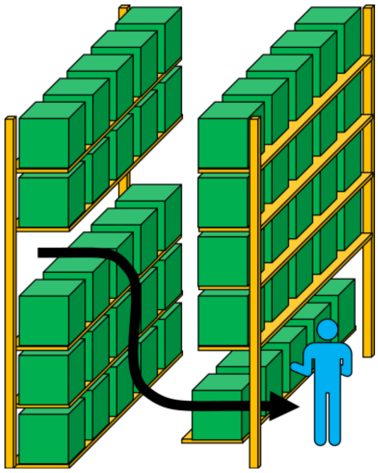


Figure 86: Vertical Lift Storage (Image Roser)

The first is a vertical lift, sometimes also called an Inlift. This is somewhat similar to a shelf, but with an automated adding-and-retrieving system that retrieves not only one part, but an entire level of a shelf. Often, an employee then picks the desired item from the presented tray of the shelf and then sends the tray back afterward.

This is a commonly used solution for small parts. Obviously, it is less common with bulky parts, since you have to move all material on a level of the shelf. Heavy items would require a stronger and hence more expensive moving mechanism.

Figure 87: Vertical Lift Storage Example (Image Kecko SBB - EIZ Erstfeld under the CC-BY-SA 2.0 license)

Here is an image of such a storage tower used at the maintenance and intervention center for the Gotthard Base Tunnel, the longest railway and deepest traffic tunnel in the world. To keep track of the locations and to reduce search time, the different slots in a tray are labeled and also given a barcode. Every time a part is added or removed, the corresponding tray slot has to be scanned. In my experience, it works *most* of the time, but be prepared to occasionally go through all shelves and search what you have missed.

8.2 Carousel

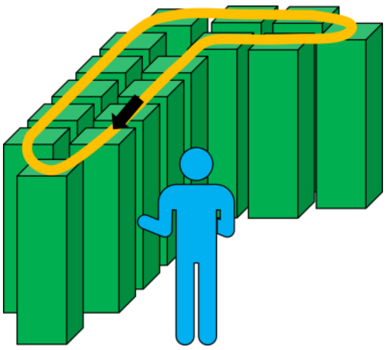


Figure 88: Carousel Storage (Image Roser)

A less commonly used option is a carousel. The material moves around in a circular loop. This loop can be a true circle, a rounded square, or any other shape. The loop can be horizontal (more common) or vertical. The material can hang from the loop, or it can be placed on shelves attached to the loop.

Figure 89: Spinner Rack in Bookstore (Image unknown author in public domain)

Probably the easiest example is a spinner rack, a simple shelf that can rotate. You frequently find these in retail, often for books or postcards. To browse through, you simply rotate the shelf. Similar but slightly larger shelves are sometimes found in offices to store filing folders.

The advantage is that it has the potential to use the storage space well. You do not need to keep internal space free for moving your items around. You only need to have an access slot somewhere where you can access the one part that is at this slot. It is also mechanically simple. Rather than a complex system of different powered axes like the vertical lift, you simply have a chain going round and a motor somewhere to power this chain. If you so will, it is a one-axis storage system.

The big disadvantage of this method is that you have to move ALL material if you want to access an item. Hence this usually does not work well for heavy or bulky items. Nevertheless, it is used not only in retail but also sometimes in industry. Below are two examples, a vertical carousel loop for tool storage at a milling machine, and a horizontal loop in a dry cleaners shop. It is also common in hospitals with medical supplies, which are also usually lightweight.

Figure 90: Automatic Tool Changer (Image GaspariniMB under the CC-BY-SA 4.0 license)

Figure 91: Dry Cleaner Rack (Image Simon Law under the CC-BY-SA 2.0 license)

8.3 Drive-In, Drive-Through

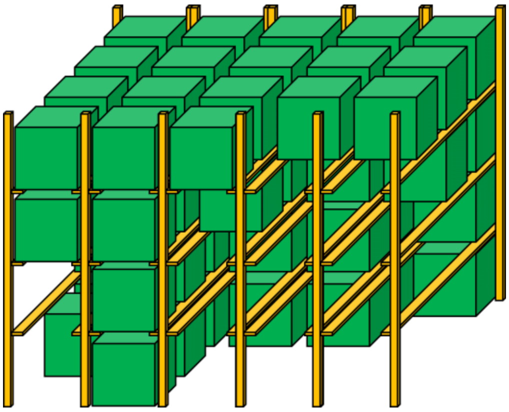


Figure 92: Drive In Storage (Image Roser)

Another option is drive-in storage and drive-through storage. In this type of storage, there is no access path into the storage. Hence it allows for the highest density packing. However, it also means that accessing the material is cumbersome. Within one row it is recommended to have only one type of material, as otherwise the need to shift things around to access something in the back becomes prohibitive. Hence this is most often used for items that need to be stored long term (e.g., seasonal items), very similar items (one type per row), or if space is truly at a premium (e.g., cold storage).

To add and retrieve material, a forklift (or similar) needs to drive directly into the storage system. This can be from one side (drive-in) or from both sides (drive-through). The image below illustrates drive-through storage with access from both sides. The principle is the same for drive-in, although you can access it only from one side. The forklift on the left wants to add material. He has to lift the material on the correct level, and then drive all the way into the shelf to set the pallet down. Afterward he has to back out again. Both driving in and out are preferably done without bumping into the shelf. A similar process in reverse happens for the removal of material.

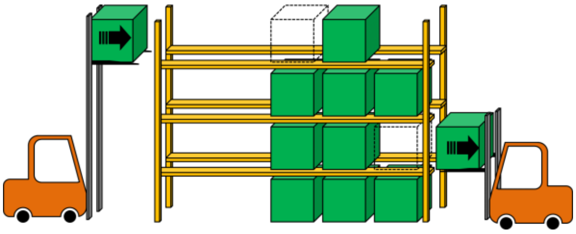


Figure 93: Drive Through Storage (Image Roser)

You can easily see that there are some limitations in adding and removing items. The forklift on the left adds to the top row. He could also add to a row below, but then the added pallet would block access to the empty space on top. Similarly, the removing forklift could access the top three rows but cannot yet remove the item on the top row, since access is blocked by material on the rows below. Getting an item from the middle would require quite some shifting around.

Overall, drive-in storage must follow the Last-In-First-Out (LIFO) principle for one row of a level of the shelf, but with the additional complication that the material on other levels in the same row may block access, and also vice versa, other levels could be blocked by material on this level of this row. For drive-through storage, it would be the First-In-First-Out (FIFO) principle, again with the complication that material on other levels of the same row can block access, and also vice versa, other levels could be blocked by material on this level of this row. Overall, it is a bit tricky to have a good adding and removing sequence here.

8.4 Radio Shuttle Storage

An automated variant is called the radio shuttle. In this system, every level on every row has a small cart (a radio shuttle) that can lift and transport a pallet along its level and row. Hence, it can bring a pallet from the front deeper into the storage or return it. This radio shuttle can drive underneath other material, but of course only when it is empty. A pallet on the shuttle cannot move past another material on the same level of the row of the shelf. Yet, this system allows a strict LIFO (for one-sided access) or FIFO (for two-sided access) within the path of the radio shuttle. It can also automatically move all pallets to one side one by one to optimize storage space and reduce pickup times.

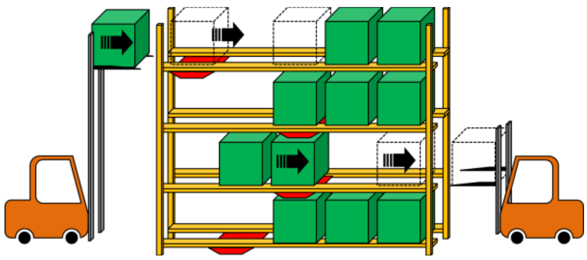


Figure 94: Radio Shuttle Storage (Image Roser)

8.5 Rolling Rack and Push Back

Alternatively, you could also use gravity instead of a radio shuttle, and install a rolling rack, where you add material on one side and remove it from the other. The material will, in FIFO sequence, simply roll down the incline to the other side.

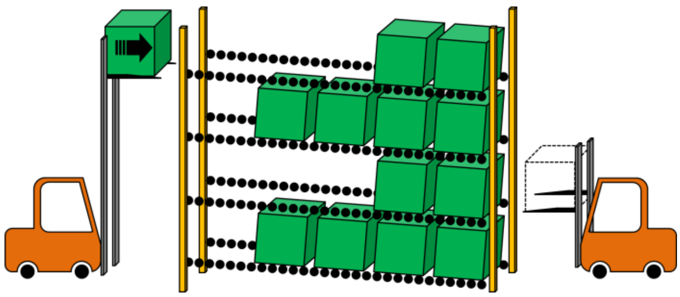


Figure 95: Rolling Rack Illustration (Image Roser)

If you have access only from one side, you can still use gravity. This is called push-back storage. The forklift pushes the entire stack backward to make space for another pallet. Of course, here we have the not-so-hot LIFO principle, where the material in the back can get quite old. You would also need some sort of system that indicates to the forklift driver if there is space at the end of the rack; otherwise he will push the entire stack against the wall, potentially damaging the goods, the shelf, or even the wall.

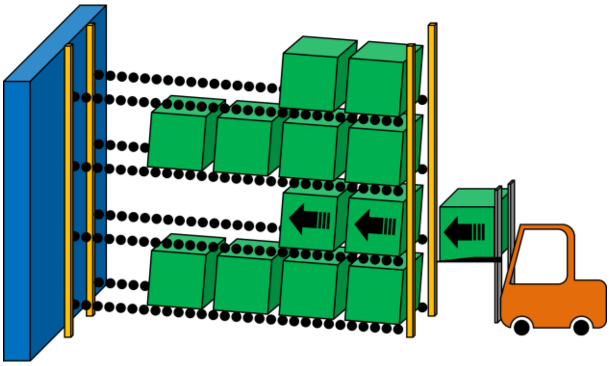


Figure 96: Push Back Storage Illustration (Image Roser)

Often, such a push-back system is built with roller similarly to a rolling rack. However, since it is LIFO, it can also be built with wheeled pallet supports within the rack. This may be a bit cheaper, since you need less rollers or wheels, making an inexpensive storage system even cheaper. Just make sure that no matter if you use rollers, pallet carts, push back, or a rolling rack, that your pallets don't get stuck in the middle of a large rack ☺.

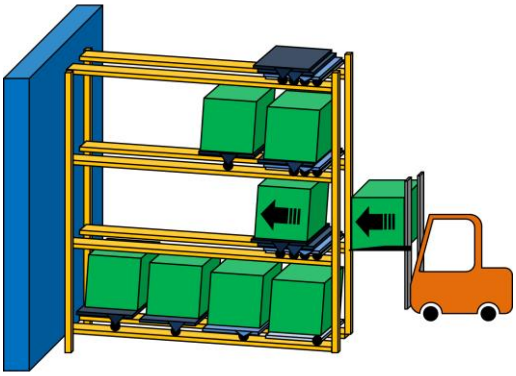


Figure 97: Push Back Rack with Carts (Image Roser)

8.6 Autostore by Swisslog

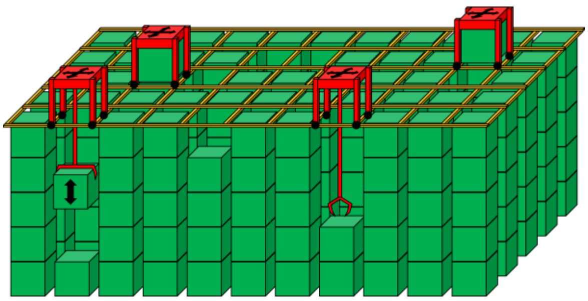


Figure 98: Autostore Swisslog (Image Roser)

Finally, there is an automated approach called Autostore by a company named Swisslog. The approach looks neat. Small robots drive around on top of your storage, and add/remove boxes from stacks of boxes. Naturally, a stack of boxes uses a LIFO principle, and to get a box at the bottom the robots have to do some shifting around. Less frequently used parts slowly settle to the bottom of the pile, while more frequently used ones end up being more towards the top. Conceptually this is very similar to the loading and unloading of container ships, except the boxes are much smaller with Autostore.

Figure 99: Container Ship Loading (Image Alexander Bobrov in public domain)

This system also has quite a good packing density, and also works well with unusual floor plans and obstructions like pillars (you just have a pillar where a stack of boxes would be). To improve performance you would simply add more robots on top. Below is a short video by Swisslog showing and explaining their Autostore.

The Video by Food Supply Chain.com is available on YouTube as "Autostore Swisslog" at https://youtu.be/jXM7D34up5c

These are even more options on how to store your material. Hopefully one of these methods can help you. Again many thanks to Juan Carlos Viela for the detailed suggestions! Now, **go out, have a look at your inventory, and organize your industry!**

9 Storage Strategies – Fixed Location

Christoph Roser, February 25, 2020 Original at https://www.allaboutlean.com/storage-strategies-fixed-location/

Figure 100: Hospital Supermarket (Image Roser)

In my last post I looked at different ways to store material. This post is a continuation, looking at where to put materials. I want to give an overview of the different options to help you choose one that is suitable for your situation. This first post looks at storage with fixed locations, and why this is usually not so hot.

9.1 Goals

Figure 101: Archery Target with Arrows (Image Casito under the CC-BY-SA 3.0 license)

Usually, any kind of storage unit has three main parameters of interest. Depending on your storage approach, different methods may have different trade-offs. The three main KPI are:

- **Retrieving and Storing Cost**: How much cost is needed to get material in and out of storage. Often, the cost in retrieving and the effort in storing is similar, except that smaller quantities are retrieved but more frequently. Storing larger quantities may require lifting equipment (forklift, pallet lift, etc.), whereas retrieving may be possible by hand. Storing and retrieving may also be on different sides for rolling racks. Of course, the goal is to reduce the cost.
- **Increase Retrieving and Storing Frequency**: How much time is needed to store and retrieve an item. Or, how many items can you get per hour. This is related to the cost, since you can easily increase the frequency by adding more workers or equipment. The goal here is to get the maximum number of items for a given number of workers or a given set of equipment. The main factor here is the distance traveled for retrieving.
- **Space Usage**: How efficiently can you use the space (i.e., how much material can you fit into the storage). Do not fall for the fallacy that you can use 100% of your storage space. You always need a few empty spots to add material before you have retrieved other material. Assigning fixed locations to your material usually is a much worse usage of space than having no fixed location.

9.2 Fixed Location

Figure 102: Labeled Drawers (Image Jorge Royan under the CC-BY-SA 3.0 license)

One of the main decisions for your storage strategies is if you have **fixed locations** for your items or not. The storage spaces are reserved for certain items, and you must not put any other item in these spaces. In effect, every storage slot is assigned to one part type, and cannot hold another part type.

The advantage is that it is easier to find items without the help of a computer. Since the location for each item type is fixed, you can easily write this on paper. The shelf can be labeled with the item type and not just the slot number, and workers will soon remember which item is where. Overall, it reduces the effort needed to find out where an item is, since it is always at the same slot.

On the other hand, it significantly decreases your utilization of available space. You need enough storage slots assigned to each item type to cover the maximum storage need. This means most of the time you have empty slots that you cannot use for other items. Overall, you need much more storage space than if you have no fixed locations.

9.2.1 Example Calculation of Fixed Location

Let's look deeper into this. First, we start with fixed locations. Assume you have an **average** storage need assigned for one product of $\mu = 10$. If you now build storage for exactly 10 parts, you will be almost always out of space, because your storage needs fluctuate! For mathematical simplicity, let's assume a normal distribution with a standard deviation σ of 50% of the mean, or $\sigma = 50$ parts. If your inventory has only 10 spaces, then this will be sufficient only 50% of the time, but surely this is not good enough for you.

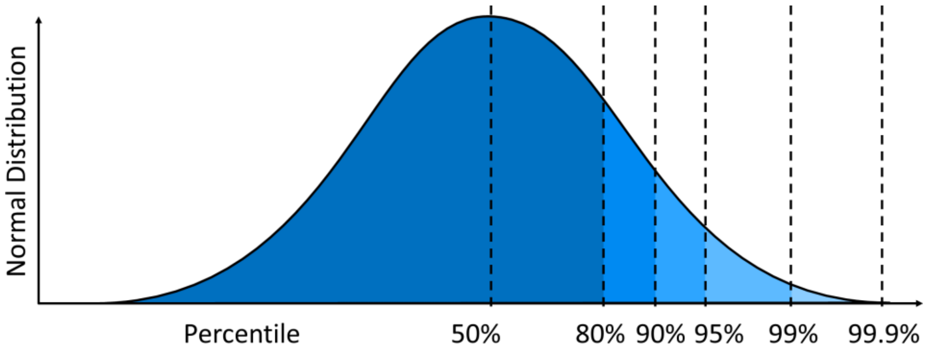


Figure 103: Normal Distribution and Percentiles (Image Roser)

If you want your inventory to be good enough 80% of the time (still not really impressive), you would need to add 0.84 standard deviations (i.e., you would need space for 14 parts). The more fluctuations you want to cover, the more storage space you need. Unfortunately, this is not linear, and for higher values the required storage increases drastically. A 100% availability would require infinite storage space. Even only 99% would more than double your needed inventory space to 22 slots.

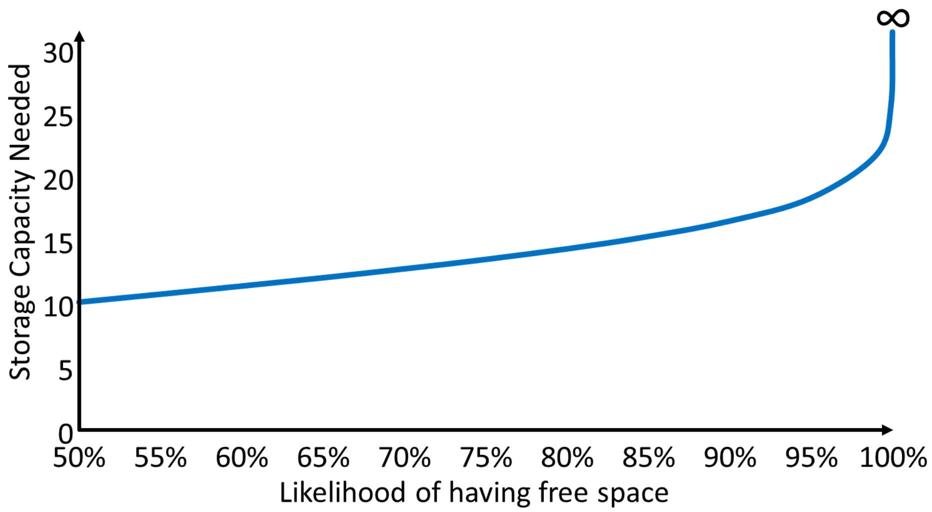


Figure 104: Storage Capacity Need Diagram (Image Roser)

Before you worry about this “infinity” too much, reality is (a tiny bit) better. You do have different distributions, and due to the limits of reality, you will never need “infinite” storage space. On top of that, you can also counteract and sell more (if you are lucky), order less (if you can), or simply rent more storage space (if you can’t sell more or order less). But, even if you don’t have to worry about “infinity,” you still certainly need more storage space than your mean storage need to cover for fluctuations.

Let’s assume a more realistic reliability of 95%. In this case you would need 18 slots assigned to this part. If you now have 1000 identical part types, all with a mean storage demand of 10 and a standard deviation of 5, then you would need 1000 times these 18 slots or storage space of around 18,000.

9.2.2 Example Calculation of NOT Fixed Location

However, this looks very different if you don’t have a fixed location assigned to each part. In this case, an excessive demand by one part may be offset by a lower demand by another part. Let’s stick with our example of 1000 parts, each having a mean of 10 and a standard deviation of 5 parts. The combined mean of all part types will still be 1000*10 = 10,000 parts. However, the standard deviation σ is calculated differently as shown below:

$$\mu = \sum_{n=1}^{m} \mu_n$$

and

$$\sigma = \sqrt{\sum_{n=1}^{m} \sigma_n^2}$$

Hence, the combined standard deviation of 1000 parts with σ = 5 is not 1000 x 5 = 5000 but only 158.

$$\sigma = \sqrt{1000 \cdot 5^2} = \sqrt{25000} = 158$$

Hence our mean storage need of 10,000 parts has a standard deviation of only 158 parts. Calculating the storage quantity that covers 95% of all cases, we need only 10,260 parts. Compare this with the 18,000 parts that we would have needed for a fixed storage location.

Below is the overview of our example. The y-axis shows how much inventory you need to cover a certain percentage of the parts. The x-axis shows how many different part types we have. The total average inventory needed is always 10,000 parts, and the standard deviation of the fluctuations is always half of the mean value (if you change this, you still get a very similar image). The top horizontal lines are for fixed locations. It does not matter if you have 10,000 of one part type or 10 each for 1000 part types, you always need the same inventory for the same required percentile we want to cover.

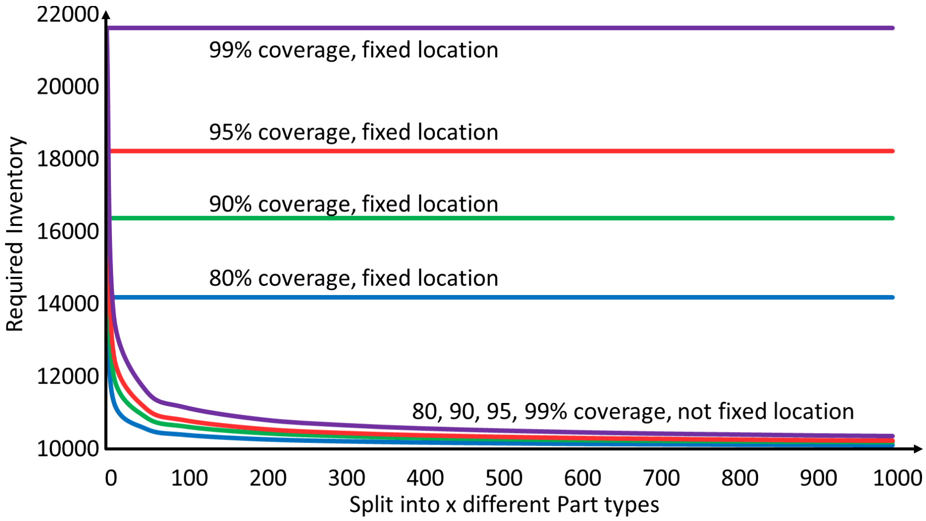


Figure 105: Coverage Fixed Not Fixed Inventory (Image Roser)

It is different, however, if the items do not have fixed locations. In this case only one part with 10,000 items is identical to the fixed locations. The more we increase the number of different part types, the lower our inventory requirement gets, approaching the sum of the means of 10,000 storage slots.

9.2.3 Caveat of the Theoretical Model

Figure 106: Critical Person (Image OpenClipart-Vectors in public domain)

It looks like you can save almost all the excess space to cover for inventory fluctuations if you do not use fixed locations. That almost sounds too good to be true.

Well, it is too good to be true. First, this is a simple mathematical model, with quite a few assumptions. The randomness of the fluctuations in your case is probably not normally distributed, for one thing because the boundaries of a normal distribution are $\pm\infty$, and you can not have negative inventories.

Second, we assumed that these variables are independent of each other. In reality, however, the inventory level of one part is frequently dependent on another part. For example, if it is high season, you probably have more of everything than in the low season. Hence, your storage requirements without fixed locations are probably a lot higher than my theoretical model. However, it will be still much lower than with fixed locations. How much? That depends on a lot of things, and is hard to calculate. Just try it out.

9.3 When to Use Fixed Locations

So, when should you use fixed locations? Well, it is easier to answer when not to. If your storage space is tight and you are constantly running out of space, then you should avoid assigning fixed locations for your part. Similarly, if you produce on order and frequently have many custom parts in your inventory, then it makes no sense to assign this “once per year” part a fixed slot.

However, if you have plenty of storage, then … I would still be careful about using it. It may be an option if you have plenty of space, items with higher quantities, and a cumbersome system of tracking parts (i.e., if you use paper to write down which part is where, then any change is a lot of effort with a risk of mistakes). The less you change your locations, the easier it may be for you. Similar applies if you still manage your locations in Excel.

Overall, fixed storage locations are usually not so hot. There are some uses in mixed systems, however. I will discuss mixed and other systems in **my next post. Until then, stay tuned, and go** out and organize your industry!

10 Storage Strategies – Random Chaotic and ABC

Christoph Roser, March 3, 2020 Original at https://www.allaboutlean.com/storage-strategies-random-chaotic-abc/

Figure 107: Amazon Manual Storage (Image Álvaro Ibáñez under the CC-BY 2.0 license)

In my last post I looked at the disadvantages of fixed location storage. Usually much better is random chaotic storage. This is, for example, the preferred method of Amazon. This approach makes best use of the available space and generates less mistakes. When Amazon started using this, they reportedly were able to store twice as many items in the same space as as before.

10.1 Random Chaotic … Meaning the Closest One for the Stowing Operator

Figure 108: Pile of Dice (Image Roser)

The complete opposite of fixed location is a random chaotic storage. Any item can be anywhere. This sounds easy, doesn’t it? Well, the challenge is to keep track of it. Forget pen and paper, forget Excel sheets. Now you definitely need a dedicated inventory management software. On the plus side, this random chaotic storage makes much better use of your space than fixed location storage, as I explained in my last post. Also, the same part type may be stored in different locations. This may go against your sense of order, but is part of the method.

Figure 109: Closest free slot is good enough … Forklift in Operation (Image Katarzyna Kobiljak in public domain)

Of course, it is usually not truly random. I do not know of any system where a computer uses a random number generator to assign a truly random slot in the warehouse. What random chaotic usually means is that the worker who places the item in storage picks the spot. Hence, random chaotic actually is the closest free spot the operator can find. That is okay. Even better, that is actually good. Random chaotic reduces the walking distance of the operator who places the items. If the operator can pick the spot, then you also avoid problems if the spot is already taken. If a computer assigns a spot, then every now and then, due to errors, the spot may be already taken by something that should not be there.

Figure 110: Scanning at Amazon (Image Amazon with permission)

Just make sure the operator correctly records the location and quantity of the items, preferably digitally with a scanner or a similar mistake-proof device. Ideally there should be three quick tasks for the operator: scan the item, scan the location, and place it in the location. Random chaotic has quite a few benefits, and is often considered a good inventory management approach.

- Space is used much more efficiently
- Storage is quicker, since the operator has to walk less
- The learning curve is faster, since workers do not need to memorize locations
- No disruptions due to an already-taken spot
- If the products are truly mixed, then you will have less picking errors. If you store your M10 screws right next to your M12 screws, sooner or later someone is going to pick the wrong screws.

Figure 111: Wherever he finds a slot at Amazon (Image Amazon with permission)

On the downside, it requires a good computerized inventory management system. If the system is down, so is your factory, since you won't be finding anything without the system. Also, if you need more than one part of the same type, you may have to walk to different locations until you have gathered enough of these parts (Thanks to Michel Baudin for the Suggestion!). But performance wise, this approach is very good. This is also the system Amazon uses for its fulfillment centers.

10.2 Individually Assigned Location

Having individually assigned location is a whole group of storage strategies. You do not have a fixed location that does not change, and neither does the operator decide the location for you as in random chaotic storage. Instead, some sort of algorithm decides on a case-by-case basis which part is stored where. The stowing operator is informed where he has to place the item. The advantage is that the inventory locations can be optimized more, but the operator now has to search for the correct location, which takes time and introduces more potential for errors. The best known approach is probably ABC storage.

Figure 112: No random seating here … (Image ty_yan in public domain)

10.3 ABC Storage

Figure 113: ABC blocks (Image Yuliya Shustik with permission)

ABC storage is a structured approach where the items to be stowed are assigned individual locations. You group your items into, typically, three categories. The A parts are required most frequently. The B parts are required less frequently. Finally, the C parts are the least-frequently retrieved items. Often, A parts are 80% of all retrievals, B parts are 15%, and C parts are the last 5% of all retrievals. As per the Pareto principle, 80% of all retrievals are about 20% of all parts in storage, whereas the remaining 20% of all retrievals are roughly 80% of the items.

The idea is to put the A parts in an easy-to-access location, the C parts in the farthest-away locations in the back, and the B parts somewhere in between. Then the worker or device that retrieves the items has to walk less, since the most frequent items are nearest to the point of demand.

Here, too, you can have variants. Generally, ABC sorting is by the frequency of retrievals, since you usually stow large batches and then retrieve multiple times in smaller batches. However, if your system stores more frequently than it retrieves (i.e., smaller outputs are added to a bigger batch, which is then shipped) you may sort by the frequency of storage operations. You can also imagine a combined value of both storing and retrieving, which should give you a good compromise.

Other criteria may be a bit more cumbersome but also possible. For example, you may opt to store large or heavy items in the front, rather than navigating through a maze of shelves.

Typically, three categories in ABC are used. However, feel free to use only two if you like; the result won't be too much different. You could also go to the other end and use a gradient. The computer determines the retrieval (and/or storage) frequency, and then calculates how deep in the warehouse it should be stored. The computer then picks the closest free location, giving you a smidge more performance, but it will keep a programmer busy for a bit.

You could even go a bit further and consider which parts are used where. If you have one production line on one side of the warehouse, and another on the other side, you may have separate ABC categories for the different lines. The parts frequently needed by a line are stored closer to that line than to the other line that does not need them. But, while this sounds cool in theory, please be aware that this will be very tough to implement and debug, giving your shop floor people a lot of headaches while the computer guys try to figure out all the bugs. Even with computers, it may be best to keep it simple.

The advantage of this approach is that it tries to reduce the time needed for stowing (and retrieving), allowing more stowing (and retrieving) operations in a given time. It also uses the space quite well. It does, however, require a dedicated computer system. If the system is down, your factory is down.

In my next post I will look a bit at combinations and variations of fixed location, random chaotic, and individually assigned locations. Until then, stay tuned, and **go out and organize your industry!**

11 Storage Strategies – Mixed Systems and Review

Christoph Roser, March 10, 2020 Original at https://www.allaboutlean.com/storage-strategies-mixed-systems/

Figure 114: Metal Profile Storage Shelf (Image Tech. Sgt. Ave I. Young in public domain)

In my last two posts I showed you fixed location storage and its disadvantages, random chaotic, and ABC storage. But there is more. Another option is some sort of combination of fixed location, random chaotic, and ABC storage. Let's look at some of the variants.

11.1 Mix of Fixed Location and Not Fixed Location

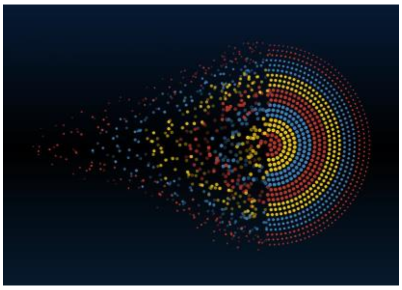


Figure 115: Sorted and Unsorted (Image Arthead with permission)

Having some of your parts in a fixed location while others are either random chaotic (i.e., the closest slot to the stocking operator) or ABC is actually not too uncommon. For your most common parts, you may select a fixed location so operators can find them easier. These may also be in a location that is easier to access. Just make sure that only your most common parts are in a fixed location. If you assign a fixed location to too many part types, your space usage will go down. You could do this mixed approach if the benefit of remembering the location and finding it quicker is worth the extra storage space needed. Resist the temptation to do this because it may look neat and orderly. If you do it only for the looks, then it won't be worth it.

11.2 Group Part Families

Another option is to cluster parts by part family. This could be done with fixed locations, but also with a variant of chaotic location or ABC storage. The basic idea is to group certain parts together and store them close to each other.

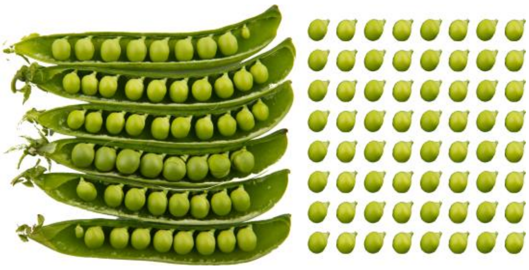


Figure 116:Looks nice but is useless … (Image Bill Ebbesen under the CC-BY-SA 3.0 license)

You may think it looks neat if your peas are sorted by size, and it certainly looks neat, but if this is your motive, then it is probably useless, or even worse. **Do not arrange similar items next to each other just so they look good!** If you have similar parts close to each other, then despite the visual appeal, you introduce errors. The operator picking the items may make more mistakes because the part he wants looks almost identical to the part next to it.

Figure 117:Often seen together (Drive Medvedev under the CC-BY-SA 3.0 license, discs JD, modifiedby Roser under the CC-BY-SA 4.0 license)

Storing items by part family makes sense only in a different aspect. If you have frequent item requests that include the same two (or more) part types, then you may choose to store these items close to each other to reduce walking distance. To give you an (outdated) example, if a customer buys a 3.5” floppy disk drive, he probably will also buy some floppy discs. Hence, if you store your floppy discs close to the floppy drives, the picker may have to walk less. There is the added bonus that the two items look different and there is little chance of mixing them up. The traditional example here would be a library or a bookshop. You want to have the *travel books* next to other travel books, *crime* next to other crime, *science* next to science, and *teen paranormal romance* … probably in the trash can … but that is just my opinion.

Figure 118: Bookstore Shelf (Image Alexandre Boue under the CC-BY-SA 4.0 license)

Hence, storing by part families may make sense not for the visual appeal, but if the parts are commonly retrieved together. But please do not underestimate the effort to set up such a system and maintain it. While you may save 5m walking for an operator every now and then, you create hours of extra work for your system maintenance guys. Often it is not worth the effort.

11.3 Multiple Locations for Easy Access

Another variant both for fixed and not fixed locations could have the same items in different sections of the storage. This would happen automatically in random chaotic storage. For individually assigned locations, this would be part of the algorithm.

Figure 119: Box of Tissues (Image annaj in public domain)

If you would need to pick this item, you would walk to the closest one. Hence it reduces walking distance. If you have an automated system, a breakdown of one row of the retrieval system will not stop your production, since you can get the part from another storage row in the meantime. It is like pens or tissues at my home. You can find a pen or a box of tissues in almost any room somewhere, since I don't want to walk through my entire apartment just for a tissue.

11.4 Which One Is Best?

Figure 120: How to store it … (Image Кирилл Рыжов with permission)

Overall, there is again a magnitude of different options how you can stow your material. As always, the answer is that it depends on your system. Across your factory you probably have a combination of different systems.

Some articles claim that **random chaotic** is pretty good, and indeed it is. But it is not a universal solution for everything. Random chaotic is good if you have a large quantity of widely different materials to store, but it requires a good (meaning problem-free) digital inventory management system. It is the system of choice for Amazon.

Fixed location storage is good only for items that you use frequently. It should be only a very small number of items, because if the employees can no longer remember the location, the advantage vanishes. It is also your system of choice if you still manage your inventory using Excel or paper, since it has the least effort in updating the material database. However, if this is your reason, you should consider investing in an inventory management system for anything larger than a garage shop.

Individually assigned locations are hard to judge. It all depends on the algorithm behind it that assigns the locations. You can explore this, but beware of the complexity. It is easy to imagine more and more criteria that determine your location, only for the system to never work reliably despite draining your software budget. A simple ABC priority is good, but don't overdo it.

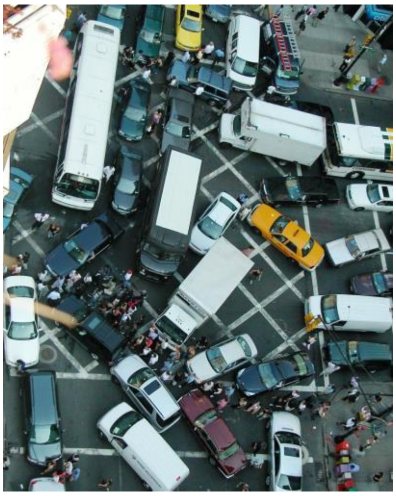


Figure 121: Gridlocked … (Image Rgoogin under the CC-BY-SA 3.0 license)

Of course, this is also subject to other requirements. Large items go into large storage slots, small items into small ones, refrigerated ones into cold storage, and so on. You should also be aware that if your inventory approaches 100% full, it becomes more and more gridlocked, just like road traffic. No matter if you have random locations or assigned locations, the walking distances of the stower become longer and longer. A general rule of thumb is that systems work well if they are no more than 80% full. And 90% is also okay-ish. But I have had tours through warehouses that were 98% full and the manager proudly told me about their ABC storage system. No, ABC doesn't work if you are 98% full!

Anyway, this concludes my small series on where to store your material. I hope this gave you inspiration for your own industry. And please, stop using Excel for inventory management! Now **go out, manage your inventory, and organize your industry!**

12 Where Is All the Toilet Paper? Don't Worry, It Is coming!

Christoph Roser, March 17, 2020 Original at
https://www.allaboutlean.com/toilet-paper-shortage/

Figure 122: Empty Toilet Paper Shelf Australia (Image Kgbo under the CC-BY-SA 4.0 license)

If you have been shopping lately, you may have noticed that due to the Corona virus crisis, your store is running short on some items like toilet paper, hand sanitizer, pasta, and other consumables with a longer shelf life. Even my next-door supermarket has been hit by the panic buying.

Since my semester just got postponed by four weeks for the same reason, I have lots of time to write and would like to dig deeper into the situation of the toilet-paper supply chain.

Update 13.04: The purchasing of the consumers continued to outstrip the supply chain. Over weeks the demand was 150% or more of the usual, and only now toilet paper is slowly returning to the stores. While the processes described below are still correct, I am surprised about the duration of the demand peak!

12.1 The Usual Situation

Figure 123: White toilet bowl (Image unknown author in public domain)

Many products have seasonal demand variations. For example, people eat more ice cream in the summer than in the winter. Toilet paper does not. No matter what time of the year, actual consumption of toilet paper is pretty constant. The consumption of toilet paper changes usually only with the growth of the population.

It is an important product, with around €40 billion revenue per year worldwide. How much paper is consumed depends, for one thing, on the country and its culture. On one end, the average American consumes around 25 kilogram of hygiene paper per year (which includes also tissues, paper towels, and other similar products). On the other end, the average Indian consumes only 123 grams of hygiene paper per year.

Figure 124: Toilet Sign (Image Roser)

The consumption is also very different by gender. The average person consumes 140 rolls per year in the USA, and less in other countries, or around 12 per month. This seems to differ significantly between the sexes, and women consume quite a bit more toilet paper. While hard data is difficult to come by, anecdotal evidence ranges from twice to ten times more. For women the cleaning procedure is more frequent, the to-be-cleaned area is larger and has a more complex geometry, and women also … often have a higher standard of hygiene than men. Also, few men ever had to dispose of a menstrual pad, which also consumes more toilet paper.

Figure 125: Avatar "Tree of Souls," budget version (Image Fernando de Sousa under the CC-BY-SA 2.0 license)

Hence, usually there are few changes in the consumption of toilet paper. Even a diarrhea epidemic makes only a small bump in the consumption of toilet paper. The same goes for new Avatar films when fans recreate the "*Tree of Souls*" of the blue-skinned *Na'vi* using toilet paper.

Hence, it is usually easy to establish pull along the toilet-paper supply chain. The fewer fluctuations you have along your supply chain, the easier it is to manage the supply chain. In normal times, the demand is rather constant and has few fluctuations. There still needs to be buffers due to fluctuations in the supply, but the system is set up for a constant and hence cheap production output.

12.2 The Toilet-Paper Supply Chain

Let's have a look at a typical toilet-paper supply chain. Very simplified and ignoring the material supply for the manufacturer, it starts from toilet-paper manufacturing. The distribution system brings it from the manufacturer to the wholesaler, and from there onward to a supermarket. There it is bought by you and brought home into a (usually) small stockpile before it becomes very familiar with your body, after which nobody wants it anymore and it is discarded.

Figure 126: Toilet Paper Supply Chain (Image Roser)

12.2.1 Toilet-Paper Manufacturing

Figure 127: Toilet Paper Manufacturing (Image PicsFive with permission)

Toilet paper is one of the cheapest goods by volume that you can find in a supermarket. Hence it makes little sense to produce it abroad, and most regions have one or more local manufacturer nearby that provide the stuff.

These manufacturers operate close to their usual output. A paper machine is a rather expensive product, and manufacturers try to run it around the clock anyway. Hence, there is not much option to increase capacity. There may be an idle plant that goes online, or maintenance can (not necessarily should) be reduced. Overall, production is increased very little. And, as we see later, it should not be. If they put in a lot of effort now to increase capacity, they would have to put in a similar effort later to reduce capacity, since **the overall demand does not change!**

If you suddenly sell more ice cream, it is safe to assume that people eat more ice cream, which is good for the ice-cream maker. If you suddenly sell more toilet paper, it is safe to assume that people do **NOT** use more toilet paper, they just increase their stockpile. This is not good for the toilet-paper maker, as this creates an artificial demand fluctuation and can lead to the bullwhip effect. Besides, the problem with the empty shelves in supermarkets does not stem from the manufacturer, but the other part in the supply chain.

12.2.2 Toilet-Paper Warehouse

From the manufacturer, the toilet paper is brought to different wholesale warehouses. These are usually multiple trucks per day departing from a manufacturer.

And these warehouses are full. They have about one month's worth of toilet paper on inventory. Below is a video of a Dutch worker in a toilet-paper warehouse, making fun of the panic buying, and his colleagues also think it is ridiculous. He does like the panic buying, however, since he makes nice money working overtime.

The Video by T P is available on YouTube as "Meanwhile at the toilet paper warehouse" at https://youtu.be/wA4KS546rZo

12.2.3 Toilet-Paper Supermarket

So why is there no toilet paper restocked in the supermarket? The problem is the shipping between the warehouse and the supermarket. For products in high demand or which spoil quickly, a truck may come every day. Toilet paper and pasta are usually not such a high demand, and they don't spoil that fast either. Hence, many supermarkets have a truck for toilet paper only every few days. This means that if there is a run on a store, it won't be stocked immediately, but two or three days later. In short, the pull system between the warehouse and the supermarket is set up for much smaller demand swings, and is currently overwhelmed by the sudden and often irrational demand swings.

Below are the toilet-paper chronicles of my nearby supermarket. On Monday, March 9, I noticed emptying shelves for the first time. However, products were arriving, and the shelves were only slightly below average on March 13. Yet on Saturday, the traditional German shopping day, the hordes bought it all, and the shelves were bare. Even so, I am confident that the shelves will be restocked shorty.

Figure 128: Rewe March 2020 Toilet Paper History (Image Roser)

Supermarkets are of course reacting. Based on the current rush on toilet paper, they will probably increase both the size and the frequency of the order until the crisis has passed and the situation is back to normal. This means means more need for truckers and for workers in the supermarket to restock the shelves. In Germany, trucks are usually not allowed to drive on weekends, but there is a temporary regulation in most German states that permit trucks on weekends for toilet paper, pasta, and other dry goods to alleviate the perceived shortage. Some stores also limited the number of items per customer to ensure people that really need it still got a roll. Another option would be increasing the price to adjust supply and demand, but luckily this seems to have been done only sparingly. It may be more of a challenge to redirect foods packaged for restaurant use towards supermarkets, as this may need quite some reorganization of the supply chain.

12.2.4 Toilet Paper at Home

The toilet paper sells out because of hoarding. Some customers are in a panic mode and buy excessive amounts of toilet paper. If a few people buy more, the stock in the supermarket will run out. There are reports of people buying four hundred rolls (around nine months' of supply for a family of four), or even all the toilet paper in multiple stores for reselling. Here's an interview with a guy that did the same thing with hand sanitizer. Since Amazon pulled his listings for price gauging ($70 for a bottle of hand sanitizer that costs usually around $3), he now has 17,700 bottles in his garage and doesn't know what to do with it.

Figure 129: Empty toilet paper roll (Image Roser)

While some have way too much, others who wanted to buy properly "just in time" are now running out of toilet paper. In effect we have the opposite of leveling. Some have a huge inventory … which they won't consume any faster than normal anyway, and others are running out.

12.3 On Pasta

The situation with pasta is similar. Below are my chronicles of pasta in my closest supermarket. Did I mention that I have time due to the semester being postponed by four weeks? Anyway, I noticed less pasta first on March 5. But it was all restocked one day later. The Monday afterward, they even managed to bring in an extra pallet due to excess demand. This inventory lasted till Friday. On Saturday the crisis was at full swing, and the shelves were bare. Even the unpopular dinkel wheat pasta was completely gone, although they still had Cannelloni and German soup noodles. But this shortage is only temporary, since the supply is not as frequent as the current demand, and I am sure the shelves will be filled again soon.

Figure 130: Rewe March 2020 Pasta History (Image Roser)

The situation is different, however, with hand sanitizers and face masks. These are indeed out of stock, as the demand currently far exceeds the supply.

12.4 Summary

Figure 131: Toilet Paper Store (Image Ville Säävuori under the CC-BY-SA 2.0 license)

However, with toilet paper and pasta, you will be fine (soon). Even though you will see lots of images of empty shelves, don’t worry (unless you are on your last roll at home). Supply will come soon (unless of course you live in the United Kingdom. In this case consider the current situation just an introductory course to Brexit). The current demand spike just overwhelms the last leg from the warehouse to the supermarket.

Besides, other stores may have toilet paper in stock, it is just not newsworthy to post images of full shelves at the supermarket. Such panic buying happens every now and then, as for example during Hurricane Catharina. Or even for no reason at all, when in 1973 there were some rumors of a toilet paper shortage. People believed it, went shopping, and made the rumor come true. But, be nice to the staff at the supermarket, they are having a tough job right now with lots of work restocking the shelves, and unhappy, worried customers.

Also, imagine the inconvenience of having no toilet paper compared to having **no toilet at all!** This will happen if you flush kitchen towels or other substitutes down the toilet. It will clog up your pipes, and *your loo will become a poop fountain*. If you must use kitchen towels, put them in a trash bag after use but not into the toilet itself.

This doesn't mean not to stockpile. The American Red Cross, for example, recommends two weeks of food and supply at home to prepare for a disaster. For a family of four, this would be twenty rolls of toilet paper. There is a whole *Prepper* community preparing for the end of the world. But if you go down this rabbit hole, be ready to meet lots of weirdos that like guns. And, don't go out buying 3 months of supply in the supermarket right now, since this just makes it worse for everybody else. **Now, stay home, wash your hands (do it!), and organize your industry from your home office!**

13 Amazon Kiva Storage Strategies

Christoph Roser, March 24, 2020 Original at https://www.allaboutlean.com/amazon-kiva-storage-strategies/

Figure 132: Amazon Kiva Close up (Image Amazon with permission)

Amazon uses a pretty neat and nifty way to store its materials using robots. These are commonly known as *Kivas*, although Kiva is only the name of the company that originally invented them. Amazon calls them *Amazon Robotics*. In this post I will look in detail at both the design of their storage pods and how Kivas manage their inventory.

13.1 Introduction

In a recent series of posts, I described in detail how the Amazon Fulfillment Centers work. Below is the overview of the flow of material and information in an Amazon Fulfillment Center.

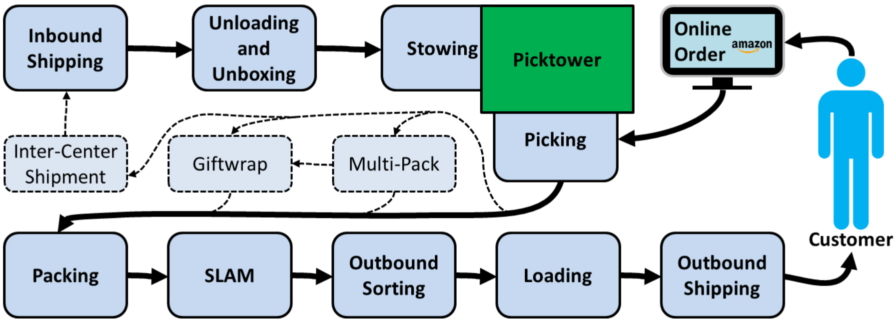


Figure 133: Amazon Fulfillment Flow Diagram (Image Roser)

But their robots especially are a great topic. I talked a lot about Kivas in my previous series of posts, especially how they work, how the stowing process works, and how the picking process works. Basically, these robots lift an entire shelf, bring the entire shelf (called a "pod") to picking or stowing, where an item is removed or added, and then take it back to the storage area. Below is a short video edited from the Amazon newsroom that shows the robots moving around, and another video that shows the picking process.

The Videos by Amazon Newsroom are available on AllAboutLean.com at https://www.allaboutlean.com/aa-all-posts-for-collected-blog-posts-of-allaboutlean-2020/

13.2 Storage Strategies with Kivas

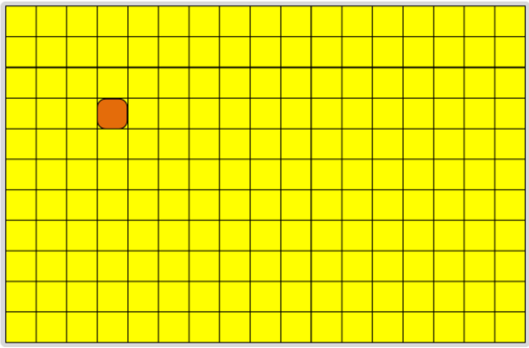


Figure 134: Kiva Max Density (Image Roser)

Looking at this made me wonder, *What is a good storage strategy for these pods?* One of Amazon's goals is to fit the most material into their warehouse. If this would be the only goal, then they should just pack as many pods as possible. This is illustrated as a top-down view on the left. This has the largest capacity and utilizes 100% of the space. However, the disadvantage is obvious: You can't really get your material out without shifting everything else around. If you would do this in reality, you probably could use around 80% to 90% of the space, while the rest you need for shifting things around. Higher percentages means more time for shifting and vice versa.

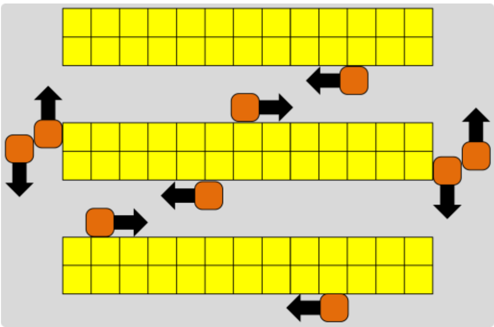


Figure 135: Kiva Two Way Roads (Image Roser)

So let's look at another option. This is inspired by a warehouse with very good access to the material using two-lane traffic. Depending on how many intersecting lanes you have, this will utilize somewhere between 25% to 50% of the space. The example shown here with thirteen pods between intersecting lanes has an utilization of 43% of the space.

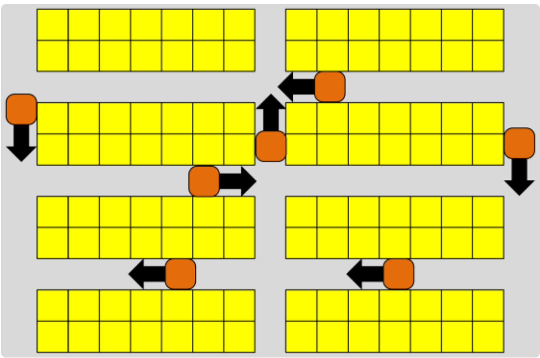


Figure 136: Kiva One Way Roads (Image Roser)

However, most warehouses do not have two-way traffic between the shelves. Instead there is only one lane between shelves. In this case the space usage would be somewhere between 44% and 66% depending on the number of intersecting lanes. The example shown here with an intersecting lane every 7 pods has a space utilization of 58%.

If you have only a few forklifts, this would not need to be regulated. But with literally hundreds of Kivas running around on a single warehouse floor, you probably would need to design lanes for one direction only.

So, how does Amazon arrange their storage? The answer did surprise me a bit, but look at the screenshot from an Amazon video below.

Figure 137: Amazon Kiva Floor Overview (Image Amazon with permission)

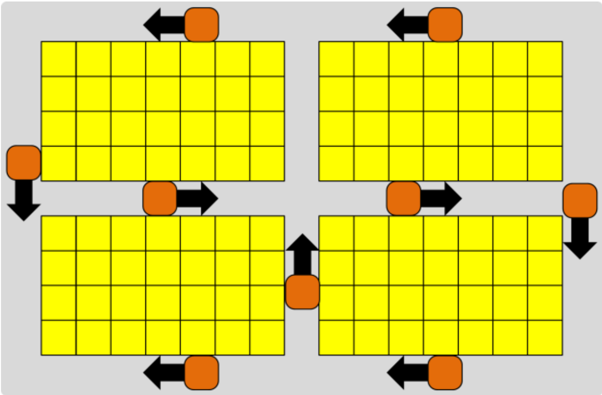


Figure 138: Kiva Reality (Image Roser)

Amazon arranges their pods in clusters with one-way lanes in between. The majority of these clusters were 3×6, 3×7, 4×6, and 4×7 clusters, with an occasional supporting pillar in between. This gives you a space use between 64% and 70%, significantly more of any of the other feasible options above. It does create a bit of a shuffle to get a pod out from inside the cluster, but it seems to work. Also note that they keep the traffic lanes straight all the way through from end to end. This is probably to allow better acceleration, but also to reduce the likelihood of items falling out during a turn.

There are also clusters of 3×4 and 4×4 closer to the picking areas, and you can also find a few 2×7, 2×6, and 2×3 clusters. These look like storage pods containing more frequently requested parts, although Amazon claims completely random storage. Besides, you could also store more frequently used parts at the edges of the clusters anyway. You will also find a traffic area for the robots to move around between the storage area and the picking and stowing operators. In comparison, Alibaba and their similar Quicktron robots use clusters of mostly 2×5 and 2×6, avoiding any shuffling since every pod is directly accessible.

In sum, using these robots gives Amazon a storage space utilization of probably around 65% (assuming a bit of shuffle space but excluding the traffic area toward picking). This is much better than their manual storage options as shown below. For manual storage they probably have a space usage of of less than 60%. This 5% does not sound like much, but for Amazon with around 175 fulfillment centers, this is the equivalent of 8 fulfillment centers (although only a few of them use robotics, and most still have manual picking and stowing).

Figure 139: Amazon Manual Storage (Image Álvaro Ibáñez under the CC-BY 2.0 license)

13.3 Pods Design

Amazon Kiva systems store inventory in pods. These pods are a simple metal structure with shelves on all four sides. They have a square base of 1m by 1m (39×39 inch). This square base makes it easier to fit them in in any direction. They are somewhere between 180 and 240 tall (6-8 feet).

Figure 140: Amazon Picking Process (Image Amazon USA Press Center with permission)

There are different types of pods (including some for heavy-duty items), but all of them have a metal superstructure. Some pods have cardboard shelves, but the most common type I have seen are actually hanging textile shelves. Yes, the shelves are hanging from the top. If you look at the picture of the picker, you can clearly see loops at the top.

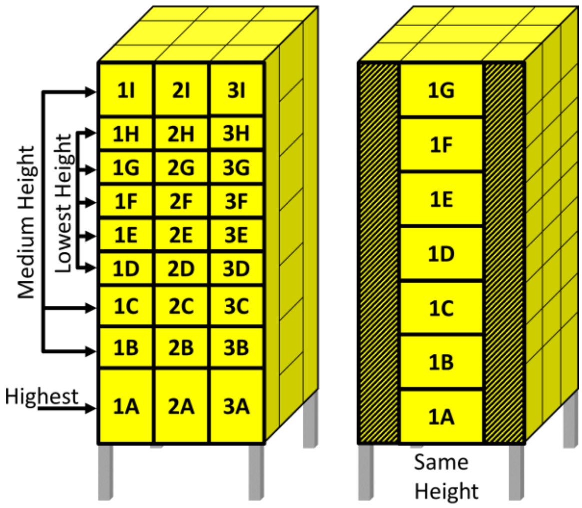


Figure 141: Kiva Pod Illustration (Image Roser)

There are usually storage options on all four sides. Two opposite sides have many small shelves across the entire surface that are not very deep. The two other sides have deeper shelves, but only in the middle. The left and right parts of these sides are blocked by the shelves on the other sides. These deeper shelves are all the same size.

The smaller shelves, however, differ in size. There are five levels that are quite low. Above and below are a total of three more levels that are a bit higher. There is one more level at the bottom that is significantly higher than any other level. If you ever had anything to do with ergonomics, you will notice that the smallest levels are at the most ergonomic access. This is no coincidence, and Amazon placed these levels so that most interactions are at a comfortable height for the operator. Please note that there are also different styles with a different number of compartments.

Naturally, all slots have a human readable label for rows A, B, C… and columns 1, 2, 3. Additionally, there is a 2D code for the scanner. To prevent items from falling out, an elastic strap is strapped across every level of the pod. This is simply clipped onto textile loops that are part of the hanging shelf. You can see these too in the photo above.

In my next post I will show you the different types of robots that Amazon uses, and how their latest generation of robots will give them much more flexibility. Until then, stay tuned, and **go out and organize your industry!**

14 The Amazon Robotics Family: Kiva, Pegasus, Xanthus, and more…

Christoph Roser, March 31, 2020 Original at https://www.allaboutlean.com/amazon-robotics-family/

Figure 142: Amazon Picking Process (Image Amazon USA Press Center with permission)

You surely know this little orange robot at Amazon commonly known as Kiva, which powers many Amazon Fulfillment Centers. Turns out, there are more robots in use at Amazon, some for similar tasks, some for something completely different. In this post I would like to give you an overview of all the robots at Amazon (that I know of). There's at least six different robots in action.

14.1 The Original Kiva

Figure 143: Amazon Kiva Close up (Image Amazon with permission)

The original Kiva is pretty much the robot that Kiva supplied to Amazon, back then called DU 1000 for a driving unit with 1000 pounds lifting capacity. Most of you still know them as Kivas. Since Amazon bought Kiva Systems in 2012, however, Amazon uses the name Amazon Robotics and avoids the term Kiva – even though everybody knows them by that name.

This robot moves shelves (called pods) around for faster and cheaper stowing and picking. (See my series on Amazon Fulfillment Centers for more details). It is about 75cm long and 60 cm wide (2.5 by 2 feet), and fits nicely underneath a pod that measures roughly 1x1m. It is 30cm (1 foot) high, weighs around 110kg (250 pounds) and can lift 450kg (1000 pounds). Like most of the robots here, it has a speed of 5 km/h (3 miles per hour), or comfortable walking speed.

14.2 The Hercules

The Hercules also dates back to the original Kiva Systems development introduced in 2007. Back then it was called DU 3000 as a driving unit with 3000 pound lifting capacity. It is designed for heavy-duty lifting. The principle is similar to it smaller cousin, but Hercules can lift much more weight. It is larger in all dimensions, and therefore the pods are also larger. There are also pallet-pods, which are pallets on a frame with legs for the robot to go underneath.

14.3 The Pegasus

Figure 144: Amazon Pegasus (Image Amazon with permission)

The successor to the original Kiva is named Pegasus after the mythical winged horse. It performs the same function as the original Kiva and moves pods around. However, it is only 19 cm high, 10cm less than the original Kiva. This means 10cm more space to store stuff! It can also lift 560kg, a bit more than the old one with 450kg. And, probably most important, it has only half the parts and is cheaper to buy!

It is unlikely that Amazon will replace all original Kivas, since this would be expensive. However, they may use the Pegasus for new fulfillment centers. Amazon states that they especially want to use it close to city centers. They want more fulfillment centers close to high-population densities to have more deliveries within two hours or even one hour. But being close to a large population means everybody else wants to be there too, and competes for the site, which drives prices up. The Pegasus helps to fit more stuff into a warehouse to reduce investment cost. A few hundred Pegasus robots are already working at Amazon. Below is a video from the manufacturing facility that produces the Pegasus bots.

The Video by NOVA PBS Official is available on YouTube as "Meet the Robots at Amazon" at https://youtu.be/HSA5Bq-1fU4

14.4 The Pegasus X-Sort Drive

Figure 145: Amazon Pegasus Sort Bot (Image Amazon with permission)

The Pegasus is also intended to be a generic base for different attachments on top. One such an attachment is the X-Sort Drive, basically half a meter of conveyor belt.

This robot has a completely different purpose and does not carry pods. Instead, it is used to sort and transport completed parcels to shipping. After labeling (called SLAM), a worker places the parcel on the robot. The robot knows which truck the parcel goes to and moves to the corresponding chute. At the chute the conveyor belt simply throws the parcel into the chute. This can be seen very nicely in the video below.

The Video by Amazon News is available on YouTube as "Amazon's newest robots mean new jobs" at https://youtu.be/4MH7LSLK8Dk

The concept itself is not new, and I saw videos from China using a similar sorting technology a few years ago. Still, it is a nice implementation. It will help Amazon become more flexible. Rather than the tangled mess of conveyor belts that are used for sorting now, the robots allow for much more flexibility in changing the fulfillment center. According to Amazon it also has halved the mis-sorting errors.

Since this Pegasus involves even more robots moving around, Amazon had to program even more traffic rules and had to create a new job position of "flow control specialist."

14.5 The Xanthus (Coming Soon?)

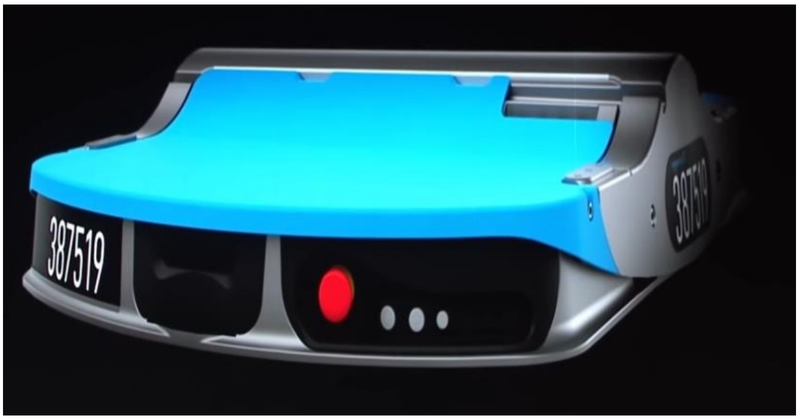


Figure 146: Amazon Robotics Xanthus Drive Base (Image Amazon with permission)

The Xanthus is the successor of the Pegasus. I am not sure where the name came from, as Wikipedia lists at least 16 different mythical figures named Xanthus, but it is probably one of the three horses called Xanthus. This robot was first presented at the Amazon MARS conference in June 2019. It is also a drive unit that can carry pods, but it also has the possibility of using numerous different attachments. The Xanthus is much thinner, has one-third the number of parts, and costs half as much as the original Kiva. Since it has less parts, it is also easier to maintain.

The Xanthus has the option of many different attachments, shown in the image below. The base unit is in the center. To the left and right of it are x-drive units, similar to the Pegasus X-Sort drive, used for sorting parcels to different chutes. These are also called Xanthus sort bots.

Figure 147: Amazon Xanthus Attachments (Image Amazon with permission)

At the very right is a Xanthus Tote Mover. This can move the yellow boxes (called totes at Amazon). These totes are used to move items from picking to packing, and also if needed to multi-sort and gift wrap (check my previous series on Amazon if you want to know more on these steps). Similar to the sort bots, these can make setting up a new fulfillment center much easier, since you no longer need as many conveyor belts. The Xanthus on the very left is a movable cabinet, which they unfortunately did not go into more detail about. These robots are not yet in use but seem to be in the late stage of development shortly before roll out.

The images above are screenshots from the Amazon Mars Keynote. Below is the video, with the presentation of the Xanthus starting at 2:37.

The Video by Amazon News is available on YouTube as "Amazon executives' re:MARS keynote" at https://youtu.be/jthXoS51hHA

14.6 The Robostow

Figure 148: Amazon Robotics Robostow (Image Amazon USA Press Center with permission)

Finally, a "normal"-looking robot that stays put where it was installed. The Robostow is a typical articulated robot used to lift pallets or boxes around. These are actually not Amazon core technology but normal third-party robots. The one shown here was made by Thiele and is called "Robostow"; a similar robot in Bad Hersfeld, Germany, was made by ABB and called "Chuckle Berry." In Bad Hersfeld it was actually the only robot, since it was a manual fulfillment center. You can find these type of robots in many fulfillment centers.

14.7 The Drone (Experimental)

Figure 149: Amazon Prime Air Drone (Image Amazon with permission)

The Amazon drone is intended to bring parcels the last mile from the fulfillment center to the customer. They are currently able to fly up to 15 miles carrying up to 5 pounds and deliver within 30 minutes. These drones can start and land like a helicopter, but fly like a plane for longer distances. It is at the moment just an experiment, and any videos you can find are shot far away from any buildings for safety reasons.

14.8 The Amazon Scout (Early Testing)

Figure 150: Amazon Scout Delivery Robot (Image Amazon with permission)

Finally we have the Amazon Scout. Like the drone, this is used to deliver the parcels the last mile from the fulfillment center to the customer. However, if you want to have your parcels delivered by this cute box on wheels, you better live very close to the Amazon headquarters in Seattle, as (at least in the beginning) an employee of Amazon walks along with it for safety reasons. Also, I am not sure how long this box of free goodies and spare parts would survive the more-demanding environment of Detroit. In any case, the neighborhood in the video below surely looks nice.

The Video by Amazon is available on YouTube as "Amazon Scout" at
https://youtu.be/peaKnkNX4vc

So that's it. To the best of my knowledge, these are all the robots that Amazon either uses or is testing for potential use. Quite an impressive lineup, with surely more to come in the future. Now, **go out, think how robots can make your life easier, and organize your industry!**

15 Fictional Movie on US-Japan Automotive Culture Clash – Gung Ho

Christoph Roser, April 7, 2020 Original at https://www.allaboutlean.com/gung-ho/

Figure 151: Michael Keaton in 2002 (Image Georges Biard under the CC-BY-SA 3.0 license)

Recently I watched a few feature-length movies about automotive plants America. The first one is *Gung Ho*, a fictional comedy from 1986 featuring Michael Keaton. The movie shows a Japanese car maker purchasing a closed-down plant in the USA, and lots of cultural clashes that threaten to close down the plant again. While not Academy Award-worthy, it offers insights into the cultural differences between Japanese and US Industry, although often exaggerated on both sides for comical effect.

15.1 Gung Ho

Figure 152: Gedde Watanabe 30 years later (Image Rob DiCaterino under the CC-BY 2.0 license)

Gung Ho is a 1996 comedy film by Paramount Pictures. The automotive plant in a fictitious town – Hadleyville, Pennsylvania – closed, and the foreman, Hunt Stephenson (played by Michael Keaton), flies to Japan to convince the fictitious Japanese automotive company, Assan Motors, to take over the plant. There he meets his (future) boss, Takahara “Kaz” Kazihiro, played by Gedde Watanabe.

Cultural clashes threaten to close the plant again, but eventually the two sides prevail and the plant and the economy of the town are saved. They used the Fiat plant in Córdoba, Argentina, for the scenes inside the plant, producing Fiat Regata vehicles. **Spoiler Alert!**

As it is a comedy movie, the **cultural stereotypes are wildly exaggerated**. The Americans talk like a waterfall with exaggerated slang and crude jokes, whereas the Japanese often don’t say anything. The “boot camp for failed managers” in Japan at the beginning of the film is also something that I do not expect to see in reality.

Nevertheless, **it does contain some truths**. Toyota Motors even used this film as a training video for their employees who were sent to America – as an example on what NOT to do. For example, Japanese work does indeed often begin with calisthenics, which is a hard sell to the American worker. Overall, three contrasts stuck out to me:

15.2 The Individual vs. the Collective

Figure 153: The Fiat Regata is assembled in the movie (Image Riley under the CC-BY 2.0 license)

Japan as a society puts a much higher focus on the group than the individual. In America, it is often said that “everybody is special.” In the movie, the Japaneses often complain to Hunt that “Everybody thinks they are special, nobody wants to be part of a team, they are too busy getting personalized license plates.”

15.3 Priority of Work vs. Family

Figure 154: Filming location Fiat Plant in Córdoba – 30 years later (Image Prensa Obrera under the CC-BY 2.5 license)

Another recurring aspect is the priority of family over work in the USA, and reverse in Japan. When Hunt (Keaton) asks his Japanese boss how his family likes America, he responds, “I did not ask,” playing on the lack of communication and interaction between spouses in Japan. Similarly, when the Japanese wife asks her husband to help her to assemble a bicycle for their son’s birthday, he is busy with work. She laments, “Why do American fathers have time?” to which he replies, “Because their work sucks.” On another occasion, the Japanese manager complains that “American workers come in five minutes late, leave two minutes early, stay home when sick, and put themselves above the company.” Only toward the end do the Japanese realize that they “work too damn hard. This is not our lives. This is a factory. Our friends, our families should be our lives. We all kill ourselves!”

15.4 Quantity vs. Quality

Probably the biggest thing is the Japanese focus on quality. The Japanese manager states clearly, “In Japan, goal is 0% defects!” to which Hunt snaps back, “How did you slip by?” When the tire falls off a scale model of the produced vehicle, all the Japanese say, “American car,” and laugh.

Figure 155: Do you compete for distance or for accuracy? (Image Chris Breikss under the CC-BY 2.0 license)

Probably the most striking example is when Hunt invites his Japanese colleagues to a softball contest, stating, “We play for beer. Afterward, we piss for distance,” to which the Japanese reply, “We piss for accuracy.” Having never been part of a pissing contest in Japan … or America … or Europe, come to think of it … I cannot verify these objectives. But I do like the colorful comparison.

Hunt and his boss make a deal: If they produce 15,000 cars this month, and hence more than any Japanese plant, they get a raise and the plant stays open. This leads to a dramatic showdown, with a race to complete the target quantity. Here, the film becomes unrealistic, with the Americans slapping the cars together, quality be damned. Wheels are bolted on with a single screw, cars are produced without engines, windshields break, and when Hunt tries to drive off, the car simply falls apart after five meters. In reality, this would be a disaster. Just finding the errors in a car would probably take longer than assembling it in the first place. Not to mention all the issues you may miss. Nevertheless, for the sake of a happy ending, the visiting Japanese CEO accepts these as good cars, they make the 15,000, everybody gets a raise, and the plant stays open.

15.5 TV Sitcom

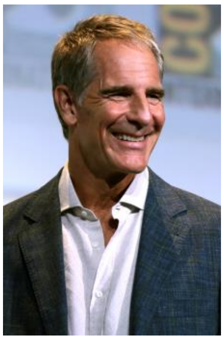


Figure 156: Scott Bakula 30 years later (Image Gage Skidmore under the CC-BY-SA 3.0 license)

The movie even started a short-lived TV sitcom, also named *Gung Ho,* with nine episodes. Most of the Japanese actors continued with the series, but Michael Keaton was replaced by Scott Bakula. The TV series covered industrial conflicts like flashes with rule books, theft, computerization, and women at work, but also romantic problems (for example, infidelity). Below is the intro for the TV show, which is about as 80s as it can get – music, hairstyles, clothes, exaggerated emotions … it has it all.

The Video by CampMovieCamp is available on YouTube as “Gung Ho TV show intro (1986)” at https://youtu.be/8QdXwVGCX2M

Not a brilliant movie, but an entertaining way to understand more of such culture clashes. Be aware, however, that a lot of cultural differences are exaggerated, and it also includes a lot of *fremdschämen* (the German word for second-hand embarrassment). However, it is one of the few shows that use realistic automotive assembly processes, since it was filmed in a real Ford Automotive plant in Argentina. Additional scenes were filmed in Pittsburgh and Tokyo.

Unfortunately, I could not find it streaming anywhere, but the DVD seems to be still available. If you want some light entertainment that you can also call work, then this film may be the right thing for you. Next week I will look at a very similar cultural clash, but then it is all real: the documentary *American Factory*. Now, **go out, bridge the cultural barriers, and organize your industry!**

16 American Factory – Documentary of a Chinese Automotive Factory in the USA

Christoph Roser, April 14, 2020 Original at https://www.allaboutlean.com/american-factory/

Figure 157: Moraine Assembly (Image aaron wolpert under the CC-BY 2.0 license)

A good manufacturing documentary on Netflix is *American Factory*. This movie follows an American automotive plant that closed some time ago, and was reopened by a Chinese car glass manufacturer. It documents the differences and problems between employees and management in general and the cultural clashes between Chinese management's and American workers' expectations in particular. It is in fact very similar to the 1986 movie *Gung Ho,* except *Gung Ho* is a fictional comedy, whereas *American Factory* is as real as it gets. Good to watch!

16.1 American Factory

Figure 158: Michelle and Barack Obama (Image The White House from Washington, DC in public domain)

American Factory is a Netflix documentary from 2019, supported by Michelle and Barack Obama. The movie follows the (real) Chinese company Fuyao, which specializes in glass production. It was filmed between 2015 and 2017 in their (real) Moraine plant in Dayton, Ohio and in Chinese production locations. It won, among other prizes, the 2020 Academy Award for Best Documentary.

The directors of the movie knew the plant well, as they had already made a documentary ten years earlier, *The Last Truck: Closing of a GM Plant*. This film also had no commentary, but featured only the dialogue of the workers, managers, and other people in the movie.

16.2 Fuyao

Figure 159: Fuyao logo (Image Fuyao for editorial use)

Fuyao Glass Industry Group Co., Ltd is a Chinese company specializing in glass, including floatglass (for flat sheets), automotive glass, and glass for construction. It is the largest automotive glass supplier, with a market share of 25% according to their website (although in the movie they state 70%).

It was founded in 1987 by Cao Dewang (曹德旺, born 1946), and currently has around 26,000 employees. It has sixteen production locations within China and nine abroad, of which four are in the USA.

16.3 Moraine Assembly Plant, Dayton Ohio

Figure 160: GM Moraine Plant (Image Kim Clay under the CC-BY-SA 2.0 license)

The Moraine assembly plant was originally a household appliance plant for Frigidaire (1951–1979) and then a General Motors automotive plant (1981–2008).

It closed in 2008, and the last 1,000 of originally 5,000 people lost their jobs. In the movie, Chinese managers claim 10,000 lost jobs, which is almost correct if you include suppliers, where another 3,500 jobs were lost.

Figure 161: Last car produced in Moraine (Image Kim Clay under the CC-BY-SA 2.0 license)

GM claim that the economic downturn, the rising fuel prices, and the subsequent drop of SUV sales forced them to close the plant.

In any case, the closing of the plant was a heavy blow for the economy of Moraine and its people. The closing of the plant was documented by the same filmmakers as *American Factory* in their 2009 documentary *The Last Truck: Closing of a GM Plant*.

In 2014 Chinese glass maker Fuyao bought the plant, receiving a package of grants and tax incentives worth almost $14 million, but in turn creating 2,000 jobs for Moraine and returning around $280 million to the Ohio economy (2016 estimate). Nevertheless, the wages were significantly lower than with GM. One worker was making $29/hour at GM, but only $12.84 at Fuyao. Nevertheless, many workers jumped at the opportunity, realizing that the good times with GM had gone and would never come back. For many, it was a chance to get back to middle class.

16.3.1 Cultural Clashes

Figure 162: No jokes about him, please. Especially no references to Winnie the Pooh (Image Palácio do Planalto under the CC-BY 2.0 license)

There are some interesting cultural comments throughout the movie. For example, when the Chinese workers have their introduction session, the moderator states, “America is a place to let your personality run free. As long as you’re not doing anything illegal, you’re free to follow your heart. You can even joke about the president. Nobody will do anything to you.”

It takes quite some time for both sides to adjust. Throughout the filming of the movie, 3,000 people are hired and either fired or quit, of a workforce of less than 2,000.

16.3.2 Bridging the Cultural Gap

Figure 163: Fuyao founder and CEO Cao Dewang (Image 王平 in public domain)

There are various efforts from both sides to bridge the cultural gap. The CEO Cao Dewang declines a suggestion to put up both US and Chinese art in the lobby, and says to use US art only, stating, “When in Rome, do as the Romans do.” He seems willing to adapt to US cultural norms. But if you have ever lived abroad, you may know how difficult it is to leave your own cultural baggage behind. Unfortunately, he does not seem to speak much English and always has to work with a translator.

At the same time, many Chinese expect obedience like they were used to from Chinese workers, whereas the US workers often speak their mind freely. This leads to multiple clashes, from the need of a tent for the opening ceremony (CEO in March: "In October, the weather will be like it is today …") to the placement of the smoke detectors (US employee: "It's required by law to have one in here, and it has to be that height." – "We can move it to that corner."). The CEO also sometimes talks down to US workers like he would in China, "…you have to think […] before you do…" which does not come across well. Often, the search for the guilty one is more important than the search for the problem. "Everyone who grows up in the US is overconfident […] Americans love being flattered to death."

On the other hand, some of the employees make good friends with colleagues from the other country. Some US employees invite the Chinese to barbecue. The BBQ is followed by another popular US pastime, shooting some guns … which the Chinese really seem to enjoy. One US employee even comments, "My brother, he's my Chinese brother. I would have his back, just like I'd have one of my own brothers. I just… I think the world of him." Some employees' trip to the Chinese plant also helps bring the two cultures closer together, with one US worker stating misty eyed, "We're one big planet."

Unfortunately, this does not apply to everybody, and others complain that the Chinese see them only as foreigners – even though they see the Chinese only as foreigners too.

16.3.3 Safety

Another issue that pops up frequently is health and safety. One worker working regularly with close to 200°C (400°F) hot glass has problems with the heat. Some workers get injured. Emergency exits and fire safety are other concerns. In another example, there is an allegedly unsafe disposal of chemicals into the sewers.

A scene in at the plant in China shows workers without safety glasses and cut-resistant gloves sorting shattered recycling glass by color. Overall, the Chinese attitude toward health and safety does not seem to be up to American expectations.

16.3.4 Productivity

A repeated complaint from the Chinese managers is the productivity of the US workers. "They're pretty slow. They have fat fingers." They frequently complain that they "haven't reached our goals," "American workers are not efficient, and output is low," "American workers are too lazy," and similar statements. Losses for January to October are supposedly $40 million.

About working times, the Chinese complain that Americans work only eight hours per day, with weekends off, whereas in China they work twelve hours per day with much fewer days off.

However, the Chinese also acknowledge that there are some extremely diligent US workers. Some Chinese also realize that many Americans – far from being lazy – have to work two jobs to make ends meet. They realize that their image of the US is not always correct. "I always thought Americans lived a comfortable and superior life. I thought they didn't have to make any sacrifices."

16.3.5 Unions

Figure 164: Senator Sherrod Brown (Image Senate Democrats under the CC-BY 2.0 license)

Probably the biggest "problem" for the Chinese are the unions. This starts with the opening speech of Senator Sherrod Brown, praising the "rich history of unions and management working together" in Ohio, to the complete surprise and strong displeasure of the (US and Chinese) managers of Fuyao. The Chinese managers are very clear: "We don't want to see the union developing here."

They have unions in China too. In fact, all workers are union members. However, the chairman of the Fuyao Workers Union is also the representative of the communist party. Since the communist party represents all people, there is no need to ask the people directly what they would like. Overall, it is doubtful how much Chinese unions actually represent workers' interest. US unions are much stronger.

In any case, since productivity does not improve as planned, and there is the risk of unionization, the Chinese take drastic measures. The president and the vice president of Fuyao USA get replaced by Chinese or Chinese-American managers, along with other US leadership. They spend $1 million on "Union Avoidance Consultants" and the "Labor Relations Institute," which keeps on telling their employees in multiple mandatory sessions how bad unions would be for them, claiming that with unions it "becomes illegal" for workers to talk to managers. Ringleaders of the unionization movement get fired. The management prevails, with 868 votes no, and only 444 yes regarding unionization, meaning there is no union at the plant. Overall, they seem to have worked out (most) of their problems. The plant turns a profit from 2018 onward, and is currently expanding.

16.4 Moraine Assembly Plant Now

At the end of the movie, the CEO Cao Dewang also ponders in self-reflection if all his work really has made a better world. "Have I taken the peace away and destroyed the environment? I don't know if I am a contributor or a sinner." But he concludes that "The point of living is to work."

Relations between the employees and Fuyao is still not very good. On Glassdoor, Fuyao Moraine is ranked with an abysmal 1.8 out of 5 stars, based on 17 reviews, although Fuyao North America ranks more mediocre with 3.3, based on 74 reviews. For comparison, the average rating for US companies on Glassdoor is 3.3. The reviews are often rather critical, often explicitly mentioning China:

- *No leadership. The Chinese could care less as long as they get the number they want to achieve.*
- *I've been there for 3 months, and can honestly say it's stressful. The pay and benefits are excellent, however you are treated like a lesser person versus the Chinese.*
- *Treated less than unless you were Chinese.*

- *Terrible management.*
- *Divided Management Failure to listen to employees*

Anyway, the movie very nicely portrays the cultural differences between China and the USA. It looks into capitalism versus communism. I enjoyed watching it, also noticing details like a "continuous improvement supervisor." A female dancing group in China singing about "intelligent and lean manufacturing" was something I haven't experienced before … or the spontaneous American YMCA dance … or the company group wedding of six couples that followed the dancing. Anyway, if you have time for some light entertainment while calling it work, this is a movie you could watch. Now **go out, watch a movie, and organize your industry.**

PS: A lot of people contacted me with more suggestions for manufacturing-related movies. Here is a short list, sorted by publication date. Some have more, others less about manufacturing, Please note that I have not (yet) watched them all. Many thanks to Michel Baudin and Steve Milner for some of the suggestions.

- *Metropolis* (1927): Famous German expressionist science-fiction drama by Fritz Lang.
- *Modern Times* (1936): Famous American silent comedy with Charlie Chaplin, which I also.
- Master Hands (1936): Documentary by Chevrolet about work in a Chevrolet Factory, available on YouTube at https://youtu.be/zU9mrrdpCE4.
- *I love Lucy* season 2 episode 1 *Job Switching* (1952): Lucy and Ethel work in a candy factory with a lack of visual management. It is available online on various places.
- *Blue Collar* (1978): American drama following three Detroit Auto workers.
- *Norma Rae* (1979): American drama about a factory worker involved in unionizing a textile factory
- Swing Shift (1984): Romantic drama about an American woman signing up for work in an Arms factory during World War II.
- *Sayonara Pet* (1985): Documentary about Sunderland Nissan employees being trained in Japan, available on YouTube at https://youtu.be/Zp6RzyP5o1s.
- *Gung Ho* (1986): Fictional comedy about a Japanese company taking over a American plant. Includes real Automotive assembly lines. (see my last post about this movie)
- *Roger & Me* (1989): Documentary of General Motors CEO Roger Smith's several auto plants in Flint, Michigan.
- *Spotswood* (1992), also known as *The Efficiency Expert* in the USA, is a drama about a consultant (Anthony Hopkins) restructuring an automotive factory.
- *Schindler's List* (1993): American historical drama by Steve Spielberg about saving Jewish forced workers in Nazi Germany.
- *Charlie and the Chocolate Factory* (2005), or the same story as *Willy Wonka & the Chocolate Factory* (1971): Fantasy about a chocolate factory, but not much actual manufacturing. It is popular with many. However, while I love chocolate, the movie somehow annoys the heck out of me.
- *The Last Truck: Closing of a GM Plant* (2009): Documentary about closing the GM plant in Moraine. It is actually the same factory and same directors as *American Factory*.
- *Les Misérables* (2012): Historical period musical film, where Anne Hathaway plays the factory worker Fantine
- *American factory* (2019): Documentary about a Chinese automotive supplier taking over a US factory. (In case you did not notice, it is this post you are reading right now)

17 When NOT to Pull!

Christoph Roser, April 21, 2020 Original at https://www.allaboutlean.com/when-not-to-pull/

Figure 165: Children Tug of War (Image Christian Schwier with permission)

Pull production is a highly useful tool in manufacturing, logistics, services, and other industries. However, there are instances where pull may be not the best option. These instances are rare, but they do exist. In this blog post I will list different cases when pull may not be the best option.

17.1 Recap: Pull Is a Limit on the WIP

Figure 166: Tug of War Children (Image LIGHTFIELD STUDIOS with permission)

Pull systems overall are very robust and stable, well suited for pretty much any production system. In fact, they can also be used outside normal industry (e.g., in healthcare, military, call centers, banking, data processing, and other service industries). See my post Why Pull Is So Great! for more. However, many people define pull incorrectly. For me, pull is a fixed limit on the number of parts or jobs in the system. I wrote about it extensively in my post on The (True) Difference Between Push and Pull.

17.2 Don’t Pull If You Have No Control on the Number of Parts Arriving

Figure 167: Normally, material arrives only when ordered. (Image alinabuphoto with permission)

Pull limits the number of parts in your system. Hence, one key requirement for doing pull is to **control the number of parts entering your system**. If you can’t do that, then you simply can’t pull.

In manufacturing, you usually have control over the number of parts arriving. Parts arrive only when you explicitly order or produce them. Without a purchase or production order, you won't get any parts. Thus, you can limit the maximum inventory simply by not ordering or producing more when you reach that limit.

Figure 168: Difficult to tell customers to stay away (Image Victoria_Borodinova in public domain)

A counterexample would be retail, a repair store, or a key-copying location. A typical store usually has no influence on when a customer shows up. They usually cannot really limit the number of customers in the store unless they want to get bad reviews. Instead, if multiple customers arrive, the customer has to wait. If very few customers arrive, the staff has to wait. There is no defined limit on the upper number of customers.

Figure 169: Black Friday Shopping (Image vverve with permission)

Of course, at one point you will hit a limit where you can't physically fit any more customers in the store. But this is usually way past any sensible workload or even way past any fire regulations, although this happens annually on Black Friday.

17.3 Don’t Pull If It Is Very Expensive to Turn Off Your Process

Figure 170: Don’t turn it off for the weekend! (Image buh123 with permission)

Another case against pull is if **it is very expensive or impossible to turn off the process**. Even if the customer purchases less, you may have to produce and build up inventory to avoid the even larger expense of shutting down your process.

Figure 171: Keep the tap open… (Image Andrew Schmidt in public domain)

This may happen in blast furnaces for steel smelting. Conventional wisdom is to turn on the furnace and then run it for twenty years without a break, until the inner lining is getting too thin and needs to be replaced. Stopping and restarting this process is very expensive, and companies try to avoid this.

Another example may be oil platforms, where the main cost is setting up the platform and drilling a hole. Once the platform is running, it often makes economic sense to keep operating even if the demand and the oil price goes down.

17.4 Don’t Pull If You Can Outperform a Pull System

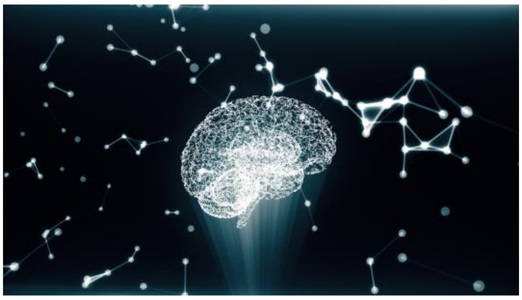


Figure 172: Are you smarter than pull? (Image raspirator with permission)

Finally, pull may be inferior if **you have a very high level of control of your system and an excellent knowledge of upcoming fluctuations** (i.e., you are close to all-knowing and all-seeing in your production system). Even then, pull would still work.

However, it is imaginable to have a push-type system that outperforms a pull system if you have such an excellent understanding of your system. A pull system reacts immediately whenever a part is consumed or completed. A push system controlled by humans, computer logic, or artificial intelligence has to be able to outperform pull systems, giving either a better availability (for make-to-stock) or better utilization (for make-to-order) for the same inventory, or having a lower inventory for the same availability or utilization, or a combination of those.

Hence, if the knowledge of the human, computer logic, or AI of future fluctuations and disruptions is exceptional, they may be able to push a production system better than pull production. Yet, I believe such companies are as rare as unicorns. While you can occasionally meet a manager who believes his organization is all-knowing (usually in the higher ranks far removed from the shop floor), it is not true.

Other than that, I am always hard-pressed to find good examples where pull is not superior to push. In literature, you can find many scientific articles that claim push is better in some cases, but if you dig deeper, you will find that they just did not understand what pull actually is. Pull is much better at handling uncertainty and faster at maintaining your inventory buffer. Hence, the only case where push may be better is a highly stable system where you have an excellent understanding of the processes or of the expected fluctuations.

The common approach is usually to let pull do the day-to-day control, and human workers adjust the pull system if they know of an upcoming fluctuation. These could be seasonal demand changes, or your ship with goods just sunk, or all your products failed the safety test and need to be remade, or there is a craze for your products just because Beyoncé said she loves them, or your products sit like lead on the shelves just because Beyoncé said she hates them, or … or … or … I am sure you are familiar with many such examples in your industry.

17.5 Summary

Overall, pull is, in my view, still the best solution for almost all cases, providing an easy-to-use system that requires little intervention except for the occasional updates. There are very few exceptions where pull is inferior, as mentioned above. Now, **go out, see where you can pull and where not, and organize your industry!**

18 How to Set Up a Shop Floor Meeting – Part 1

Christoph Roser, April 28, 2020 Original at https://www.allaboutlean.com/shop-floor-meeting-1/

Figure 173: Shop Floor meeting (Image Wavebreak Media Ltd with permission)

Regular meetings are necessary to keep yourself and others informed. This is also true for the shop floor. Many factories have set up meeting corners for the workers and their supervisors to meet. In this series of posts I would like to show you what you need for a successful shop floor meeting. This first post looks at the hardware and content of the team corner where the shop floor meeting usually happens, as well as the most important KPI that should be addressed in the team meeting.

18.1 Team Corner Hardware

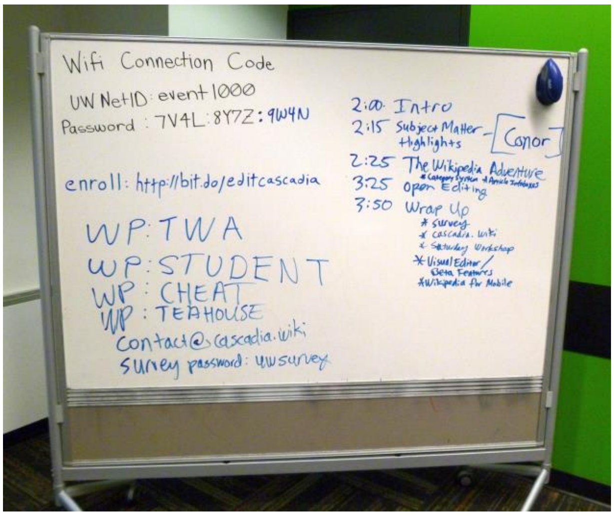


Figure 174: Whiteboard Mobile (Image Pine under the CC-BY-SA 4.0 license)

Most team corners consist of a few whiteboards in an area not too far from the actual workplace. These boards are either permanently mounted or can be movable. Often they form three sides of a rectangle. The fourth side is open so people can walk in and out.

A tall table is often also part of the team corner so participants can put down their clipboard or coffee cups. However, there are usually no chairs. A standing meeting helps to make the meeting shorter and more active. Hence, avoid chairs. Besides, there usually is not enough space for chairs for everybody anyway.

Figure 175: Markers, Eraser, Magnets … (Image unknown author in public domain)

Other pieces of common equipment are whiteboard markers in different colors and an eraser. Some corners hang up these markers with strings, others have a small magnetic tray on the whiteboard itself. The most basic option is to put them on a table, although these tend to go lost most often too. Make sure these are all non-permanent, otherwise you will end up with a very messy whiteboard. Additional writing equipment like pens or text markers are also often available. If necessary, a cheap calculator may also be part of the set.

Figure 176: Not a good shop floor meeting? (Image Thomas Karol in public domain)

Some companies also include computers with displays and keyboards/mouse/tablets. These have the advantage of being able to show a lot of data that is available on the network. The disadvantage is that I have never seen them used. I guess it helps the bosses to feel more "Industry 4.0," but workers usually don't use it, partially because they are not that easy to use. If you believe they help your team, feel free to get these, but otherwise avoid.

On the other hand, feel free to use different non-digital tools. I commonly see (and like) small magnets in different shapes to highlight or indicate items. Red, yellow, and green round magnets can be used for a traffic light system to show if something is good, barely OK, or a problem. Magnetic arrows with labels can point out different things (i.e., "today's person in charge" or similar). Magnets can indicate which worker is at which machine today. If you buy magnets, **get the stronger magnets**. I once made the mistake of buying cheap and weak ones, and the magnets frequently fell off if someone walked past the paper it was on.

18.2 Use Pen & Paper Whenever Possible

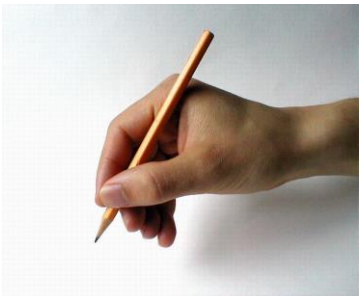


Figure 177: Hand holding pencil (Image Johnny Magnusson in public domain)

Many companies like to work with computer printouts for different data charts. They look nice, but they lock out the worker from interacting with the data. Try to use handwritten data instead. Provide blank forms, and have the employees fill out the data every day themselves. See The Advantage of Handwritten Data on the Shop Floor for more detail. Toyota and many other Japanese companies even use pencil so mistakes can be corrected easily.

18.3 KPI in the Team Corner

The team corner should have different information and data in it. Typically there is one or more data sheets for each of the following categorizes:

18.3.1 Safety

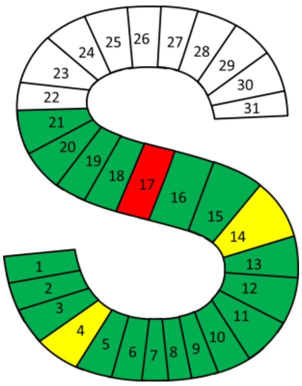


Figure 178: Team Corner Safety S (Image Roser)

The first and possibly most important section is safety. What accidents happened? How many days since the last accident? A popular format is a S-shape with the days of the month (or week). The "S" stands for safety. Every day has its own field. Another variant is similar but shaped like a cross (for the first aid cross), with square fields numbered 1 to 31. Feel free to use a symbol or letter that fits your culture. For example, Muslim countries may prefer a crescent instead of a cross.

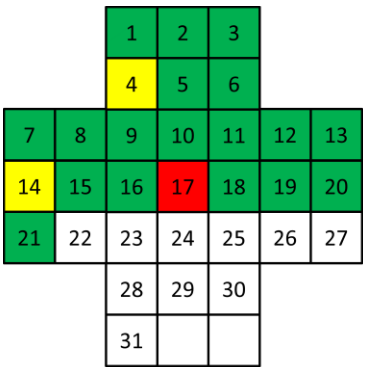


Figure 179: Team Corner Safety Cross (Image Roser)

Every day the safety status of the previous day is added by filling out the previous day. Different colors can represent different things. A green field stands for no accident. A yellow field could be a minor accident that required some medical aid, but no sick leave. A red field would be a major accident that requires sick leave. Gray could be days not scheduled to work. You can also add colors for near misses.

At one glance you can see how safe the section was. Details would have to be looked up elsewhere, but the previous months of data are often kept in the team corner behind the current month. Just in case you want to use this safety S or safety cross numbered from 1 to 31 for the days in the month, I have here a free Safety S and Cross Template that I made myself. Feel free to download the template and use it. If it helps you to reduce accidents, then I am happy ☺.

18.3.2 Quality

Another important factor that is usually represented is quality. Depending on your product, you should show a few of the most important quality measures. Ideally, these are represented as a bar graph over time, possibly with upper and/or lower limits or targets. This allows you to see trends and the quality history. Avoid just filling out a table with numbers. A graphical representation is often much easier and quicker to understand! Similar to safety, the charts from the previous months/weeks are also often kept in the team corner.

Make sure to have enough space on your chart toward the “bad” direction. I knew of one plant that invested quite a bit of money into a electric quality performance display with colored lights for the plant entrance hall, only to have quality turn sour shortly thereafter. The quality was literally “off the charts” for every visitor that walked in. You may make comments directly on the paper if necessary.

18.3.3 Performance

Figure 180: Computer Performance (Image Murrstock with permission)

Another important measurement is the performance of the production system. This could be productivity. How many items were made yesterday? Or it could be some sort of cost measure. Use whatever is common in your area. Similar to quality, this is often a timeline of the performance of the previous days. Most commonly you see the number of items produced per day or per shift, but use whatever is commonly used in your company.

In my next post I will look at some more items that are commonly found in team corners for shop floor meetings. Until then, **go out, meet some people on the shop floor, and organize your industry!**

19 How to Set Up a Shop Floor Meeting – Part 2

Christoph Roser, May 5, 2020 Original at https://www.allaboutlean.com/shop-floor-meeting-2/

Figure 181: Two People in Shop Floor Meeting (Image pressmaster with permission)

In my second post in this series on shop floor management I will look at more things that go into the team corner besides the tracked KPI. How do you manage your improvement activities? What organizational stuff should go in there? Hopefully this will help you make more successful shop floor meetings. In my next post I will also talk about what should NOT go into a team corner on the shop floor.

19.1 Improvement Management

Figure 182: Team Corner Whiteboard (Image MicroOne with permission)

Another common section in the shop floor meeting corner (or team corner) is for improvement. This section contains a list of problems that have happened and are worked on. There are two common approaches. The first one is to have a table, with a line for every issue. The second one uses some sort of cards, with one card per problem. I usually prefer the cards since they can be moved around easily. The top priority goes to the … well … top. Lower priorities are moved down. A completed card is archived.

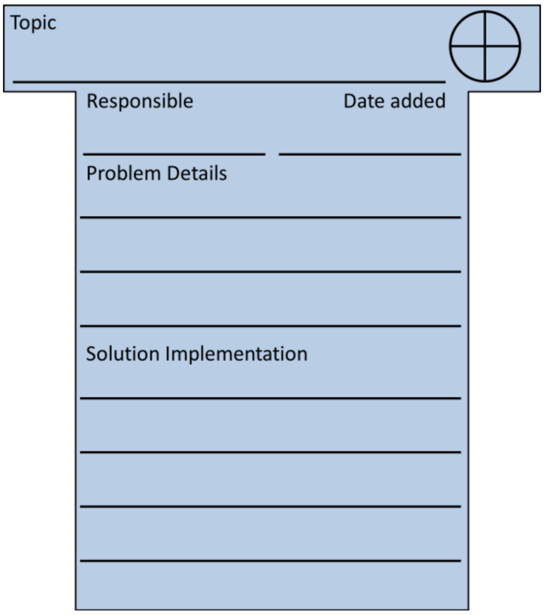


Figure 183: T-Card Example (Image Roser)

Some companies use **T-Cards**, which are cards shaped like a T, so they can be inserted in slotted boards, but without falling too deep into the slots due to the "T"-bar. Others use some sort of Post-its, although you have to make sure that they do not fall off easily.

If you are using a table to track your improvements, however, you eventually will end up with lots of completed entries, and only a few open ones, with more on the next sheet. This requires some searching to find out what is still ongoing and what not.

Regardless if you use a table or a separate set of cards, the structures are very similar. It is in effect a micro-version of the A3 report. There is a brief **description of the problem**, and a **suggested set of solutions and/or measures**. A **check if the implementation works** is also highly suggested, but just like the PDCA often forgotten. Frequently there is also a field for the person **responsible** for this issue and the **date** it was added. Finally, the **PDCA circle** is often also shown. This is a circle divided into quadrants. Whenever a quadrant is completed, the quadrant is filled out. This is an easy tool for visual management to see how far the problem solving process has advanced. Often, variants are found that slightly deviate from the PDCA, but I like to stick to the PDCA.

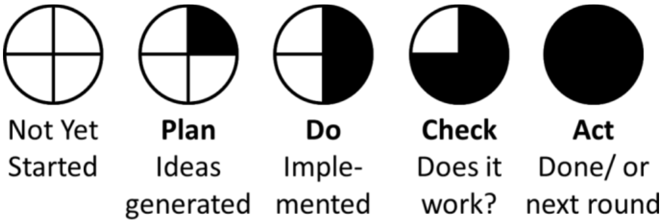


Figure 184: Team Corner PDCA Circles (Image Roser)

In all likelihood you may have more issues than you and your team can solve in a reasonable time. Do NOT make the mistake of putting all topics on your to-do list of topics to be resolved. Instead, keep a separate **backlog of open problems**. If you try to attack all problems at the same time, you are like the young tiger that wants to catch all ducks at the same time … you will end up with none.

If you have **larger improvement projects** going on, you can also add some info on the larger projects. For example, you could hang up the A3 report (original or copy) for ongoing projects.

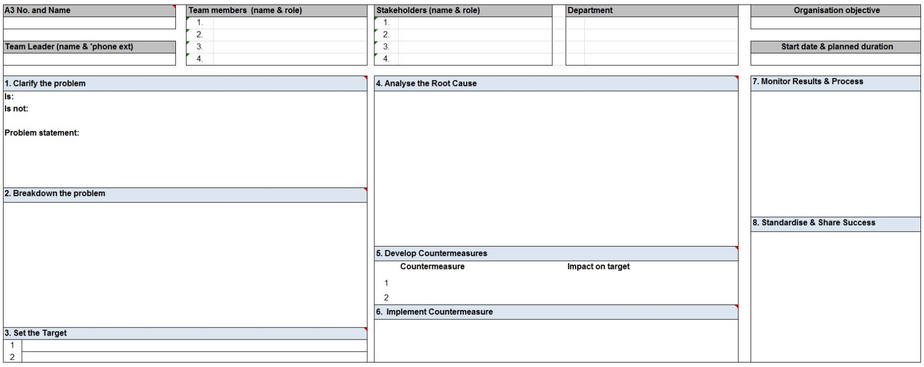


Figure 185: A3 Report Example (Image Zsever in public domain)

19.2 Organizational Stuff

Often, the team corners also contain organizational elements.

19.2.1 Worker Assignment and Absence

Figure 186: A Whiteboard on a Forklift ??? (Image Wavebreak Media Ltd with permission)

One possibility is to add an overview of the workers in this section, which ones are in/out today, and where they are working. This can be combined with a qualification matrix, showing which worker is trained on which processes. If you track your workers' attendance, make sure that you do not go into too much detail unless the workers agree. If you make it publicly visible who was sick on which days, then a lot of workers would feel unhappy, morale would go down, and you may be heading for trouble with the unions. This is usually not worth the benefit. Find a trade-off between worker-related data that you need on the team corners rather than just on file, and the happiness of the workers about not being put on display.

19.2.2 Contacts

Figure 187: Worker in Factory making a Phone Call (Image Standret with permission)

Sometimes there is also a small note about who is in charge of this team corner. This may also include a corporate mobile number. Often, additional contacts are also listed, for example the names and photos of the first responders (employees with additional first-aid training) in case of an emergency. You always hope that you never need this, but if you do, you will be glad that you have. Including the photos in the team corner also helps the employees to memorize this. In an emergency, they know who to reach out without having to look it up first.

19.2.3 Participants

Figure 188: Everybody here? (Image monkeybusinessimages with permission)

Yet another element of a team corner is often a list of participants for the team meeting. This can include the workers and foremen that are covered by this team corner, although this is usually not really that helpful. More helpful is tracking the participation of other employees that usually do not belong to the team corner. In many companies, a representative of logistics or engineering may be present during at least some of the meetings.

In some plants, even managers up to the plant manager are scheduled to attend such team meetings. Naturally, a plant manager cannot attend every meeting every time, but he could have to attend at least one meeting per week. This helps the managers to get a grasp of what is really going on on the shop floor.

Often such an attendance is tracked in a simple table, with a row for each name, and a column for the days of the months. Additionally, there may be a note if attendance is not required every time but weekly or monthly. Filling out a day in green means this person attended, yellow means it was an absence but with prior excuse, and red means the person was missing without prior explanation. If the person is scheduled to attend less than daily, you can fill out the entire period if that person attended at least once. Maybe mark the actual day of attendance.

Of course, tracking the time of your bosses can land you in hot water if your boss did not give you permission for this. I have seen such manager attendance tracking a few times, but it always started with a suggestion from the top. I also strongly recommend not tracking the attendance of your boss unless your boss wants to be tracked … or your boss's boss tells your boss that he should be tracked.

19.2.4 Checklists or To-Do Lists

Figure 189: Checklist (Image Clker-Free-Vector-Images in public domain)

Not always but in some cases you can find checklists on the team corner. If there are a number of steps that have to be done regularly AND should be checked in the team meeting, then you may add such a checklist. Examples would be some maintenance, sending of a report, or similar. A check mark or name can be added for every entry and the corresponding day to see if it was actually done. But please only use this on the team corner if necessary, not only because you can. The team meeting is probably already full of topics, and adding more will delay everything else.

19.2.5 General Info

The team corner also frequently can contain additional information that is relevant. It could be printouts of general announcements, or info on upcoming changes, or a message from your unions, or … or … or. I am sure you can think of a lot of things in your plant. Just don’t overdo it. The space in the team corner is limited, and you won’t be able to fit everything on it that somebody would like to add.

19.3 Not Necessary

There are a few more things that are sometimes found in team corners, but in my view are completely not necessary.

19.3.1 Value Stream Map and Layouts

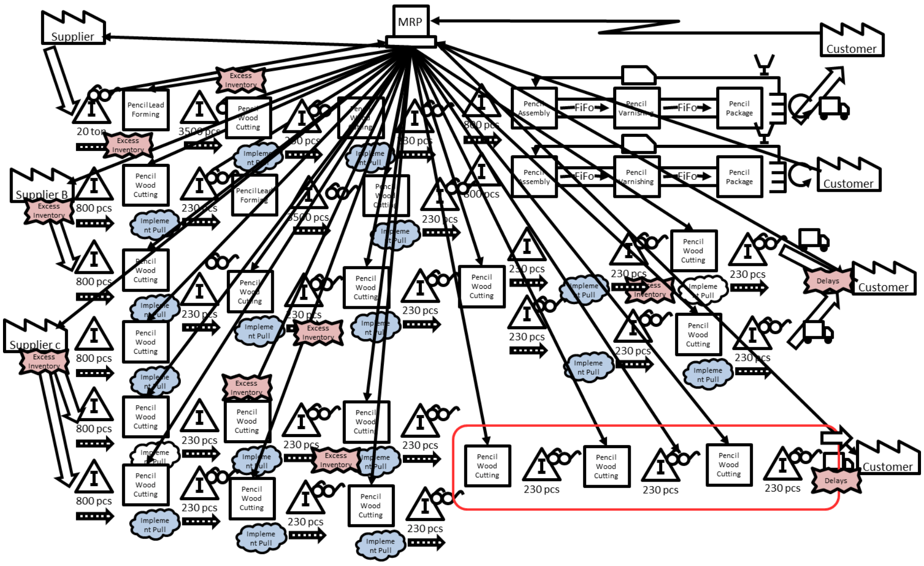


Figure 190: VSM Example Overload (Image Roser)

Many Western lean companies love to do value stream maps. They do have their uses, but are in my view widely overused in Western companies. I see them as a tool for specific projects, and not as an “always on” KPI. Besides, the people that are usually in the team corner know their value stream probably better than anyone.

Similar applies to layouts. They are only helpful for certain types of improvement projects, or for people unfamiliar with the area to get an understanding. But again, the people in the team corner know their area better than anyone else.

19.3.2 Mission Statements

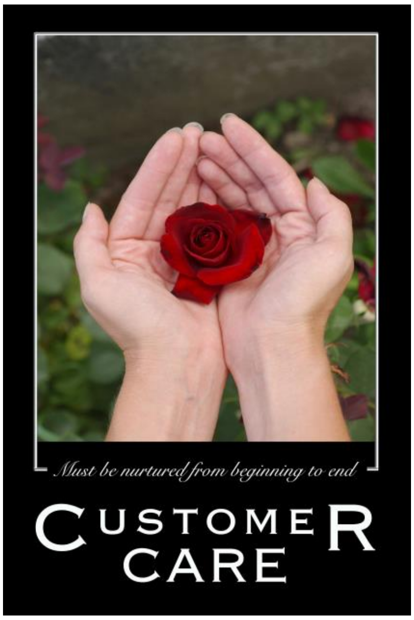


Figure 191: Uh … okay … (Image the U.S. Air Force in public domain)

Company executives love to have mission statements. Unfortunately, these mission statements often live in a parallel world disconnected from reality. Often, they are a collection of fancy modern management buzzwords. It is full of "aspirations," "strive," "exceptional," and "achieve." They talk about "global strategy" and "leadership," and occasionally also the "customer."

If it is a good mission statement aligned with how the company really is (not how the CEO wants it to be), the workers will ignore it. If it is a bad mission statement, it will be ridiculed. Overall, it is a waste of space in the team corner. Hang it somewhere else where it is not in the way.

However, if there is truly something praiseworthy and connected to this section of the shop floor, feel free to hang it up. If there was an award for quality or performance in this section, put it up in their team corner. It is fine to have motivational items in the team corner, if it means something to the team.

This wraps up the design of the team corner. In my next post I will talk about how to actually conduct a shop floor team meeting as part of the shop floor management. Until then, **go out, prepare your whiteboards, and organize your industry!**

20 How to Conduct a Shop Floor Meeting

Christoph Roser, May 12, 2020 Original at https://www.allaboutlean.com/shop-floor-meeting-3/

Figure 192: Blue Collar Meeting (Image style-photographs with permission)

In this last post (for now) on my series on shop floor management I will talk about how to conduct a shop floor meeting. Who should be there; when, how long, and how often you should have such a meeting; and what is on the agenda. I will also talk about common mistakes that you should avoid.

20.1 Who Should Participate in a Shop Floor Meeting

Figure 193: Factory Workers (Image Cherie A. Thurlby in public domain)

The shop floor meeting is primarily for the people on the shop floor. Since in all likelihood your entire factory is too large for a meaningful single meeting, such meetings should happen for different sections of your factory separately. Align this with the structures you already have in place. Every foreman/supervisor conducts a meeting for his own team. In my experience, the number of participants range somewhere from 3 to 20, although I prefer 5 to 10 to keep it manageable and effective.

Besides the workers and the supervisor, you may have other people involved, as for example logistics, maintenance, management, or other support staff. But please be considerate of their time too. Even if you distribute the shop floor meetings across the day, a support staff worker will do nothing else if there are twelve meetings to attend every day. A common strategy is to have the support staff join not daily, but once per week or once per month, depending on the number of shop floor meetings you have in their area of responsibility altogether.

Another option is to invite support staff on a case-by-case basis. If a problem benefits significantly from the attendance of a certain support staff, then this support staff may join for one meeting or a small number of meetings to help resolve the issue.

I have seen attendance of upper management up to the plant manager on a regular basis. The plant manager attended a different meeting every day, and his attendance was tracked by the shop floor meeting supervisor.

20.2 How Often, How Long, and When Should You Have a Shop Floor Meeting

Figure 194: Manager looking at Watch (Image Mangostar with permission)

A shop floor meeting should happen with every shift. All the employees currently working in this section of the shop floor should attend. The duration varies, but is often somewhere between 10 and 30 minutes. Don't make it too long, since this will directly reduce productivity.

Usually it is at the beginning of a shift to get the maximum benefit from the information shared. However, if multiple teams use the same team corner space, or if a manager wants to attend multiple meetings, the start of such meetings can be adjusted. In other words, Team 1 meets 8:00 to 8:20; Team 2 8:20 to 8:40; and team 3 8:40 to 9:00 in the same team corner. Similarly, if the shop floor supervisor and his team meets at 8:00 to 8:20, with the shop floor manager in attendance; the overarching shop floor manager meets and his staff meet afterwards. Naturally it makes sense to start the meetings at the lowest hierarchies and work your way upward. This permits the fastest transfer of information from the shop floor (the "*Gemba*") upwards.

20.3 How to Conduct a Shop Floor Meeting

Figure 195: Checklist (Image Clker-Free-Vector-Images in public domain)

The shop floor meeting usually has only a few agenda points. It often starts with **taking attendance**. Next comes a look at the **key performance indicators** of the previous day. These usually include safety, quality, and cost or performance. If an accident happened it should be discussed(briefly) to prevent reoccurrence. If it is a bigger issue to solve a separate meeting or project may be necessary, as the shop floor meeting is too short for a detailed analysis.

Another block looks at **current problems** and **improvement activities**. What went wrong yesterday? What is the progress of the open items in the improvement list. Please keep in mind that this meeting does not have enough time for extended discussions, the focus is on conveying information. If there are non-obvious problems to solve, a separate problem solving process should be initiated. A third block may give various updates and **organizational information** that came up since the last meeting.

In pretty much all cases I know, this was a standing meeting. In general, standing meetings tend to be shorter. Besides, you usually don't have the space to put up chairs on the shop floor.

20.4 Outside of the Shop Floor

Figure 196: Crazy Office People (Image Poznyakov with permission)

Similar meetings are also becoming more common outside of the shop floor. Such meetings could happen, for example, with logistic teams (which I have done myself regularly when I was a manager of such a team), or maintenance, or any other organizational groups. Things on the shop floor change with a very high frequency, and due to the nature of the work there is usually not as much time to exchange information. Hence, a meeting every shift is well justified.

However, this may be different in other areas outside of production. It may be justified to meet only twice or three times per week, or even only weekly. If it is less than weekly, however, these meetings start to lose their effect.

20.5 Common Mistakes in Shop Floor Meetings

Figure 197: Shouting Worker (Image Krakenimages.com with permission)

There are a few common mistakes in shop floor meetings. Probably the biggest one is to let it **degrade into a discussion group**. Pros and cons are argued, or even worse, blame is assigned, and the time is up before reaching any meaningful conclusion. The next day the story repeats, and since the points from yesterday are repeated no progress is made.

Figure 198: Silenced Worker (Image Krakenimages.com with permission)

Another common problem is the opposite: A **lack of employee involvement**. Only the boss talks and the employees listen. It is good practice to assign different parts of the meeting to different employees. Employee A takes attendance. Employee B goes through the KPI, and so on. Not only does this significantly increase the involvement of the employees, it also frees up the mind of the supervisor from organizational tasks and gives more time for actual knowledge value add, and maybe even a little bit of coaching and mentoring. Also allow the employees to adjust the content of the team corner. Some companies provide a shop floor meeting template, but often it is better to adjust this template to the actual needs of the team.

Figure 199: Sleepy manager with Clock (Image Elnur with permission)

Another mistake is to **relax the meeting times**. Try to avoid delaying the start or end of the meeting. In some companies this works well, but in others adhering to a meeting schedule seems to be impossible … with the employees following the role model of their managers. You probably know where on this spectrum your company sits.

But if you avoid these mistakes (at least most of the time), a shop floor team meeting can be a very helpful part of your shop floor management. It facilitates the exchange of information, and helps you to run a shop floor smoother than if you have no such meeting. **Now, go out, meet you people regularly, and organize your industry!**

PS: In the discussion on linkedin, Osamu Higo suggested that the foreman gives a brief summary (verbal or short memo) to his own supervisor. I do like this idea. Thanks for the suggestion, Higo-san!

21 Why Are Job Shops Always Such a Chaotic Mess? Part 1

Christoph Roser, May 19, 2020 Original at https://www.allaboutlean.com/job-shops-mess-1/

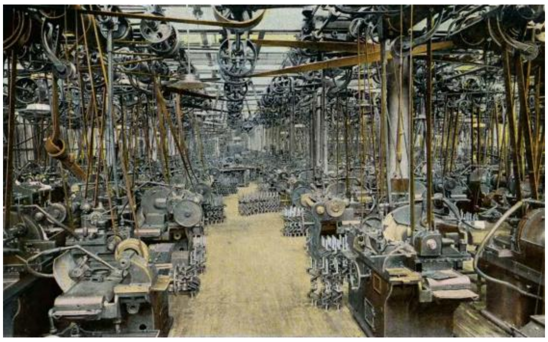


Figure 200: Ford Crankshaft Shop 1917 (Image Ford in public domain)

Job shops have a strong tendency toward chaos. Even well managed plants struggle to maintain order in a job shop. This is due to the inherent nature of a job shop, and there are no good solutions to manage job shops. The only good way to improve a job shop is to turn it into a flow shop. I will talk more about such changes later in this short series, but first let me explain why job shops are always a mess.

21.1 Flow Shop, Project Shop, Job Shop

There are three main groups of material flows in manufacturing. First, there is the **flow shop**, where the main material flow is the same for all products (i.e., all products have the same process sequence). Second, there is the **job shop**, where the material flow is different for all products. Finally, there is what I call the project shop, where all material flows to one process only. This is not that common, but can be found, for example, in shipbuilding, where everything comes to the ship in the dry dock. Please also note that these types of material flow have a large overlap. There are plenty of flow shops where some material has exceptions, and plenty of job shops where there are small stretches of flow-shop-like behavior.

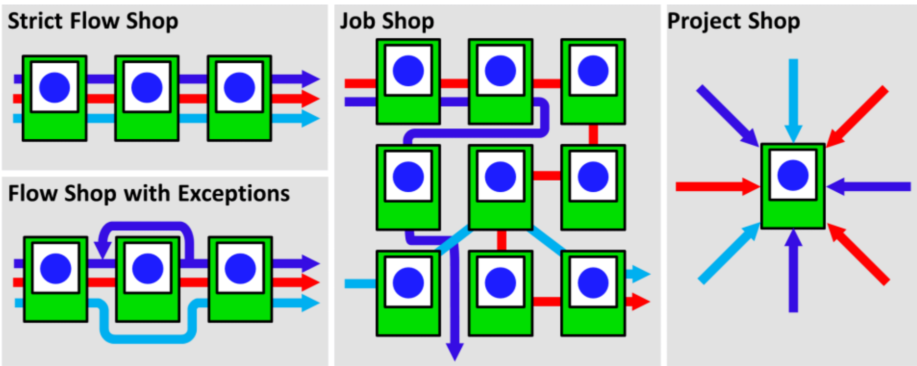


Figure 201: Flow Shop, Job Shop, and Project Shop (Image Roser)

I have written about flow shops, job shops, and project shops before, but flow shops are usually much, MUCH easier to plan and manage. Let me show you why job shops are such a source of chaos.

21.2 Irregular Material Flows Cause Inventory Imbalances

One of the main causes of problems typical to a job shop are irregular arrivals. Below is a hybrid between a flow shop and a job shop, to illustrate the point. Material flows from left to right, but may be processed by different machines at different steps. I use this hybrid, rather than a full job shop, to make the points easier to understand, but trust me, it is worse in a full job shop.

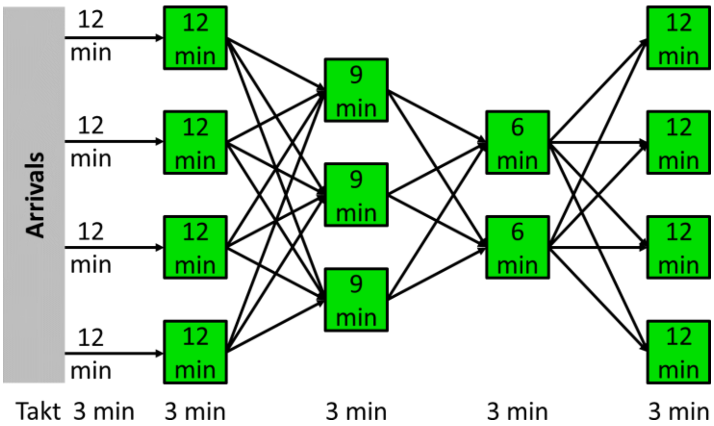


Figure 202: Messy Job Shop Example Basic (Image Roser)

Furthermore, to simplify the argument, let’s also assume that the processes are nicely balanced and every part can be processed at every machine, and also let’s assume not to have any randomness. (Yeah, absurd, I know. But it is the privilege of professors to make unrealistic assumptions so that it works in theory 😉.) Anyway, on the first column a part arrives at every process every 12 minutes, hence our arrival takt is 3 minutes. The first column of processes can process a part every 12 minutes, which gives these four processes together also a takt of 3 minutes. The second column of processes needs 9 minutes per part and process, which gives also a takt of 3 minutes. The third column needs only 6 minutes per part and process, again for a takt of 3 minutes. And the last column needs again 12 minutes per part and process, for a takt of … 3 minutes.

Hence overall, the processes in this example are nicely balanced, with every stage of these four process columns having the same capacity. If you would be producing water, it would flow though the system at the same speed without being slowed down.

Unfortunately, you are not producing continuous goods like water, but discrete goods like parts. Hence, you will sometimes have two parts arriving at the same time at the same process, and sometimes none. Even with the best distribution rule, you will have more material at some spots and less at others. The material distribution is uneven.

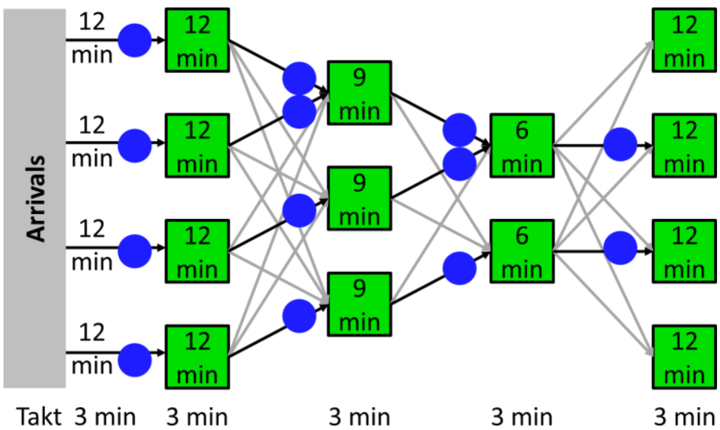


Figure 203: Messy Job Shop Example 1 (Image Roser)

The above example also assumes every part can be processes by every machine. If we would have the restriction that some parts can be processed only by some machines, the “clumping” of material will quickly become even more pronounced as shown below.

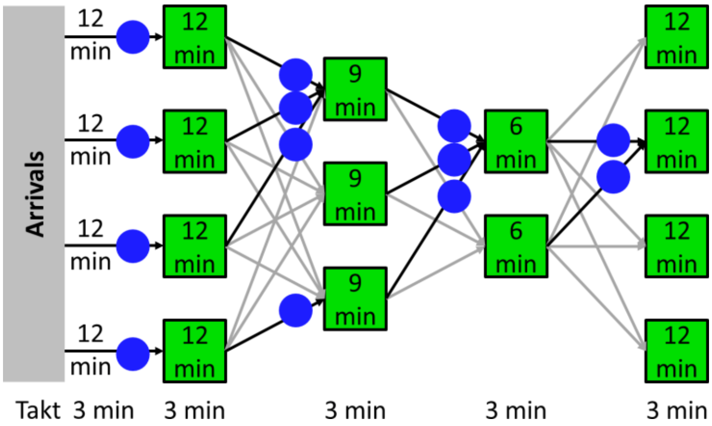


Figure 204: Messy Job Shop Example 2 (Image Roser)

And, remember, this is a perfectly balanced system without any randomness (i.e., my theoretical example). If you add random events (breakdowns, short delays, etc.) and make the system imbalanced (you have a bottleneck that may also depend on the part mix produced), it will become even worse.

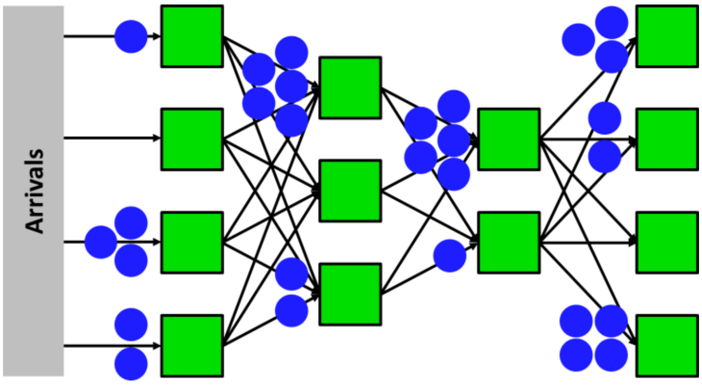


Figure 205: Messy Job Shop Example Real (Image Roser)

The point here is that depending on the arriving product mix, the arrival of material at a process is fluctuating widely. One process may have multiple parts arriving almost simultaneously, whereas other processes may have none. If more parts arrive than what the process can handle, the material starts to pile up. If less arrive than what the process can handle, the pile will shrink and eventually disappear, causing the process to idle.

21.3 Inventory Imbalances Cause Large Safety Buffers

Having clumps of material in your value stream is not good. But for the shop floor, often even worse are idling workers. A worker that is unable to work due to a lack of material is waste. To be more specific, it is the waste of waiting as part of the seven types of waste (muda).

Figure 206: Seven Trash Cans Labeled (Image Thomas Söllner with permission)

To prevent or at least reduce such waiting times, the inventory in front of the processes is increased. If there is more inventory, the likelihood of having to wait is reduced … but at the cost of increased inventory.

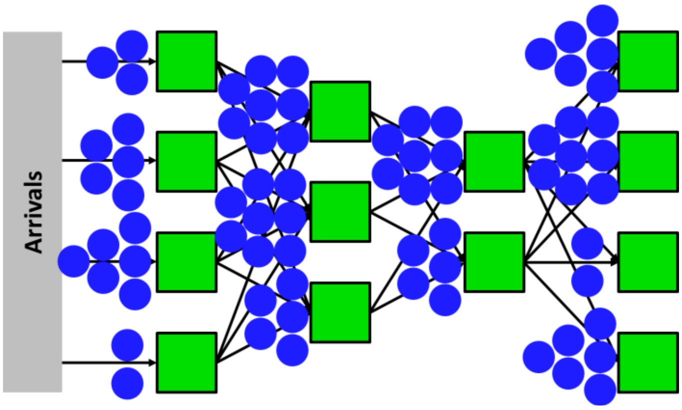


Figure 207: Messy Job Shop Crowded (Image Roser)

21.4 Inventory Imbalances Cause Changes in Staffing

Imbalances in the workload can be buffered somewhat by inventory. Larger imbalances, however, eventually require some processes to work more than others in the long term. This is usually done by reassigning workers. If a process is running out of parts, the workers are reassigned to an process that has way too many parts. In a flow shop, workers often work for longer periods at the same spot, changing the location only at predetermined times. In job shops, such changes are much harder to predict. It is usually impossible to have a preventive planning of the staffing, but only a reactive action. If the process runs out of parts, you check where the workers are most urgently needed (and qualified to work at), and reassign the workers there.

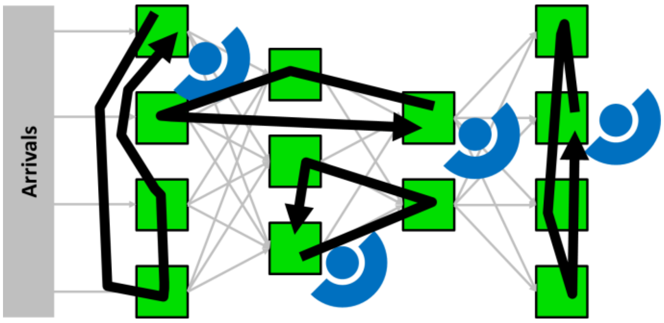


Figure 208: Messy Job Shop Example Change of Staffing (Image Roser)

In my next post I will continue to lament about the woes in a job shop … which unfortunately does not help you much except that I know your pain in managing a job shop. In the post after that, however, I will look into how to transfer a job shop into a flow shop. Now, **go out, wrangle with the multi-headed hydra that looks like a job shop, and organize your industry!**

P.S.: This blog post was inspired by a part in a video presentation by Nampachi Hayashi, which I found through an article by Dirk Fischer. Thanks to all 🙂.

22 Why Are Job Shops Always Such a Chaotic Mess? Part 2

Christoph Roser, May 26, 2020 Original at https://www.allaboutlean.com/job-shops-mess-2/

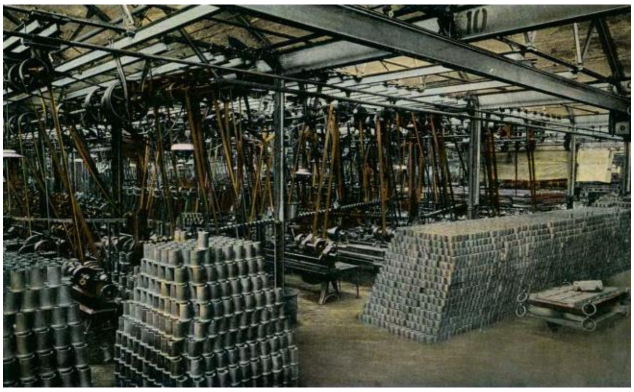


Figure 209: Ford piston shop 1917 (Image Ford in public domain)

Job shops are a mess. Period. The increased and uneven levels of inventory cause a host of other problems. In my last post I described how these inventory imbalances are caused by irregular material flow, how subsequent safety buffers increase inventory even more, and how this causes staff to change their workplace irregularly in a job shop. In this post I will continue the long list of ills in a job shop with staff changeover losses, extra searching and organizing, fluctuating lead times, and general un-plannability of job shops.

22.1 Changes in Staffing Cause Changeover Losses

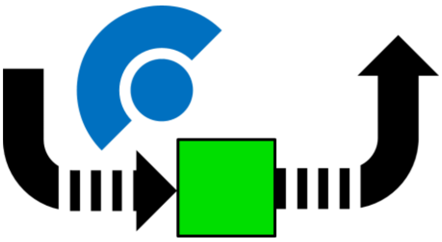


Figure 210: Flow Shop Worker Change Losses (Image Roser)

Due to these imbalances in material, the workers have to change locations. This also causes waste. The workers have to physically move to the next location, familiarize themselves with the current situation there, and get ready to work. They may also use this opportunity for a small break that will never show up on your time sheet. Overall, you may lose anywhere from five to thirty minutes due to such a change of location. Hence, the more you change locations, the more you lose the time of your workers.

And this does not even take into account the time needed to figure out where to assign the workers next! This is either the time of the supervisor or, if the workers decide for themselves, the time of the workers. If the workers decide for themselves, a major factor may also be what type of work they like and which one they dislike. If you leave it up to the workers, the popular processes (easy, clean, good money) will be well staffed, while the unpopular processes (dirty, difficult, dangerous, lower pay rates) will have piles of material.

To compound the problem, this is very difficult to plan ahead of time due to the butterfly effect (more below). And since it is difficult to plan ahead, it is impossible to optimize the work sequence. A worker may work at a process at one end of the shop floor, but then may have to work far away at a process at the other end of the shop floor. You will have longer walking distances between processes. Furthermore …

22.2 Irregular Flows Cause Searching and Organizing

Figure 211: Magnifying glass (Image Roser)

In a flow shop it is easy. The next part to produce is simply the next part in line in front of the process. Material transport can easily be standardized or automated to reduce handling time and effort. This is much more difficult in job shops. The workers may not know automatically where the next material comes from, or where the completed goods should go, or both. There may even be multiple choice options. The completed product could go to either one of three processes, but which one would be the best choice?

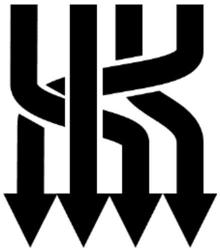


Figure 212: Arrow Crossing (Image Roser)

There may be a lack of standards for moving the goods, and probably no automation. Often, the “standard” is only for the forklift driver to keep a lookout for finished goods at the processes, look at the material sheet, and try to figure out where to put it next.

If there was a mistake in the transport, it may take some time for people to notice the wrong part in the pile of open jobs at a process, even more time to inform someone, and then even more time to bring it to the (hopefully) correct location.

22.3 Searching and Organizing Requires Skilled Personnel

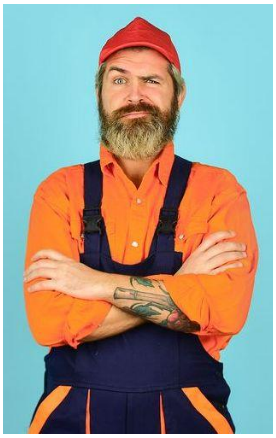


Figure 213: He has seen it all! (Image photosvitwith with permission)

Even though there are often many mistakes, it is due to the skill and experience of the operators and logistic that the system will not crash totally. Try staffing the job shop logistics with lots of newbies, and see how everything grinds to a halt, whereas with experienced hands it at least stutters not too much.

Figure 214: He still has to see a lot… (Image VaLiza14 with permission)

Overall, you need a longer time to train your staff, where "training" is often simply a sequence of trials and errors over a prolonged period of normal work, with the occasional tip from older colleagues. If you don't have that many logistic workers to begin with, an *old hand* leaving can have a bad impact on the performance of the job shop.

22.4 Inventory Imbalances Cause Fluctuating Lead Times

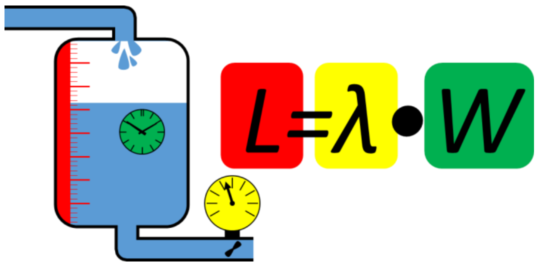


Figure 215: Water tank example for Little's law (Image Roser)

Besides the waste of additional material, waiting, searching, and unnecessary organizing, another major problem in job shops is the lead time. The **average** lead time for a job shop is easy to determine using Little's law. You divide the inventory (in pieces) by the throughput (in pieces per time) and get the lead time (a time). Since a job shop often has quite a bit more material than a comparable flow shop, the average lead time is usually quite a bit longer than in a flow shop.

However, not only is the average lead time larger, it also fluctuates more due to the inventory imbalances. Some parts happen to have a process sequence that is not so busy, and hence may pass through the system faster. Other parts happen to have a process sequence that is much more crowded, and hence these parts will take much more time. These fluctuations also make it much more difficult to predict a completion date and hence a delivery date with any reasonable accuracy. The given delivery dates usually include quite a bit of time buffer … and even this is sometimes not enough.

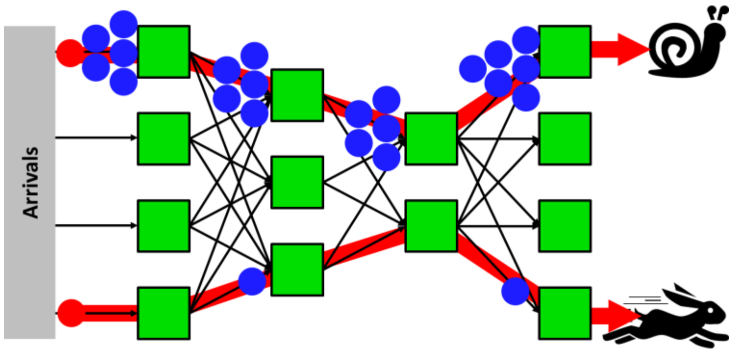


Figure 216: Messy Job Shop Lead Time (Image Roser)

22.5 Butterfly Effect Causes Planning Uncertainties

Figure 217: Watch out for the evil butterflies! (Image Michael Apel under the CC-BY-SA 2.5 license)

Finally, there is the issue of the overall sensitivity of the system. There are software packages available that try to model the flow of material through a job shop, but such analytical predictions suffer from the butterfly effect. The butterfly effect is a term from nonlinear dynamic systems, where a minor change in the system can drastically change the overall outcome. The example is named "butterfly effect" where (hypothetically) "the flap of a butterfly's wings in Brazil set off a tornado in Texas."

You won't find many butterflies in a job shop, but the effect is the same. A minor delay in one process may causes the part to be behind another part rather than in front of it, which can change the level of utilization (overloading or idleness or in between) for other processes. Hence any deterministic plan you make for your job shop will soon deviate from the reality. It is like the weather report, good for the next few hours, acceptable maybe for two days ahead, but highly unreliable when looking two weeks in advance. Since reality is always right, your plan is wrong, and all the careful effort in planning is wasted.

22.6 Planning Uncertainties Cause Reaction Instead of Preventions

Since any plan you make goes out of the window soon due to these uncertainties, a job shop usually has much less planning beforehand, and prevention of issues is difficult. There are some average utilization and workload estimates, but detailed plans when to make which part at which machine are difficult.

Instead, a lot of the effort on the shop floor is reactive, where you try to fix problems as they pop up. However, if the problem is already happening, then it is too late to prevent it, and you can only mitigate the damage. Yet this is common in job shops.

There are lots of software packages out there that try to help you in managing the mess of a job shop, but a job shop is and stays a mess. The only true cure for the mess of a job shop is to turn it into a flow shop. **Now go out, turn your messy job shop into a flow shop, and organize your industry!**

P.S.: This blog post was inspired by a part in a video presentation by Nampachi Hayashi, which I found through an article by Dirk Fischer. Thanks to all 🙂.

23 How to Convert a Job Shop into a Flow Shop – Part 1

Christoph Roser, June 2, 2020 Original at
https://www.allaboutlean.com/job-shop-to-flow-shop-1/

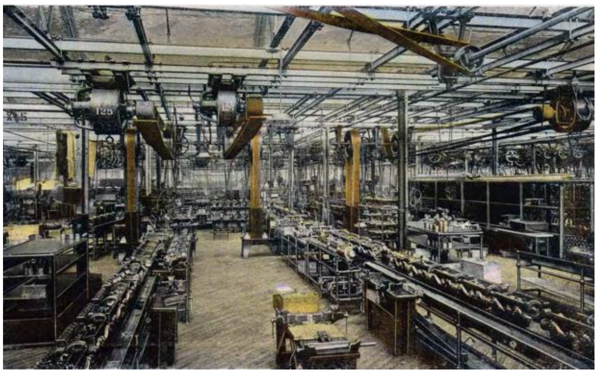


Figure 218: Ford motor assembly with moving conveyors 1917 (Image Ford in public domain)

Job shops are always very difficult to manage. As I described in my previous posts, the irregular material flow causes fluctuations that are very hard to contain. In my view, the only true fix for a job shop is to convert it into a flow shop. In this post I will talk a little bit about how you approach the idea of converting a job shop into a flow shop … although this is not always possible. However, in many cases it is possible to increase flow-shop-like segments, even though the whole system is still a job shop.

23.1 Required: Dedicated Processes

Figure 219: Dedication! (Image unknown author in public domain)

There is one requirement for establishing a flow line: You need processes that are dedicated to the flow line. The processes within the flow line should handle only parts of the flow line. If you have a "flow line," but parts from the job shop frequently enter the flow line sequence to be processed, then it is not a flow line. Try your best not to have outside parts jump in and out of the flow line, as this will water down the performance of the flow line significantly.

Having said that, let me walk you though a couple of things you can do to move toward flow lines. Below are a few suggestions. These are not necessarily a sequence of improvement steps, but a few ideas that also support each other through iterations. Go though them repeatedly and try to find the best system that you can imagine.

23.2 Identify Materials with Similar Process Sequences

Figure 220: One is not like the other (Apple unknown author in public domain, orange Photoshot in public domain, peach Marco Verch under the CC-BY 2.0 license, dumbbell unknown author in public domain, pear Apple and Pear Australia Ltd under the CC-BY 2.0 license)

The first step in converting a job shop into a flow shop is to **identify products with similar process sequence segments**. Now, you may be thinking, *Dude, if all my products would have the same process sequence, I would have established a flow shop ages ago.* First of all, there are indeed still a few plants out there that have such a situation but have not yet converted to a flow shop due to important things like "tradition" or "no time." But secondly, **there is a lot of wiggle room**.

True, you may not be able to have a full flow shop right away, but there are quite likely some possibilities in the right direction. Let me repeat my sentence from above with some emphasis: *Identify products with **similar** process sequence **segments***. The process sequence does not need to be identical for all products, but similar. It also does not need to be for the whole value stream, but it is okay to do it for segments. Every step you take away from a job shop and toward a flow shop helps!

When looking for products with similar process sequence segments, you also would need to keep an eye out for the total workload. It does not help to identify one hundred products with perfectly equal process sequences if they are all extremely rare and make up like 5% of your total workload. Often it makes sense to start with your high runners. Surely you know the Pareto principle, that 20% of your products make up 80% of your sales. If you get even only 10% of the high runners on a flow line, you have gained much ground toward a flow line.

23.3 Separate Line for Flow Parts

If you have some parts that are somewhat similar for at least part of the sequence, you may establish a flow line for these parts, at least for the sequence where they have a similar process sequence. I have illustrated this below using the example from the previous posts.

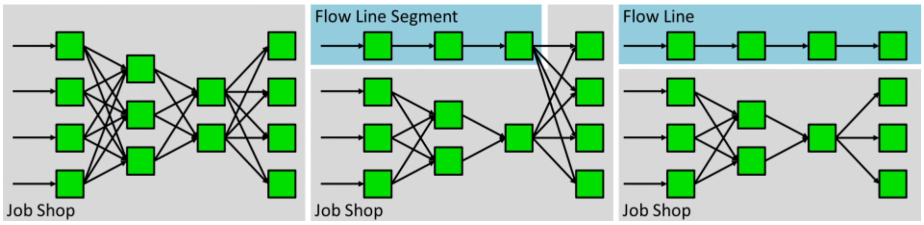


Figure 221: Flow Line Segments in a Job Shop (Image Roser)

Often, sub-assemblies are more suited to flow lines compared to final assemblies, since components often have less variation. Hence, the more-standardized components may be a good a candidate for flow segments.

23.4 Skip a Process, Add a Process

Please note that it is usually not a problem if you have a bunch of similar products but one product does not need one process. In this case, you can still have a flow line. The product in question just moves through the process without being processed. This happens commonly in industry.

Similarly, if there is a product that has an additional step, you may also add this process into the flow sequence. All other products then simply skip this process that is required only for this one product. Many combinations of this are possible (i.e., processes that are required only for half of the products), but not the other half of the products that are produced on this flow line.

The image below visualizes this. However, in this visualization I have the lines for the products go “around” a process. In reality, however, the parts would go through the process, just without being processes.

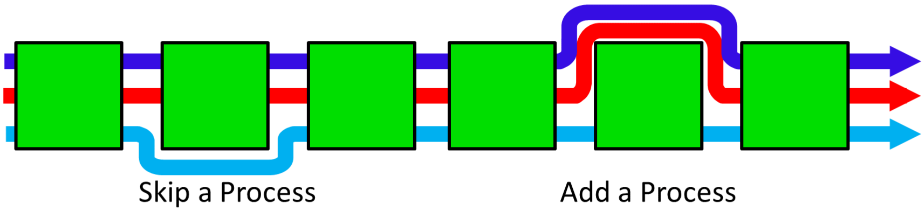


Figure 222: Flow Shop Skip and Add a Process (Image Roser)

Hence, you can have processes that are not for all parts. This sometimes solves a problem in establishing flow lines, but creates another albeit often smaller problem, namely how to balance the line. There are different possible solutions. If it is a fully automated process, then we don’t really care about the waiting time of this process. The products that are not processed on this automated machine simply go through, the machine idles, and we don’t care since machines that idle due to lack of demand are very far down on our list of priorities.

If it is a manual process, we can work with the operators moving around different processes. Common examples are bucket brigade, rabbit chase, chaku chaku line, or other similar approaches. In the simplest case for the example above, one worker could move between the two partially used processes to cover them both. For very long cycle times (think hours), you could even assign workers to this process when needed, and elsewhere when not.

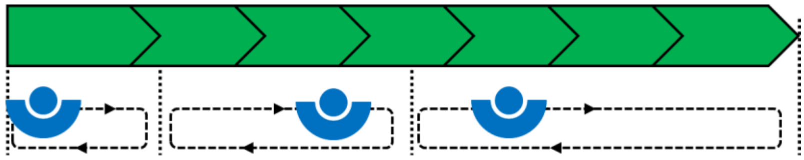


Figure 223: Animated Bucket Brigade Loops. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

This, however, does not work for a fully manned line with shorter cycle times. In this case we may have options with mixed model sequencing, where a part that requires this process is followed by a part that does not require it, and the worker is on average still working well. I have written a very long series of posts on mixed model sequencing if you need more details.

Only if we cannot do automation, partial staffing, or mixed model sequencing would we need a worker who idles until a part comes along, which is not good. Workers having a lot of idle time is a big waste, and it is also disrespectful to the worker.

There are more ideas that will help you in converting your chaotic job shop into a leaner flow shop. I will present these in my next post. Until then, **go out, straighten out your material flow into a nice line, and organize your industry!**

P.S.: This blog post was inspired by a part in a video presentation by Nampachi Hayashi, which I found through an article by Dirk Fischer. Thanks to all 🙂.

24 How to Convert a Job Shop into a Flow Shop – Part 2

Christoph Roser, June 9, 2020 Original at https://www.allaboutlean.com/job-shop-to-flow-shop-2/

Figure 224: Ford final assembly 1917 (Image Ford in public domain)

Turning job shops into flow shops is not easy. This is my second post explaining such transformations as I try to help you in improving your shop floor from an (always) messy job shop into a much more efficient flow shop.

24.1 Add Flexibility

Figure 225: Be flexible! (Image Kennguru under the CC-BY 3.0 license)

Another possibility to consider is the flexibility of your processes. Can you change the process so it can handle more product types? If you have some products that are milled and others that are turned, can you use a machining cell that can do both instead of a separate mill and late?

For automated machines this may be a larger investment, but for manual processes this is often much easier. Can you train the worker at one process to be able to also make the other products? You may have to provide some more tools that are required for this process, but this may be not as expensive.

Just keep an eye out for the changeover time. If the changeover time is large, you may be forced to use larger lot sizes … or do a changeover optimization, better known as SMED.

A common example for such flexibility is automotive assembly lines. A few decades ago, an automotive assembly line was dedicated to one type of car, and you had separate lines for different models. Then Toyota started to use **mixed model lines**, where different car models are produced on the same line. Currently they have lines where seven or more different models are produced on the same line. This was not an easy process, and it required quite a few specialized tools. For example, the car body is clamped down during welding and assembly. These clamping points are different for different models. Toyota built a triangular base, where every side of the base has the clamping tools for a different model. If another model has to be produced, the tool simply rotates to have the correct clamping points. This can be done on the fly, the changeover time is effectively zero, and Toyota can make multiple models on the same production line. Now this is very common with other car makers as well.

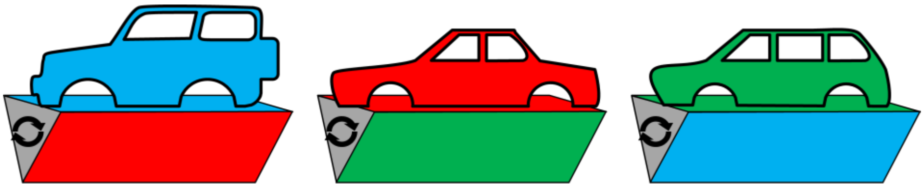


Figure 226: Toyota Triangular Clamp Base (Image Roser)

24.2 Add Capacity

Another possibility is to add capacity. This is also visualized (albeit simplified) in the image below. Through the strategic adding of three processes, it was possible to transform the job shop into four parallel flow lines.

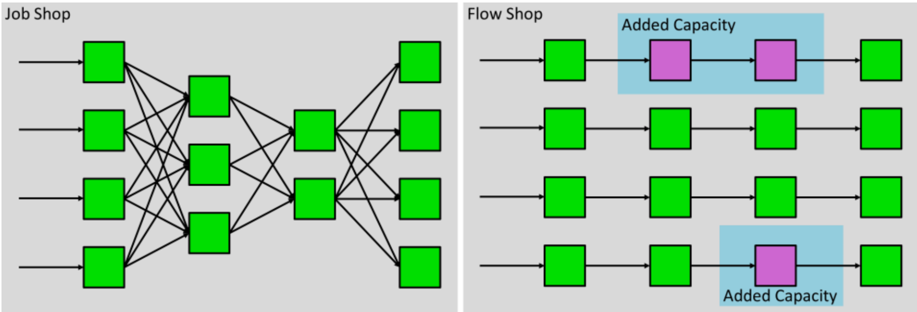


Figure 227: Job Shop to Flow Shop Add Capacity (Image Roser)

True, these additional processes will probably be not 100% utilized, but this is often a manageable problem. As I explained in my previous post about skipping and adding processes, for automated processes we don't care, and for manual processes we can use a bucket brigade, rabbit chase, chaku chaku line, mixed model sequencing, or similar methods to distribute the workload.

On the downside, however, you will need some investment, but this is offset with the benefit of a much more efficient flow line instead of a chaotic job shop. The benefits of a flow line are not to be underestimated. Another problem is often the floor space. Many factories are cramped, and there is little available space. However, as a flow line usually has much less inventory than a comparable job shop, you will probably save space that is occupied with material. With a little bit of luck, this is enough for the additional processes, or even a bit more.

24.3 Design Change

Another possibility is to change the design of your products so that they are more similar and hence more suitable for flow lines. I know that changing product design is hard, but I never claimed that turning a job shop into a flow shop is easy. However, it is often worthwhile.

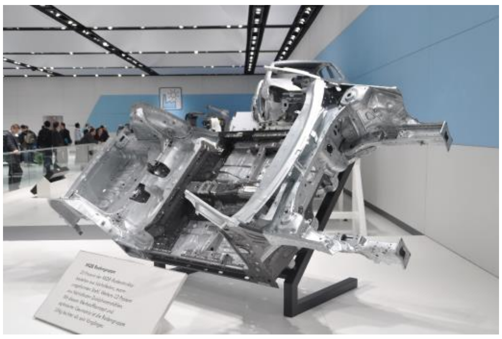


Figure 228: Volkswagen Modularer Querbaukasten floor assembly (Image Ra Boe under the CC-BY-SA 3.0 Germany license)

Such a design change probably also has additional benefits, as for example a reduced variety of components or easier automation through similar design. The keywords here are *Design for Manufacturing* (DFM) or *Design for Assembly* (DFA) or the combination *Design for Manufacturing and Assembly* (DFMA). This is also commonly done in industry through modular strategies or platform strategies. Different models from the same car maker often contain a lot of identical parts. Often, the clamping points are identical even though the models itself are different. At Volkswagen this would be, for example, the *Modularer Querbaukasten*, or MQK for short, although it is not sure if this met the expectation of Volkswagen…

24.4 Iterate the Above

Now we have a couple of ways that can help you to turn a job shop into a flow line segment, a flow line, or a complete flow shop. These are:

- Identify Materials with Similar Process Sequences
- Separate Line for Flow Parts
- Skip a Process, Add a Process
- Add Flexibility
- Add Capacity
- Design Change

Figure 229: Iterate! (Image Roser)

These are not a particular sequence, but rather a bullet list that you should iterate through a few times. You could. for example. identify similar materials and create a flow segment, only to later find out that through machine flexibility or a design change you can extend the flow segment into a flow line. Hence think things through a few times until you have collected enough ideas for the next step.

Also, it is not always possible or even suggested to convert a job shop into a flow shop in one major transformation. More likely, you will have to do this in smaller steps. Create a flow segment here, another line there, and bit by bit move towards a flow shop.

24.5 Implementation Plan

Once you have identified your flow segments or lines, it is time to implement.

24.5.1 Rearrange Processes in Sequence

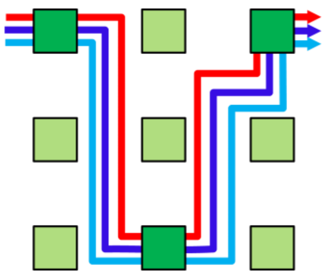


Figure 230: This flow shop sucks! (Image Roser)

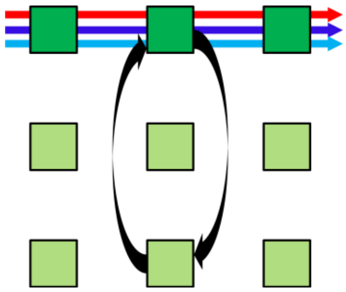


Figure 231: Much better! (Image Roser)

Rearrange the processes in the sequence of the flow line. A flow line benefits mostly from this rearrangement. If the process sequence is a flow, but the material still zig-zags across the shop floor, you will loose a lot of the benefit of flow lines. It is no longer easy to see where the material is, the material handling will be much more work, and it is tough to plan and organize.

Hence try to arrange your processes in sequence as much as you can. If a particular process is difficult to move (very large and heavy, built in foundations, or other constraints that make a move unpractical), can you arrange the other processes around it? The more the processes are in line, the better.

24.5.2 Organize Material Flow

Another benefit of the flow line is the easier way to organize the material flow. Can you create a rolling lane, hanging spacecraft transport, conveyor belt, or similar mechanized or automated transport? Or, even if you still transport it manually, can you at least create a good standard for the material transport? If in any way possible, make it a FIFO sequence!

At this time you should also consider how much buffer inventory you want. This is best estimated, as a calculation would be quite messy. It may turn out that you can move the processes much closer to each other and save a lot of valuable floor space.

24.5.3 Improve Processes and Create Standards

Finally, since you have arranged the processes in sequence and managed the material flow, can you also standardize and improve the processes themselves? Now since there should be only very similar parts arriving at the processes, you may be able to tweak these processes to get more performance out of them.

As for the work assignment, can you do a fully manned balanced line? Or will you do a bucket brigade, rabbit chase, or a chaku chaku line? There are lots of possibilities, similar to any new line layout. Covering them all would be beyond the scope of this blog post, but let your imagination run wild.

It may look difficult or even impossible to convert your particular job shop into a flow shop. However, a lot of companies have turned job shops that “looked impossible” into flow shops.

Figure 232: Airacobra fighters and Kingcobra fighters aircraft assembly line (Image unknown author in public domain)

The image here shows an aircraft assembly line. Trumpf uses assembly lines for large machine tools with a takt of eight hours. There were probably also a lot of people in both cases that said that it will never work, but in the end it did. It was not a smooth and easy way, and a myriad of problems had to be solved to make it possible, but at the end it worked!

So, do you think it is possible for your own job shop to move in the right direction and toward a flow shop? Even for only some segments? Okay? Now **go out, tackle the beast of a job shop, turn it into a (partial) flow shop, and organize your industry!**

P.S.: This blog post was inspired by a part in a video presentation by Nampachi Hayashi, which I found through an article by Dirk Fischer. Thanks to all 🙂.

25 Design for Manufacturing and Assembly Basics

Christoph Roser, June 16, 2020 Original at https://www.allaboutlean.com/dfma-1/

Figure 233: Sony Walkman (Image Binarysequence under the CC-BY-SA 4.0 license)

Lean is most often associated with production. However, it can also be used in other areas, like design. Bridging the gap between design and production is **design for manufacturing** or **design for manufacturability** (DFM) and **design for assembly** (DFA), often combined into **design for manufacturing and assembly** (DFMA). Lean can also be combined with lesser-known topics like design for inspection (DFI) or, more recently, design for additive manufacturing (DFA). There are many more. Let me give you an introduction to the reasoning behind design for manufacturing and its "Design for X" variants before going into more details on how to do it in subsequent posts.

25.1 The Basic Idea

Figure 234: Piggy Bank (Image Ken Teegardin under the CC-BY-SA 2.0 license)

One frequent company goal is to minimize the cost of their products. Some companies are even interested in the cost during the product's actual use or even the disposal cost. Hence, it is of great interest to look at these costs, including material, labor, and overhead, not only where they occur but especially where the cost is determined.

Design for manufacturing and assembly optimizes not only the function of the product, but also the cost of making or assembling it, or even the cost across the entire life cycle of the product. The idea itself is probably quite old, and often combined with general cost reduction through optimizing the product for manufacturing and assembly. The method itself was formalized (and commercialized) by Geoff Boothroyd at MIT around 1977, and together with Peter Dewhurst they developed computer software to support this in 1981. However, most examples of design for manufacturing, etc. that I am aware of are still done manually.

25.2 Where Do the Costs Originate?

Figure 235: Happy Money (Image denisismagilov with permission)

We need to distinguish where the cost is defined and where the cost happens. Product development is usually not so expensive compared to the production, and most expenses happen in production. Yet the product design fixes a lot of the costs that happen later during production, use, and disposal.

You may have seen a graph similar to the one below somewhere before. It shows the total cost (not per part) throughout the product life cycle. To be more precise, it shows when you have how much influence on the total cost, and its inverse, the cost that is committed over time. It also shows the cost that actually happened. While this graph is pretty generic, it does contain a lot of truth. As it turns out, while product design does not cost that much itself, it does fix a lot of the cost later on. Most of the cost happens during production, but production itself has little influence on the costs.

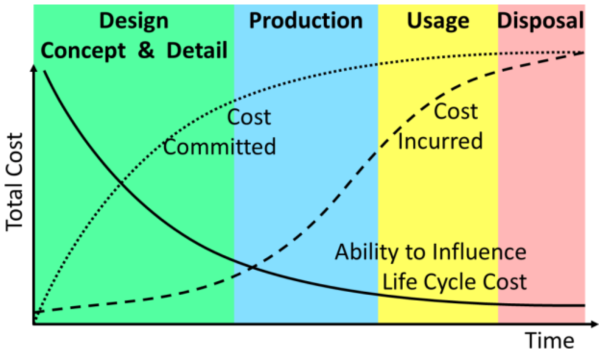


Figure 236: DFMA Cost Influence (Image Roser)

This graph is very generic, and the curve for your product may look slightly different, but the basis remains the same. Changes in the curve depend especially on product complexity and production quantity. If your product is complex, you have more development cost than a simple product. If you produce a large quantity, the production cost will be larger than for a small quantity. More for inspiration than for hard facts is the graph below showing you the total incurred cost for different scenarios.

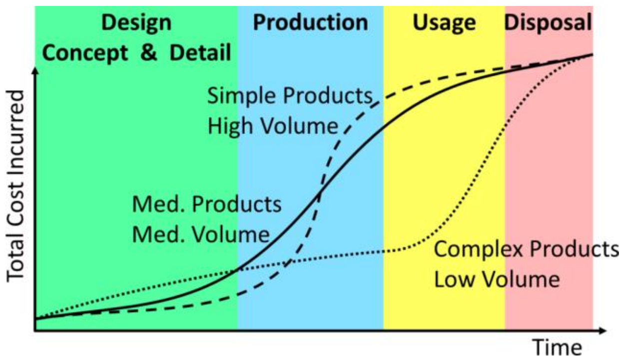


Figure 237: DFMA Cost Incurring by Part Variant (Image Roser)

It is often claimed that 80% (or sometimes 70%) of the total cost is determined by development, albeit a good source is never cited, simply because there is none. Barton et al thoroughly debunked this claim. Ulrich et al actually calculated that design causes 50% of manufacturing cost for coffee makers (all sources below). Yet, even influencing only 50% of the total cost is quite a potential. Also, before you get excited about reducing total cost by 50%, this won't happen. No matter how good your design is, you still have to produce the goods and have production costs.

Yet, if you can reduce the cost even only by 5%, it will be a huge savings. I participated in a design for manufacturing and assembly workshop where the participants initially were highly skeptical, since they believed that they had a very finished design with no further potential for improvement. After the workshop they were flabbergasted that we were able to find potential for almost €3 per product that retails for €60. They completely reversed their initial view of "a waste of time" to "one of the best workshops we ever did."

25.3 Design for X

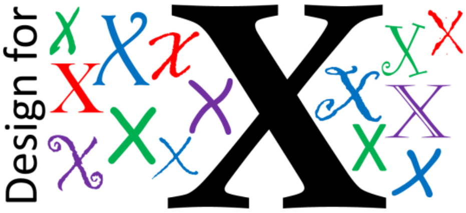


Figure 238: DFMA Design for X (Image Roser)

Above I mentioned quite a few variants of a general *design for excellence*, or more generally "**Design for X.**" But there is more. Here is the result of a brief search for variants of *design for X*:

- Design against corrosion damage
- Design for additive manufacturing
- Design for assembly
- Design for cost
- Design for inspection
- Design for lean manufacturing
- Design for logistics
- Design for manufacturing/manufacturability
- Design for manufacturing and assembly
- Design for minimum risk
- Design for postponement
- Design for quality
- Design for reliability
- Design for safety
- Design for short time to market
- Design for six sigma
- Design for standards
- Design for test/testing
- Design for variability

There are probably a lot more. Don't try to cover them all. Sometimes it is just a fancy name for some sort of optimization, but then, all of them are just methods to optimize the design for one aspect or another besides the product functionality. Please do note that it is quite possible to look at more than one during the same workshop, but you should not overdo it. If you focus on everything, you focus on nothing. The most common workshop is a combination of design for manufacturing and assembly, since they are also thematically very close.

Within this short series of posts I will also focus more on design for manufacturing and assembly. My next post will look at the basic prerequisites for a design for manufacturing and assembly workshop, and subsequent posts go into more details on the different levers and aspects that can be used to improve the design. Until then, stay posted, and **go out and organize your industry!**

25.4 Sources

- Barton, J, Doug Love, and G Taylor. "Design Determines 70% of Cost? A Review of Implications for Design Evaluation." Journal of Engineering Design 12 (March 1, 2001).
- Ulrich, Karl T., and Scott Alan Pearson. "Does Product Design Really Determine 80% of Manufacturing Cost?" Working Paper. Cambridge, Mass. : Alfred P. Sloan School of Management, Massachusetts Institute of Technology, 1993.

26 Design for Manufacturing and Assembly Workshop Preparation

Christoph Roser, June 23, 2020 Original at https://www.allaboutlean.com/dfma-2/

Figure 239: Swatch (Image Khalid Mahmood under the CC-BY-SA 3.0 license)

Design for manufacturing (DFM) and design for assembly (DFA) or its combination, design for manufacturing and assembly (DFMA), as well as its many *design for X* variants are a way to improve a design beyond its mere functionality. In my last post I gave you a basic introduction. This post will look at the prerequisites for organizing a design for X workshop. Subsequent posts will look at the different questions you can ask to further design for manufacturing and assembly.

26.1 Which Part to Analyze and For What

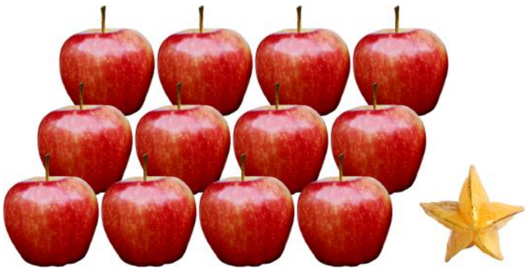


Figure 240:Common and exotic parts (Image Ana Santos & SMasters under the CC-BY 2.0 license)

Design for manufacturing (DFM), assembly (DFA)(DFMA), or inspection (DFI) is usually done for only a few parts or products at a time. Hence, the first step is to decide which parts to look at. The most interesting parts are naturally parts that have a large production volume, or a large share of the revenue or expenses. There is just more potential to optimize the high runners than the exotics.

You can look at a single part at a time, or multiple parts. In the latter case, don't overdo it. The number of parts you can look at depends on the complexity and similarity of the parts. If it is a simpler product like a faucet, you probably can look at multiple similar products in one workshop. If it is a more complex product like a dishwasher, you may look at only one product at a time. If it is even more complex like a car, you may look only at components but not the entire car.

Figure 241: Complexit of Car, Dishwasher, Faucet (Car chapay in public domain, dishwasher Carlos Paes in public domain, faucet Matthew Bowden in public domain)

Overall, you have to judge how much a team can look at and consider reliably within the time for the workshop. The goal is to go more into depth rather than width to find improvement potentials.

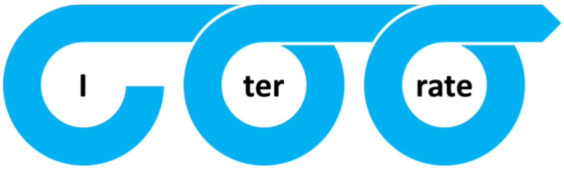


Figure 242: Iterate! (Image Roser)

For each part you want to analyze, you should go through the bill of materials and look at every part or component. Ideally, not only once, but in multiple iterations to see if an idea for another part later on can also be used for a previous part that was already looked at.

26.2 When to Do It

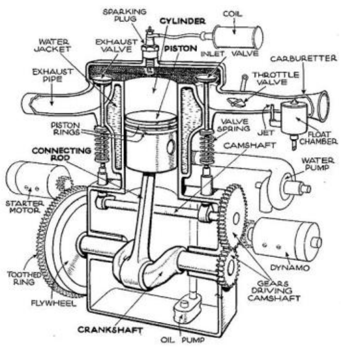


Figure 243: Engine drawing (Image Andy Dingley (scanner) in public domain)

Design for manufacturing can be done anytime, but it makes the most sense during the design process. Ideally, you already have drafted but not yet refined a design when you improve it for manufacturing. It is also possible to do this with a more complete design, although in this case you may have to redo previous design efforts to make the part easier to produce. On the other hand, this has the advantage that a more complete design allows you to see more problems.

You can also do a design for manufacturing for completed parts that are already in production. The benefit is here that production already has lots of experience with the part, and knows a lot of the problems, and maybe even some ideas on how to improve it! On the other hand, any design change involves an often lengthy process in changing the plans, changing the tools, adjusting the standards, recalculating the costs, and many more. Nevertheless, it can be worth it, and I have done successful design for manufacturing workshops for parts that were already on the market for some time.

26.3 More Than Just a Checkbox

Figure 244: Checkboxes checked… (Image Clker-Free-Vector-Images in public domain)

In some companies, design for manufacturing is a mandatory checkbox on the design checklist, which then dutifully gets checked by a (probably also overworked) designer after thinking about it for less than a minute. The formalities are satisfied, but the part is still the same as before.

Real design for manufacturing will take more time, and is usually a group effort. It takes at least half a day to analyze a part and determine the potentials. And this does not even include the actual change of the design, which follows afterwards.

26.4 The Challenge of People Working Together

One of the underlying problems is that often designers and manufacturers live in different corners of their corporate world. Designers know little about the problems of manufacturing. Similarly, manufacturers know little about the problems of designers. A good design for manufacturing workshop can also help to educate one side about the problems of the other side and vice versa. I had examples where the workshop was quite eye opening both for the designers and the manufacturers.

Hence, to optimize a design for manufacturing, assembly, or inspection, you would need to get a small group of people together to look at the part in question. The benefit is in bringing both design knowledge and manufacturing and assembly knowledge or even inspection knowledge into the same room. Especially in larger companies, the design department has little interaction with the production and vice versa. I've had, for my taste, way too many experiences where the design department just dumped the design on manufacturing, and then it was no longer really their problem but the problem of manufacturing.

Since it is an additional effort for the design department with benefit primarily for manufacturing, manufacturing is usually all for it, but design is quite hesitant. Especially since sometimes manufacturing uses the opportunity to blame design for everything that went wrong in the past, which of course upsets design. Therefore, making a design for manufacturing workshop should involve people from different departments, and should be initiated by some higher-ups who have hierarchy over both the design and the manufacturing department.

A typical team often involves one or two designers of this product, one or two people manufacturing and assembling this product (both operator and supervisor), a person from the construction of the corresponding machines and tools, a person from service if you want to include service, and maybe a manager or moderator. The emphasis is on **participants from manufacturing and/or assembly**, as they bring crucial knowledge to the workshop. A team consisting only of designers will give a much smoother and conflict-free workshop, but will miss out on much of the improvement potential.

26.5 Bring Samples and Documentation

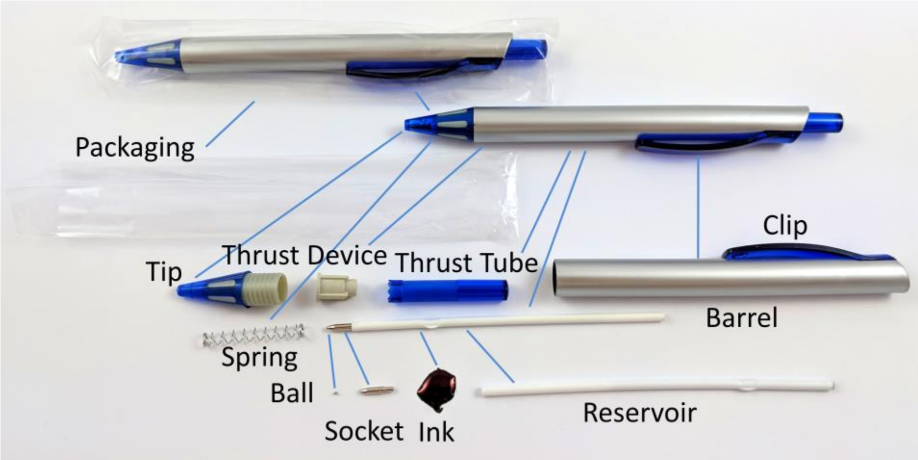


Figure 245: The bill of materials for a ballpoint pen (Image Roser)

It is really helpful for a design for manufacturing workshop to have samples of the products to look at and to disassemble. It is even better if you also have products from the competition too. Make sure you also have some tools to take them apart. Depending on your or your competitors product, you should make it clear if some parts must not be damaged, although it is easier if all parts are replaceable and can be ripped apart. If you need bigger tools like a band saw, make sure they are available and there is someone who knows how to use it.

It is also necessary to have the bill of materials (if it is an assembly process) and the process sequence or work instructions. Going through these step by step gives a lot of ideas for improvement.

26.6 Caveats

There are a few common mistakes when doing a design for manufacturing workshop. **The goal is to optimize the overall cost, not only the cost of the part**. There will be instances when a more-expensive part can make the total cost go down because it is easier to manufacture or assemble. The challenge here is that these cost relations are often not clearly visible and depend a lot on *guesstimates*.

Functionality has priority! Even with the cost savings, the part should still work as intended. Saving money and making products that no longer work doesn't save money at all. However, be aware that there is often a gray zone, where more of something would be better for functionality, but it would still work without. If the discussion gets heated, some may exaggerate and claim that a minor change in something will totally ruin the product. Maybe they are right, maybe not.

Figure 246: Does it matter? (Image Anton under the CC-BY-SA 3.0 license)

My common example for this is a coating for a pump in a luxury brand automobile that prevents surface rust, but costs €1 per pump. The functionality is not hindered, and most customers will never even see the pump unless they crawl underneath their car. Nevertheless, there was a lot of argument for the coating with the claim that rust may damage the brand reputation.

26.7 Summary

The steps above will help you to organize a successful design for manufacturing workshop. For more details on creative problem solving, see my post on My Workshop Structure for Creative Problem Solving.

In my next posts I go into the actual questions that you should ask (repeatedly) during a design for manufacturing workshop. Until then, stay posted. Now, **go out, consider which parts can be produced easier, and organize your industry!**

27 Design for Manufacturing Questions

Christoph Roser, June 30, 2020 Original at https://www.allaboutlean.com/dfma-3/

Figure 247: Milling Example (Image ZM2010-LWL-BBW-Soest under the CC-BY 3.0 license)

After two post on the basics and workshop structure, I can finally start to go into the details of which questions to ask for **design for manufacturing** (DFM). In subsequent posts I will have more questions on design for assembly (DFA), which can of course be combined into design for manufacturing and assembly (DFMA). I will also have a brief refresher on creativity techniques. Let's start asking questions!

27.1 Design for Manufacturing Questions

Figure 248: Milling Machine (Image Kitt Amaritnant in public domain)

Design for manufacturing looks for cost potentials during manufacturing. The details here are very part specific, but creativity can be inspired by a series of questions. Here I look in particular at design for manufacturing. This excludes the related design for assembly, which I will discuss later. Hence, manufacturing is any type of casting, forging, cutting, or similar operations that do NOT assemble the product. Although, there may be quite a bit of overlap in the questions.

27.1.1 Can You Use a Softer Material?

Processing cost for cutting processes may depend a lot on the hardness of the material. Using a hard material may take more time, and a softer material may be handled with increased cutting speed and/or depth, reducing processing time. The harder material may also wear out the tool faster, or even increase the wear on the machine due to the harder chips that are created. For example, can your replace hardened steel with normal steel, or normal steel with aluminum, or aluminum with plastic, etc?

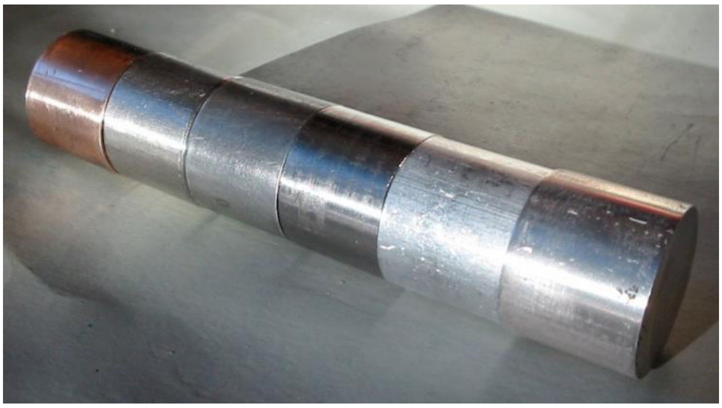


Figure 249: Beryllium copper; copper; inconel; steel; titanium; aluminum; magnesium (Image Bill Abbott under the CC-BY-SA 2.0 license)

Overall, a softer material may be able to reduce the machining cost, as long as the function is still adequate.

27.1.2 Are There Cheaper/Better Production Processes?

It may be possible to replace an expensive process with a cheaper or better production process. This is especially useful if you have not yet purchased the machines or tools. Can you change the design so a three-axis milling machine is sufficient and you don't need the more-expensive five-axis milling machine?

Figure 250: Bicycle hub (Image Juergen Brauckmann in public domain)

Another example is to replace an expensive cast-iron part with formed sheet metal. Often, sheet-metal parts are much easier to produce than cast parts. For example, Papst Manufacturing was THE bicycle company around 1890. Their bicycle hubs were made from cast steel. They were extremely strong, but also very expensive and heavy. Its competitor Western Wheel Works designed these hubs using sheet metal, which was much more profitable and popular, and that helped them to overtake their competitor.

Especially with plastic injection molding, undercuts is a big topic. Every undercut requires an often-complex mechanism in the mold to handle this undercut. Every single undercut can easily add tens of thousands of euros to the cost of the mold. Luckily, any mold designer worth his money is already trying to avoid undercuts. But see if maybe you can reduce them even more.

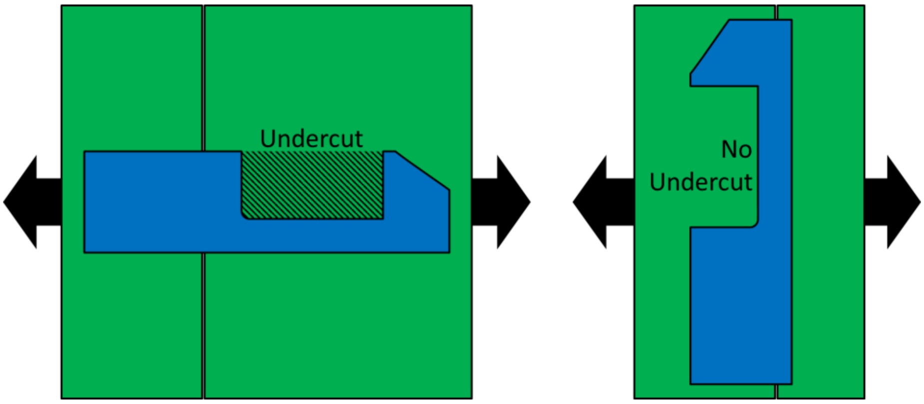


Figure 251: Undercut Example Injection Molding (Image Roser)

27.1.3 Can You Reduce the Number of Process Steps?

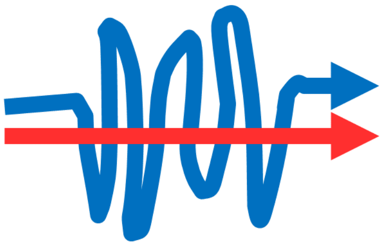


Figure 252: Shortcut (Image Roser)

Another big question is if you can reduce the number of process steps. Every additional process step increases handling, transport, waiting, and a lot of other factors that can cause additional cost. You may not always find potential here, but it is possible.

27.1.4 Can You Loosen the Tolerances?

Tolerance limits are hard to define. Make them too lose and quality suffers. Make them too tight and costs go up. The design department is measured, among other things, on product quality but not so often on product cost. Hence, in case of doubt design, departments will often go for tighter tolerances. Production, on the other hand, is more often measured on the production cost, and would like to have loser tolerances. These conflicting goals are complicated by the fact that most tolerances are not based on hard facts but rather on gut feeling and opinions. Arguing based on opinions has a lot of conflict potential. Yet, often there is also potential in loosening tolerances and therefore reducing manufacturing cost.

27.1.5 Can You Use Common Parts?

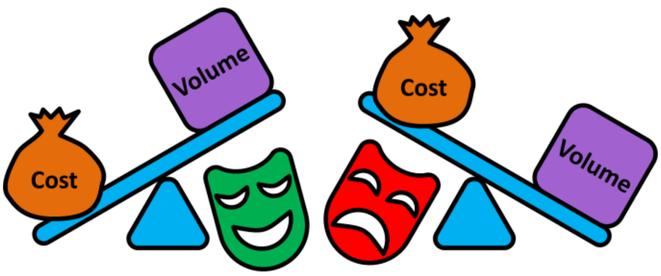


Figure 253: Cost-Volume See Saw (Image Roser)

The use of common parts is often a big potential in design for manufacturing. This overlaps later with design for assembly where we try to reduce the number of part variants. Rather than having a custom-designed part for your product, it may be better to re-use a part that you have already designed. Or even better, can you use an off-the-shelf standard part?

The more common parts you have, the larger the production quantity for these parts. Larger quantities benefit from the economy of scale. It is usually cheaper per part to make twenty parts instead of ten. This doesn't even include the additional benefits that we will find during assembly.

27.1.6 Can You Simplify or Eliminate the Set Up?

Figure 254: Eliminate the set-up? (Image Beadell S. J. in public domain)

It may also be possible to change the part design to simplify the set-up or the changeover. This topic crosses into the topic of changeover optimization, also known as SMED. Can you design your parts in a way that makes it easier to change your machines from one part to another? Or generally cheaper to set up the part in a machine?

For example, in the early history of American industrialization, John Hall managed to introduce interchangeable parts to gun making around 1800. Interchangeability required precision, and to make precision manufacturing easier, Hall used a reference point that he called a bearing point to his parts. This was the starting location for any dimensions measured or gauged, simplifying the later manufacturing processes.

Maybe you can eliminate the set-up altogether? Can you design your part in a way that it is machined only from one side, eliminating machining on the other side and hence eliminating a set up altogether. There are parts out there where the machining itself takes mere minutes, but the set-up requires hours of labor and downtime of the machine.

27.2 Creativity Techniques

These design for manufacturing techniques require creativity and new ways of thinking to improve your product design for better manufacturing and/or assembly. This is a good time to use creativity techniques. Probably the most common one (but also a bit boring) is brainstorming. For more on this see my post How to Do Brainstorming.

Figure 255: Creative Brain (Image kirasolly with permission)

Figure 256: Stressed Worker (Image Wayhome Studio with permission)

But there are more techniques out there. One of my favorites is creative provocation, where the moderator tries to figure out where some unsolved problems are based on the discussion. Next the moderator adds an artificial limitation by requiring the team to design a part that avoids this problem altogether. For example, in one of my previous workshops, the team had trouble finding a good way to bring a workpiece carrier back to the beginning of the line. I then challenged them to design a line without any workpiece carriers. The resulting solution amazed them. Again, this creative prevocation is one of my favorite creativity techniques. For more see my post on creative provocation.

This post looked at how to make manufacturing easier. My next posts will look at how to make assembly easier. This design for assembly has a lot of potential, and I have a total of three posts looking only at design for assembly. Now, **go out, make your parts easier to manufacture, and optimize your industry!**

28 Design for Assembly Questions – Part 1

Christoph Roser, July 7, 2020 Original at https://www.allaboutlean.com/dfma-4/

Figure 257: Assembly Line (Image Siyuwj under the CC-BY-SA 3.0 license)

In my last posts I discussed basics and workshop preparation for design for manufacturing and assembly (DFMA), as well as the questions for design for manufacturing (DFM). The juiciest part, however, is the options for design for assembly (DFA). This post starts with the specific questions to ask for design for assembly. However, there are so many options that I won't be able to fit them into one blog post, and this will continue in subsequent posts. Anyway, let me show you how to do design for assembly.

28.1 Design for Assembly

Figure 258: Kuka Industrial Robots assembling car bodies. Image by Mixabest from Wikipedia and available under the CC-BY-SA License (Image Mixabest under the CC-BY-SA 3.0 license)

While design for manufacturing looks at the cost of making a part, design for assembly looks at the cost of joining parts together. These two approaches have a lot of overlap, and should be looked at together to achieve an overall cost improvement. Nevertheless, I will discuss them here separately for didactic reasons.

28.1.1 Can You Reduce the Number and Complexity of Fasteners?

Particular attention should be given to any kind of fasteners like screws, clips, nuts, spacers, or washers. They are often good candidates for either simplification or removal. This overlaps partially with subsequent questions, but since fasteners are such a juicy topic for optimization, I have them here separately. Hence you should go through your bill of materials and look at all fasteners. You may skip glues and lubricants. There are products out there where over one-third of the bill of materials are fasteners. While an individual fastener may be quite cheap, the number of all fasteners may make this the most expensive group of a product. These have a lot of potential for improvement.

For all fasteners, try to go toward a simpler or easier-to-use design. In general, screws are the most expensive solution. You may reduce some effort by using nuts that include washers, or by using self tapping screws. Rivets are usually cheaper than screws, with tubular rivets or self-piercing rivets being even cheaper. Nails may be an option, as would be a pin to secure something or a wedge to hold it in place. Gluing, welding, or soldering is often even cheaper than rivets. Joining by forming may also be possible, where you simply bend a nub to secure the part in place. There are thousands of different techniques out there if you want to attach part to each other. The challenge is finding out which one is the cheapest for you.

Figure 259: Fasteners (Image Roser)

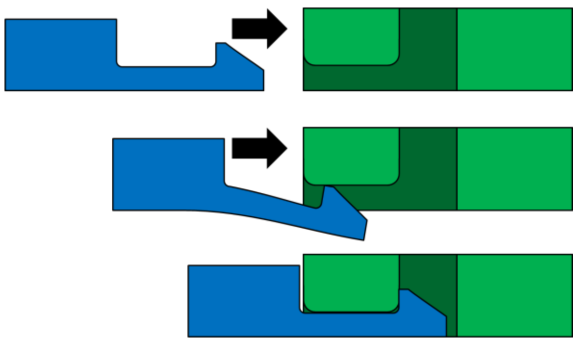


Figure 260: DFMA Plastic Snap Joint (Image Roser)

Plastic parts especially are often designed to snap into each other. These **snap joints** make assembly a breeze (although disassembly is often a bit trickier). However, it is quite possible to design such snap joints also for disassembly. Due to their large cost advantage, this type of connection is very common in plastic products.

28.1.2 Can You Reduce the Number of Parts?

Another key question to ask is if you can reduce the number of parts (other than fasteners, which we already looked at). You should go though the list of all parts in your bill of materials, and check every one to see if it is needed. The less parts you have, the less assembly you have to do. Beyond that, this also means less part variants and therefore less inventory, less logistics effort, less chances of running out of stock, and a whole lot of side benefits.

Fundamentally, there are two ways to eliminate a part from your design. You can either **remove the part completely**, or you can **merge two parts into one part**. In the latter case, the manufacturing cost of the single part may go up, but the manufacturing cost for two parts in total may go down. You will have additional savings in assembly and logistics.

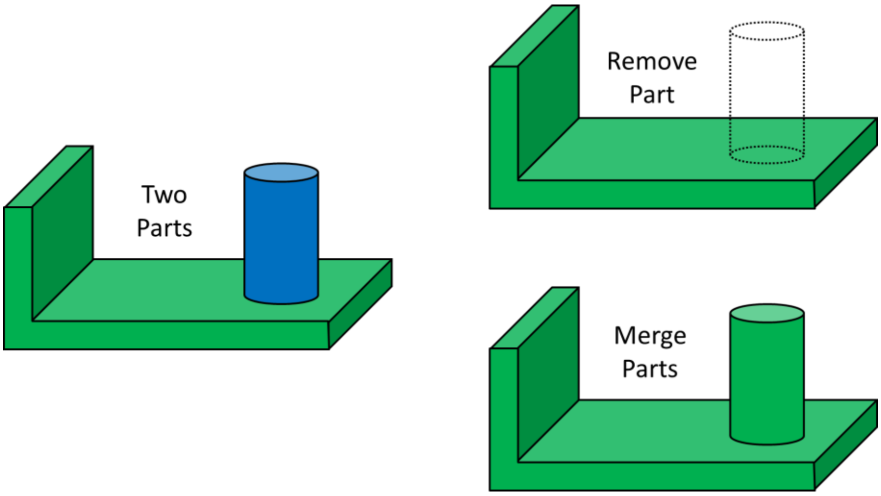


Figure 261: DFMA Two Parts Eliminate One (Image Roser)

There is actually a whole logic tree to determine if parts have to be separate. This is based on three primary aspects: Is there **movement** of the part relative to other parts? Parts that have movement relative to the other parts usually need to be separate parts. In a second step you may ask if this movement is actually necessary or if it can be avoided. You can also ask if the movement or the function in general is also possible without this part.

If there is no requirement for movement, then another consideration is if the part is made from a different **material.** If the part is indeed a different material, it is necessary to find out why it is different. Often, different materials have a functional requirement behind them. For example, it may be needed to isolate electricity or heat from other parts. It may also be simply for aesthetics or optics. Nevertheless, you can check if this functionality would also be possible with the same material.

Finally, if the part is the same material and not moving, you may determine if it needs to be removable for **maintenance** or also adjustable. It may be helpful to have a separate part to make repairs easier. A related example would be car headlights, where for some cars you have to exchange the entire headlight unit just because a bulb or a LED burned out. If the part is removable for maintenance, check if this is truly necessary. Also check if you can achieve maintenance or adjustment without a separate part.

If none of the above reasons require movement, different materials, or maintenance, you may consider removing the part. An overview of this decision tree is shown below.

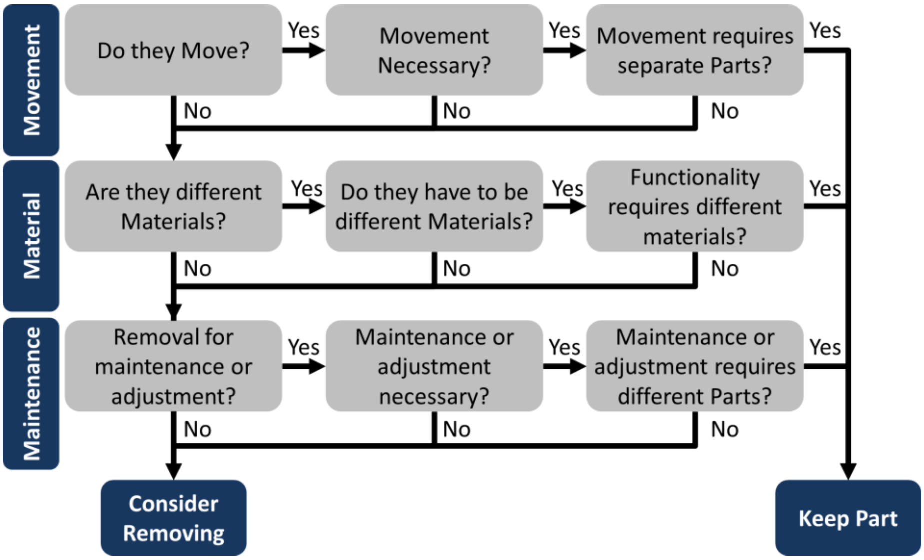


Figure 262: DFMA Logic Tree Remove Part (Image Roser)

There may be a few more exotic reasons to keep part separate. If so, the design team will surely know. Anyway, every part you remove omits one step from the assembly location, and also eases the load on the supply chain.

This reduction of the number of parts is often a big potential in design for assembly. However, there is more. A lot more, in fact. I have two more posts only on design for assembly coming up. In my next post we will look at reducing the number of part variants. Now, **go out, reduce your part count, and organize your industry!**

29 Design for Assembly Questions – Part 2

Christoph Roser, July 14, 2020 Original at https://www.allaboutlean.com/dfma-5/

Figure 263: Industrial Valve Manufacturing And Assembly Factory (Image The Light Writer 33 with permission)

Design for assembly (DFA) is a large part of design for assembly and manufacturing (DFMA). In my last post I looked at how to improve fastener design and usage as well as reduce the part count. In this post I will look at reducing the number of variants, secondary processes, and making handling easier. This post continues my previous post with questions that can be asked in design for assembly.

29.1 Design for Assembly (continued…)

29.1.1 Can You Reduce the Number of Part Variants?

Figure 264: Identical and Non-Identical Screws (Various screws Haragayato under the CC-BY-SA 2.5 license, identical screws Ssawka under the CC-BY-SA 3.0 license)

If you cannot reduce the number of parts, then maybe you can reduce the number of part variants. This won't simplify the assembly action itself, but will simplify the logistics around the assembly. The material supply directly at the assembly needs less boxes or pallets since there are less part variants. This reduction of part variants goes back in the value chain. Wherever you had two or more part variants that had to be ordered, stored, and tracked separately, you now have only one.

This one part variant is therefore also ordered in larger quantities, which may reduce the price. Even more important, larger quantities have, in general, less fluctuations, and you are less likely to have excess parts … or to run out of parts. Every part variant that is reduced eliminates a complete logistic chain to provide this part, and makes the logistic chain for the common variant easier due to higher volume. Just as a bit of information: It is estimated that simply adding and maintaining a part variant in the ERP database costs car makers around €50,000 per part over the lifespan of the part. For less-complex products this can still be a couple thousand euros.

Any part that is eliminated before the design is finalized saves quite a bit of money through this reduction alone.

A reduction of part variants can be done through standard parts. Often, fasteners are a good target for this, but you should check all parts in your bill of materials. Let’s take screws as an example. You could try to limit yourself to two or three types of screws for one product. Or expand this to five types of screws for all products of an assembly line. Or have only ten types of screws in the entire plant. Or maybe only fifteen types of screws in the entire company. Or limit the different types of screws to the entire world.

Figure 265: 8 different Screw Threads (Image Roser)

The last one may be strange to most of the world (outside of the US and UK), where everybody uses standard metric screws that come in fixed diameters and lengths. But some countries (especially US and UK) still use different screw standards besides metric. There is the unified thread standard fine and also coarse, or British Whitworth also fine and coarse. The image here are all different screw threads of different standards. As you can see, these are easy to mix up, even though they are all incompatible to each other.

As a counterexample, I once worked with an assembly line that had M5 metric screws 30mm long with a cross slot Pozidrive head. There were two types of screws of this type. One had a normal black coating. The other screw had a special coating … also in black. They gave me one screw of each, and – try as I might – I could not tell the difference! The employees eventually pointed out a truly minor difference (a corner of the cross slot was a bit shinier on one screw than on the other). Keeping these two screws apart was nearly impossible, and I assume lots of products left the plant with the wrong type of screw. Using only one type may have made it much simpler.

Figure 266: Open Desktop Case (Image Dllu under the CC-BY-SA 4.0 license)

Another approach to reduce variants is a modular design. You build custom products using standard components. These standard component can then be ordered in larger numbers. Common examples are desktop computers where a wide variety of desktops can be build using standard components. Another example are many modern cars, where car makers aim to use similar components in the vehicle that are invisible, and only the parts visible to the customer are customized.

On a very related side note, one HUGE way to reduce the number of part variants is to reduce the number of product variants. Do you actually need this product? Does it give you enough market share and profit to justify the expense of developing it as well as adding lots of additional parts to the value chain? Many companies I know would be in dire need of reducing the number of product variants. Yet, for important reasons like "tradition," "Boss likes it," "design department needs justification," or "nobody cares," the number of product variants keeps increasing every year, often beyond what is reasonable.

29.1.2 Can You Eliminate Secondary Processes?

In some cases it may also be possible to eliminate secondary processes. This is probably not quite as common as eliminating a part or reducing variants, but it should be checked anyway. Can you avoid any type of welding, soldering, or gluing. How about painting, hardening, lubricating, and coating? What about cleaning and washing? Or can you reduce the amount or effort needed for testing by making the design more mistake proof? Again, this is often not possible, but it may still be worthwhile to check.

29.1.3 Can You Make Them Easier to Handle?

Figure 267: One can entangle, the other one not (Image Qz10 under the CC-BY-SA 3.0 license)

Another question you may ask is if you can make the part easier to handle. Is it slippery or small? Does it have sharp edges? Is it easy to grasp? For thin and long parts, is there a risk of entanglement? This is especially true for springs and similar products like paper clips. The image here shows two types of springs. One with open ends can entangle easily. The other one with closed ends is much less likely to entangle.

Figure 268: Vibrating Bowl Feeder (Image Richdsu in public domain)

Some smaller parts may be separated and oriented for a machine in an vibrating bowl feeder as shown here. Depending on the part shape and design it may be easier or more difficult to provide a reliable orientation in such a bowl feeder. Maybe a small design change can make this process easier? This question does not always yield results, but it should still be asked.

In my previous post I looked at how to improve fastener design and usage as well as reduce the part count. Here we looked at the number of variants as well as secondary processes and handling. Hence, we already have a lot of angles in which we can reduce assembly cost. However, I have one more post with questions specifically on design for assembly, looking at the possibility of making assembly easier. Now, **go out, reduce the number of part variants, and organize your industry!**

30 Design for Assembly Questions – Part 3

Christoph Roser, July 21, 2020 Original at
https://www.allaboutlean.com/dfma-6/

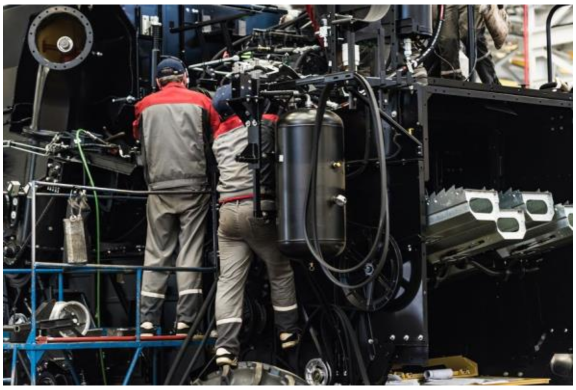


Figure 269: Tractor Assembly (Image Oskanov with permission)

This post finally concludes my list of questions to ask for design for assembly (DFA). I myself was surprised that there is enough material for three posts, and this does not even include the introductions and the design for manufacturing aspects (DFM). Anyway, let’s have a look at how you can make assembly easier.

30.1 Design for Assembly (continued even more…)

30.1.1 Can You Make Them Easier to Assemble?

Figure 270: Sony Walkman (Image Binarysequence under the CC-BY-SA 4.0 license)

Another question to ask is if you can make the parts easier to assemble. This is again one of the bigger questions that often have lots of potential. There are also multiple aspects on this question. Design the parts so that they can be **assembled from only one side**. This one-sided-assembly avoids reorienting the part during the assembly. Often, this involves a larger “base” part onto which additional components are added. It is recommended to have this assembly side top down, rather than sideways or upside-down assembly (yikes!). Gravity is your friend here.

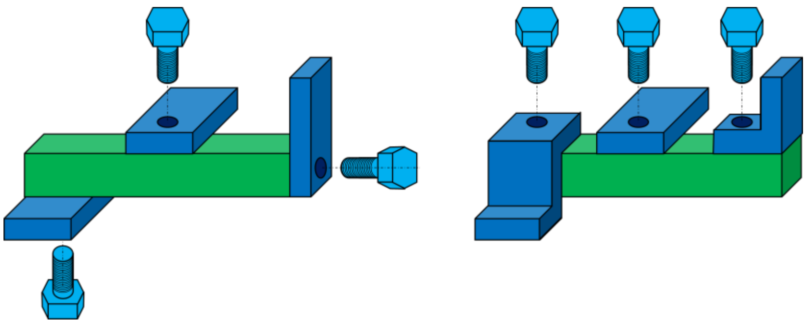


Figure 271: DMFA Assemble from one Side (Image Roser)

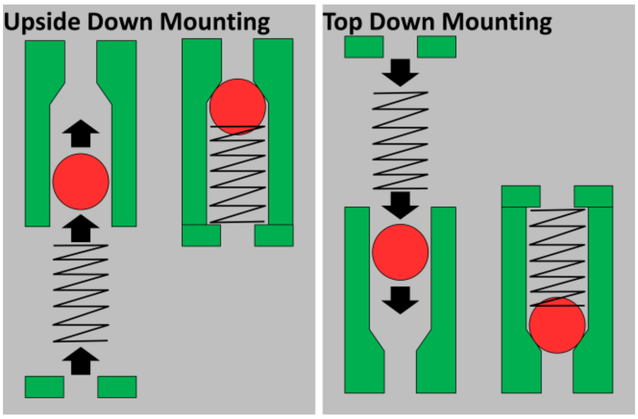


Figure 272: DFMA Upside Down Mounting (Image Roser)

Many modern electronics are built using this concept. One famous part that was designed especially with this assembly from one side only was the original Sony Walkman in 1979. One example that I witnessed did this (initially) spectacularly wrong. It was the assembly of a simple spring-loaded valve, where a small steel ball was pushed into the valve by a spring until the pressure became too great and the valve opened. The original vision of the automation engineers was to mount this upside down. The ball was supposed to be balanced on the tip of a tool, followed by a spring before closing the valve. I am sure you can see a lot of things that can go wrong here. After some feedback, they decided to simply drop the ball and the spring top down into the valve.

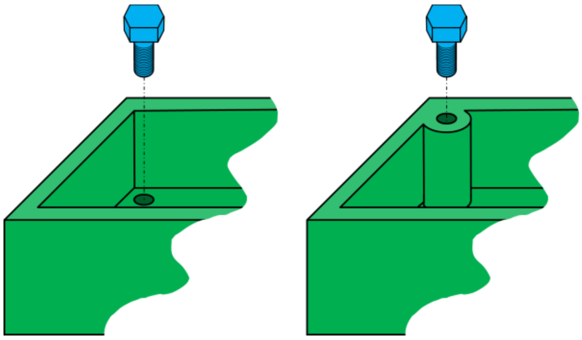


Figure 273: DFMA Easy Access (Image Roser)

Assembly in one axis only also helps with another aspect of easy assembly. Is the **assembly location visible** and **easily accessible**? If the worker (or even the robot) cannot reach the assembly location well, it will take more time and effort, and also has more risk of mistakes. The same if the worker cannot easily see the location (although this is less of a problem for robots). Can you design the part in a way that all assembly locations are easily visible and accessible?


Figure 274: Black Front Car seat parts before assembly (Image Mr.1 with permission)

A good example for this is car seats. They are bulky, and if you design them not so well, the screws are hard to access underneath the seat and out of view. Try to put the screws in a location where they are easier to reach and see, even though it may still be a bit cumbersome.

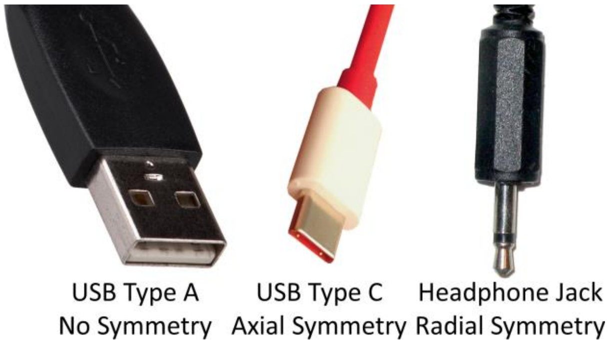


Figure 275: DFMA Symmetry USB Type A, Type C Headphone Jack (Image Evan-Amos in public domain)

Another major factor that simplifies assembly is to have **symmetric parts**, especially when one part needs to be inserted into another one. The more symmetric a part is, the less time is needed to find the correct orientation. An example you are all familiar with is the USB Type A connector. It fits in only one way. In my case I often need three tries to get it in. An improvement is the USB Type C connector, which has axial symmetry and can be inserted in two different orientations. Even better would be the common headphone jack, which as radial symmetry and can be inserted in any orientation. Below is another abstract example.

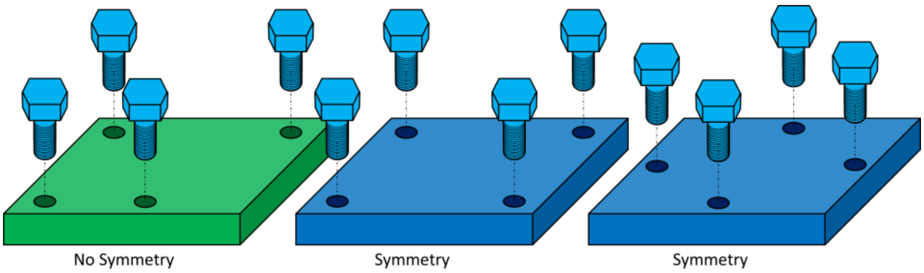


Figure 276: DFMA Symmetry (Image Roser)

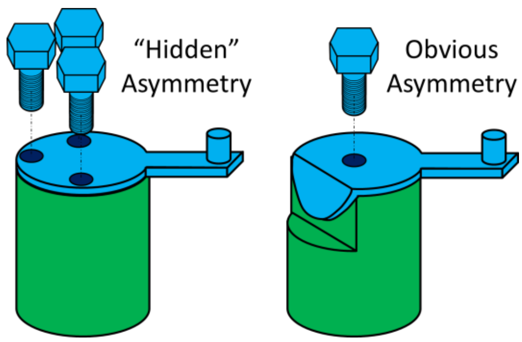


Figure 277: DFMA Hidden &Obvious Asymmetry (Image Roser)

Please note, however, that there are cases where the part has to be in exactly the correct orientation later on. In this case it may be best to have as little symmetry as possible so that the part can be assembled only in one correct orientation. This asymmetry should also be not a "hidden feature," but completely obvious during assembly.

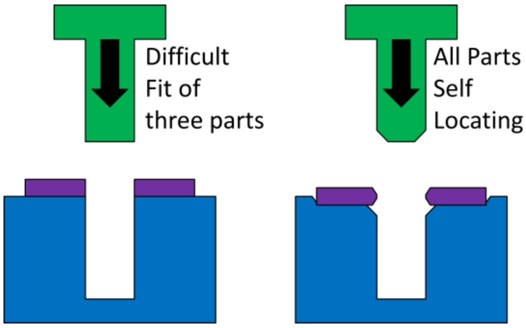


Figure 278: DFMA Self Locating (Image Roser)

Another factor to check for is if the parts are **self-locating** and **self-aligning**. When putting the parts together, do they fit together easily or does the worker need to pay careful attention to make them fit? Often, adding a chamfer makes parts easier to join, or having additional features that make positioning easier.

If you can have parts that can be assembled with **one hand only** it will be easier than with two hands. If you need three hands or more, it becomes even more complex, as by the nature of hands you need more than one person to do the assembly. In general, one-person assembly is better than two, and one hand is better than two. It may not always be possible, but it may be worth a look.

Finally, depending on the quantity you produce, you may consider making assembly **easier for machines** and robots. For example, robots have more difficulty inserting a screwdriver into a screw. A slotted screw has only two positions how to enter the screwdriver. Cross-slotted drives and Robertson screws have four positions with 90 degrees in between. Hex screws and Torx screws have six possible positions. There are screws with even more positions, like the triple square (XZN), which has twelve possible positions. The more positions you have, the easier it is for a robot screwdriver to handle the screw.

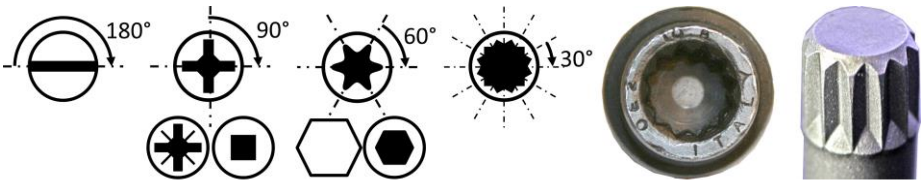


Figure 279: XZN Screws for Automation (Image Roser)

There may be other ways to design parts for easier automated assembly, giving the machine additional clues to recognize and orient the part correctly. Of course you need those only if you actually plan to use automated assembly for these parts.

30.1.2 Can You Avoid Adjustments?

Depending on your product, there may be small adjustments as part of the assembly process. Can you eliminate these adjustments? Can you design the part in a way that an adjustment is no longer needed? This question may not be relevant for all products, and may not yield results for those products that do have adjustments. However, in manufacturing history, it was one of the major productivity gains. Before there were interchangeable parts, assembly was mostly filing parts down to fit the other parts. Assembling a car in 1900 required more than half of the time for filing things down.

Figure 280: Do you need to make it fit? (Image Dake under the CC-BY-SA 3.0 license)

While you probably do have mostly interchangeable parts, are there some that are not? Are there some mix-and-match operations or steps to make things fit? These still exist in may products, and can be found even in automotive.

30.1.3 Can It Be Assembled Incorrectly?

Can your parts be assembled incorrectly? This topic correlates with the well-known poka yoke, or mistake proofing. Design your parts in a way so that they can be assembled only in the correct position as well as used only in the correct position.

While this post concludes the list of questions on design for manufacturing and assembly, there is still much more out there. These are often summarized as Design for X, which will be the topic of my next post. Now, **go out, make your parts easier to assemble, and organize your industry!**

31 Design for X

Christoph Roser, July 28, 2020 Original at https://www.allaboutlean.com/dfma-7/

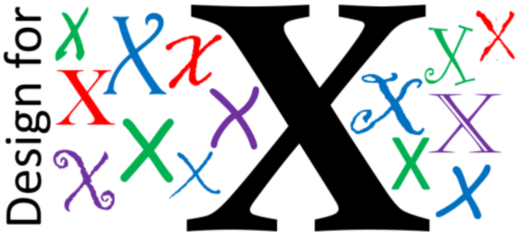


Figure 281: DFMA Design for X (Image Roser)

In my last couple of posts I looked at design for manufacturing and assembly DFMA. However, there is more out there. Often, they are grouped as **Design for X**, where X could be anything related to the product life cycle, including development, production, shipping, servicing, use, disposal, and many more. There seems to be a large number of more-or-less well-known terms that are used somewhere. Many of them claim to be essential, but not all are. If you try to do them all, you will never get the design done. Focus on the ones that are most promising for your case. After all, all designs are designed for something, usually a trade-off of functionality versus cost. This is sometimes also known as **design to cost**.

31.1 Design for Inspection

Figure 282: Inspection of Process (Image unknown author in public domain)

Design for inspection aims (unsurprisingly) to improve the design for easier inspections. Here, inspection most often means inspection during and shortly after manufacturing to ensure that the parts are produced within the tolerances. Since there is usually much less inspection than manufacturing, the potential is also less than design for manufacturing and assembly.

Nevertheless, if your production process has a lot of inspection, you may consider checking your options here. This overlaps quite a bit with Jidoka, the idea that machines stop automatically if there is a problem. The famous example is the Toyoda Model G loom, which stops automatically if a warp breaks as shown in the video below.

The Video by AllAboutLean.com is available on YouTube as "Toyoda Model G Warp Break Auto Stop" at https://youtu.be/PdGcfHucmKc

For this warp-break auto stop, there was no need to change the design. However, in other cases, a small design change may make detection much easier. For example, the flammable gas used for cooking and heating in many houses is naturally odorless. If there would be a leak, no one would know until the whole house explodes. Therefore, the gas plants add another gas that has a very strong smell of rotten eggs. Your nose can now detect a gas leak, and you can take countermeasures (turn off gas, open windows, evacuate, etc.)

31.2 Design for Maintenance

Figure 283: Tire change (Image Trix and friends under the CC-BY 2.0 license)

Design for maintenance aims to make maintenance and service operations easier. This is often neglected, since service and maintenance is often paid for by the customer. It is also sometimes used to increase profit by enabling the sales of more goods. For example, in some cars you have to exchange the entire headlight unit if a light bulb is burned out. The cost for the consumer is much larger, as is the profit for the company. Some car makers also put the battery in hard-to-access locations (behind the wheel, under the driver seat, etc.). In sum, design for maintenance is not an issue for many companies, although you can make life easier for your customers.

31.3 Design for Logistics

Figure 284: Amazon Tetris Truck (Image Amazon with permission)

Design for logistics is yet another topic related to but significantly smaller than design for manufacturing and assembly. The goal here is to reduce logistic costs. Often, this is more about the packaging than the product itself. Can you make the packaging so it fits well into a larger container or onto a pallet? A good package fits well onto standard pallets. Is the packaging robust enough? More robust packaging may be more expensive but may save money on additional padding for shipping. Is it easy to repack and track?

Figure 285: Ikea Warehouse (Image W.carter in public domain)

A good example here is Ikea, the famous Swedish furniture store. The concept is that the customer assembles the furniture. The packages of Ikea are designed to be as compact as possible, so the company ships less air and more products. This compact package can also more easily be carried. If the product is too big, Ikea uses multiple smaller packages rather than one big one that the customer can no longer lift. They are also using more and more renewable packaging material, including honeycomb paper inserts instead of plastic foam.

31.4 Design for Administration

Figure 286: DFMA Bad Interface Design (Image Roser)

This one falls a bit outside of the scope of the other Design for X approaches. First of all, I just made the term up. Second of all, here you optimize not a product but an administrative process or service. Can you design your paper forms or computer interfaces in a way so that they are easy to use? Are the forms easy to understand using a language that the audience can understand? A form used by engineers can, for example, be more technical than a form used for the layman. Is it clear where to fill things out? Does the color coding of a software interface help? Are certain steps even necessary?

I once came across a person whose job it was to compare the results of one computer with the result of another computer to see if there was any difference … all day long. I asked him if he ever found a difference, and he said, "No, but I've been working here for only six months now." I just felt sorry for him. Anyway, even though I just created the term "design for administration," I believe the idea behind it is quite viable.

31.5 Design for Additive Manufacturing

Design for additive manufacturing is a more specialized topic if you design parts for 3D printing and similar production approaches. This is often specific to the technique employed. For example, laser sintering has difficulties in getting the powder out of long, thin tubes. Fused Deposition Modeling, on the other hand, needs support structures for overhangs. Laser sintering may need these too, due to the thermal expansion and shrinking of the part during production.

Figure 287: 3D printed titanium part for Airbus A380 (Image Roser)

Other aspects are less specific to the 3D printing technique. Since there is a lot of flexibility in the geometry, it is possible to design parts in an almost natural-looking shape, where you add material only where needed and leave it out where not. The inside of parts also often have a honeycomb or lattice structure to provide stability while reducing weight and production time.

31.6 Design for Interchangeability

Figure 288: Shower Valve Handle and Hand Shower Holder (Image Roser)

If you make multiple similar products, it can really help if they are interchangeable. This makes upgrading or downgrading much easier. For example I have a normal shower handle valve. I would have liked to exchange it with a higher grade temperature controlled shower valve. The valve sits in a plastic box in the wall for easy installation and maintenance. Unfortunately, this plastic box is not compatible with the temperature controlled valves from the same brand ☹. Upgrading would now require chiseling out part of the wall.

Another example from the same shower. The hand shower was in an angled holder. To save space in my shower I wanted to replace it with a straight holder from the same brand as shown in the picture. For some unknown reasons the holes in the straight holder were 5mm more apart than in the angled holder. I managed to get the screws into the same drilled holes, but it was not a pretty process ☹. A little bit of foresight during design would have my process easier, and the maker could have sold another shower handle valve to me.

31.7 Design for Environment

Figure 289: Green city (Image 9comeback with permission)

Another aspect relevant nowadays and probably even more relevant in the future is the design for environment along the entire product life cycle, or the very similar design for recycling focusing on the product end of life stage. The goal here is to reduce the overall impact on the ecosystem.

This can have multiple aspects. Are your materials and energy from a renewable source? Is the material biodegradable? Or is it even recyclable with reasonable effort? Anything can be recycled if you just pump enough money in, but if it is too expensive it won't be. Can it be disassembled easily for recycling? Or can it be even reused or refurbished to avoid recycling for one more life cycle. Is it energy efficient and/or carbon neutral?

There is a lot of activity ongoing, but it is always hard to tell how much is actually happening and how much is just marketing. The underlying problem is that while a design for environment benefits all, the expenses are usually with the manufacturer. Many CEOs do indeed want to help the environment, but they still have to watch the bottom line. A very green company does no good if it is bankrupt. Luckily, both legal changes to force responsibility and the pressure by customers and society are slowly changing the manufacturing environment. But there is still a lot to do if we want to stop global warming.

Anyway, I digress. What I wanted to show you in this post is that there are many more possible aspects to improve a product through a Design for X. However, not all of them are for everybody (but please take heart to the design for environment). You have to find out which one is helpful for you. Now **go out, design your products for X and the environment, and organize your industry!**

32 On the Safety of Workers During Corona – Part 1

Christoph Roser, August 4, 2020 Original at https://www.allaboutlean.com/corona-worker-safety-1/

Figure 290: Lean Corona (Image Roser)

The world is suffering from a pandemic. SARS-CoV-2, better known as the coronavirus, is killing people all over the world and damaging the economy. One major topic (among many) is how to keep workers safe during the pandemic. Hence, I would like to provide my thoughts on this topic.

Please note, this is not a guideline to solve all your virus-related manufacturing problems. The current situation is causing headaches for most manufacturing companies, and these headaches are hard to avoid. Second, I am an engineer and not a virologist. Hence, all virus-related information is only to the best of my knowledge. But, come to think of it, so is my engineering knowledge too. Use this information at your own risk. The recommendations here are based on the common recommendations to avoid infection, with a view on how they can be applied on the shop floor. This is the first out of two posts on worker safety during the pandemic, followed by a post of the influence of corona on logistics.

32.1 Introduction

Figure 291: The easy part … (Image Cabeca de Marmore with permission)

First, do the obvious and do not let people in the plant if they don't have to be there. Visitor groups and tours should be canceled to reduce the risk for your workforce. You may also consider special attention to high-risk workers (i.e., those over sixty years of age and those with diabetes, lung or heart problems or similar risk factors – if you know about them).

Avoiding infections at work is usually easier for office workers. Most times they can work from home, staying in touch through the phone, email, and the now-common video meetings. Sometimes, however, the office worker needs to work from the office. For example, if the worker handles sensitive data that must not leave the company premises. Or if, because of an outdated legal system, they still need to sign documents by hand (this is the reason most Japanese salarymen still have to go to work almost every day). But even in these cases, you usually can easily increase the distance between the employees.

Manufacturing workers rarely have these options. They have to be where the machines are, and the machines are often difficult to move. Hence, manufacturing workers are often still working closely together, increasing the risk of infection. Regarding this risk, there is no guaranteed safety. The measures below only **reduce the risk, but they cannot eliminate it entirely**. A combination of multiple, or ideally all, measures are better than doing just one.

32.2 Testing

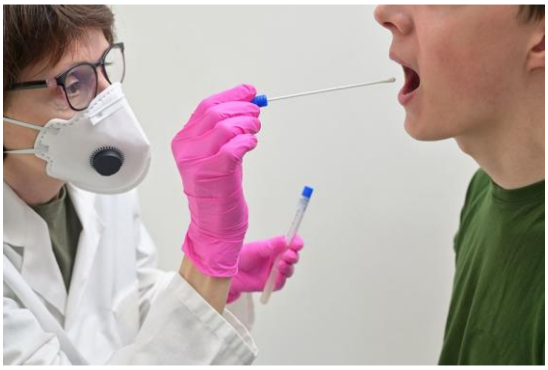


Figure 292: Throat Swab (Image laurentiu iordache with permission)

One way of reducing the risk of infection is testing. There are different types of test. An **antibody test** checks if you have had the virus in the past. More interesting, however, is an **antigen test** or **molecular test**, which checks if you have the virus now. However, these tests are currently still in somewhat limited supply, expensive, and may take a few days to analyze. Even then, there is still a small error rate, and the test may fail to detect an infection (false negative) or claim an infection where there is none (false positive). Testing research may give us cheaper and more reliable tests in the future. Yet, at the moment, these are the best tests we have.

An alternative is measuring temperatures. This can be done quickly and cheaply, but the reliability is not good at all. There will be plenty of false positives and false negatives with a quick temperature check. Besides, the virus can be spread before there are any symptoms. Still, some companies do the temperature check, as it may reduce the risk slightly, or at least makes it look like they are doing something.

Many countries have paid sick leave, and workers are not penalized if they are sick. If your country does not have this (and yes, I am looking at you, USA!), workers may go to work even if they have symptoms because they need the money to survive. In effect, by not having paid sick leave you penalize your workers for protecting others by staying home.

32.3 Distancing

Figure 293: All Alone … (Image olly2 with permission)

Another approach is to keep distance. This is known as *social distancing*, although at work it would be more like *professional distancing*:). Unfortunately, there is no vote out there yet as for how much distance we need. Some countries require 2 meters, some 6 feet (1.8 meter), some 1.5 meters. There is an often-cited paper with the claim that the risk halves for every meter further away. However, these citations miss that this is not a result of the research, but an assumption made for the model. Although, in general, more distance seems to be better. Additionally, there seems to be a much lower risk of infection outside, whereas the small droplets in the air can distribute throughout a room easily, regardless of the distance. Unfortunately, most manufacturing happens indoors.

Many factories try to increase the distance between workers. Depending on the country, this may be between 1.5 and 2 meters, although this also seems to be a compromise between reducing the risk and still trying to fit enough people into the factory to run it.

In some manufacturing locations, the processes are far enough apart to allow this required distance. The challenge is here to ensure your workers stay apart when moving around in the plant. Visual management can help here to make the distance more … well … visual. You probably have seen similar lines on the ground in your supermarket. Some plants also made the walking paths into one-way streets so workers can stay apart easier.

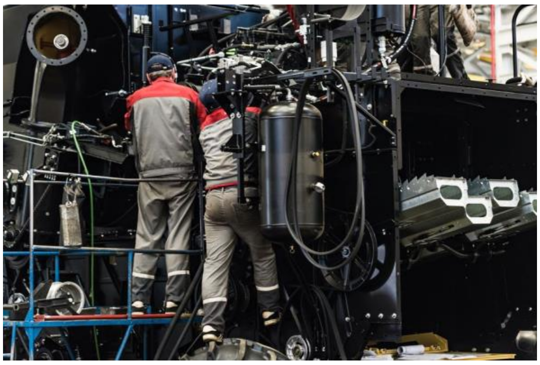


Figure 294: Close together ... (Image Oskanov with permission)

Some processes, however, have workers in close proximity. If it is a two- (or more) person operation, you may be able to reduce it to one person with automation … assuming the robot arrives before a vaccine becomes available and the crisis ends. For assembly lines or manufacturing cells, it is often possible to reduce staffing. Instead of ten people in an assembly line, you have only five, and each person also handles the work of the no-longer-present person next to them. This can significantly increase the distance, but it also reduces your output by half. It is effectively a [flexible manpower line with]() reduced staffing. I know the reduced output is a bummer, but unless you can move your processes around and have the space, you may have to do this to protect your workers. Reducing the number of workers reduces the output. Although, many industries like automotive can happily do that, since sales are reduced drastically due to corona anyway.

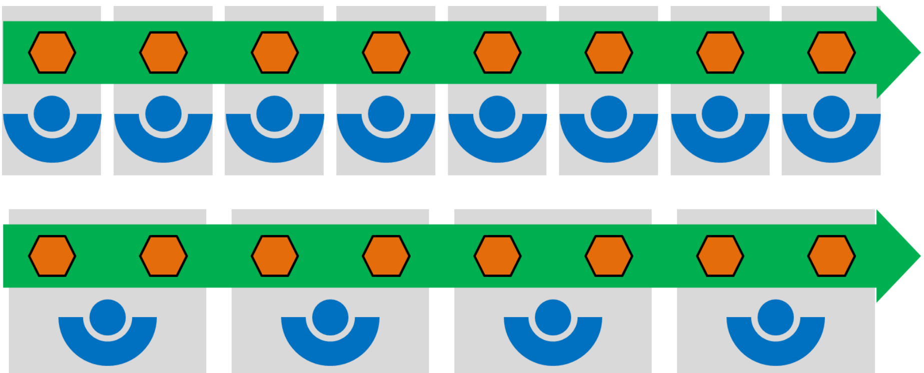


Figure 295: CORONA Distancing Assembly Line Before After (Image Roser)

Distancing is more difficult in the cafeteria, especially since you can't wear a mask while eating. Consider switching from buffet-style to served or pre-packaged meals, and serve drinks in the bottle.

Figure 296: Going Viral… (Image davit85 with permission)

In many countries, meat-processing plants were hit especially hard by the virus. Distancing in a meat-processing plant would seem similar to distancing in an assembly line. After all, a meat-processing plant is nothing but a disassembly line for animals. The problem here is that many of the workers are often low-paid migrant workers staying in housing assigned by the plant. Often, these living quarters are quite cramped, distancing and hygiene are difficult, and hence a virus can easily infect others. It may also be that the virus survives easier in a cold and wet environment. There are also reports of employers not providing masks or failing at other safety guidelines.

Overall, as an employer you are responsible for the safety of your employees. Please do your part in containing the virus. I will continue this topic in my next post, including the in my opinion two most important aspects: hand hygiene and masks. Now, **go out, save the health of your people, and Organize your Industry!**

33 On the Safety of Workers During Corona – Part 2

Christoph Roser, August 11, 2020 Original at
https://www.allaboutlean.com/corona-worker-safety-2/

Figure 297: Lean Corona 2 (Image Roser)

The Corona pandemic is still spreading around the world. Some countries could contain the virus, while it still spreads in others. Other countries are experiencing a “second wave”, which is bigger than the first wave. One of the potential ways to get infected is at work. Hence, I would like to write about ways to reduce the risk of infection at work. This is the second post on workplace safety during Corona. After this, another post will look at how Corona influenced logistics around the world. As before, I am an engineer and not a virologist. Hence, all virus-related information is only to the best of my knowledge. Use this information at your own risk. I still hope that it helps you to provide a safe environment for your people!

33.1 Ventilation

Figure 298: Opening Window (Image Eldar Nurkovic with permission)

The virus is transmitted, among other ways, through airborne droplets. The bigger ones fall down quickly, but the smallest ones can float in the air for quite some time. Hence, they can easily spread in a closed room. It seems that infections are more likely to happen in closed rooms than outdoors. Yet, you can’t really move your production lines outside. One often underestimated way to reduce the risk of infection is good ventilation. Open the windows, crank up the fans, and try to get fresh air in and stale, potentially viral air out. In manufacturing halls you can open the doors to help with ventilation.

33.2 Protective Equipment

Figure 299: A surgical mask (Image World Image with permission)

Probably the most important personal protective gear is a facial mask to filter the air. They should be worn over mouth AND nose. If the nose hangs out, it will have little benefit.There are different types of masks. Surgical masks are designed to protect the environment from the wearer. When breathing in, some air may come in unfiltered from the edges of the mask. Only when breathing out is most air filtered.

Figure 300: Single use respirator with valve (Image Visoot with permission)

The other type of mask are technically called respirators. There are single use respirators as well as reusable half or even full face mask respirators where you only swap the filter. They are designed to have a tighter seal around the face and to protect the wearer from the environment. These may have exit valves to make breathing easier, but in this case they do not protect the environment from the wearer. It seems the bigger benefit of masks is to protect others, hence surgical masks or even simple textile masks or shawls will be fine. If you use respirators, make sure they do not have an exit valve, so you can also protect others.

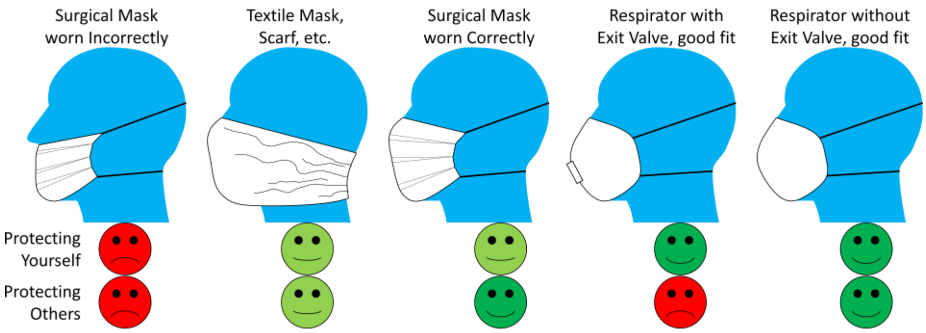


Figure 301: Mask Comparison – use at your own risk! (Image Roser)

Figure 302: Welding mask with filter (Image AlexChirkin in public domain)

Figure 303: Reusable half face mask respirator (Image AlexChirkin in public domain)

Some of your employees may wear protective breathing equipment by default, as for example welders or grinders. But keep in mind that these are usually designed to protect the welder from the environment, not the environment from the welder. Hence, ideally, the exhaled air would need to be filtered too. However, it may be a tough sell to convince the welder why he has to wear TWO masks. Luckily, most of these workplaces are distanced from the next one, anyway.

A mask may be uncomfortable to wear for longer periods, and some companies require it only when the worker is moving around. Since some air also escapes at the edges of the mask, glasses may have a tendency to fog up.

Some employees prefer to wear a face shield instead of a mask. I am not sure how effective these are, but you can see them in many supermarkets. In German supermarkets they are sometimes worn by staff instead of the mask, but I am doubtful if they protect against viral micro droplets floating in the air. For increased protection you may also wear goggles to prevent infection through the eyes, albeit this is mostly in hospitals when treating infected people.

Figure 304: Stretch Wrapping Machine (Image AlexLMX with permission)

There are also all kinds of barriers in use. Some companies put up transparent plastic barriers or shields to reduce the exchange of air. I also have seen plastic tents around individual work places. These are sometimes only a metal structure around which industrial sized saran wrap was wrapped. Make sure you leave an opening for people to enter and exit! Another company where workers worked on both sides of a hanging conveyor simply put a sheet of plastic on the hanger, dividing it into a right and left half. The challenge is to find a way to put up a barrier without it being in the way (too much).

33.3 Hygiene & Cleaning

Figure 305: Hand Washing (Image thisispatrice in public domain)

Another important step is hygiene. Hand washing with soap and water and **single-use towels** is best. Make sure to get all corners of your hand and wrists clean. A secondary alternative are hand sanitizers. Make sure you get the type effective against viruses, as some brands are best against bacteria and not efficient against a virus.

Often, cleaning cycles are also increased. This is especially for surfaces that are frequently touched. Light switches, door handles, handrails on stairs, toilet seats, etc. would benefit from additional cleaning. If you can reduce the number of surfaces a worker has to touch, do so.

Figure 306: Corona DocDoor (Image DocDoor with permission)

If you ever considered having an automatic door, now is a good time! If you don't have the money for that, there is also a low-cost alternative. You add a Gizmo to the door handle that allows you to press the lever and pull the door open with your elbow or lower arm. One such device is shown in the picture here. This one is from DocDoor, a company started by students from my university 🙂 ! The pushing side of the door needs one to open it, the pulling side need one to close it.

33.4 Training

Finally, the last important step is training your employees. Teach them how to keep themselves and their colleagues safe. Motivate them to actually do it – there are many people that do not (yet) see the need for these actions. Follow up to see if the safety standards are actually followed. The best safety equipment does not help if your people don't use it. And, don't forget to lead by example!

33.5 Summary

The above measures reduce the risk of infection, but there is no 100% safety (there never really is). Research is still underway to determine the effect of different measures. In case of doubt, more is better. Also, follow the legal requirements in your location. Please take measures and lead by example. I don't get those people who risk the health of themselves and others by refusing to wear masks, or wear them sloppily without covering the nose. Now, **go out, put on your mask properly, wash your hands, stay safe, and organize your industry!**

34 How the Corona Virus affects Logistics

Christoph Roser, August 18, 2020 Original at https://www.allaboutlean.com/corona-logistics/

Figure 307: Logistics during Corona (Image Roser)

The coronavirus, also known as COVID-19 or SARS-CoV-2, is running through the world like a wildfire. Besides killing hundreds of thousands of people, it is also creating a huge headache for the economy. Many countries are currently experiencing a second wave. In this post I will look at how the pandemic affects supply chains, how they react, and how this may shape supply chains in the future.

34.1 Drop in Demand

Figure 308: Some markets are crashing. (Image Thue in public domain)

Changed circumstances due to the COVID-19 pandemic caused a significant drop in demand for some industries. The mighty automotive industry is under significant pressure. In Germany, domestic demand dropped by 30%. The regions in Italy hardest hit by the virus saw sales shrink by 85% (March 2020 compared to 2019). April was even worse, with sales all over Europe being only 50% as the previous year. Related services are also down, including gasoline consumption and maintenance. Restaurant-related services took a nosedive when restaurants were forced to close. The travel industry is running on empty. Even after reopening, business is much less than before. Anything related to travel has much less demand than before.

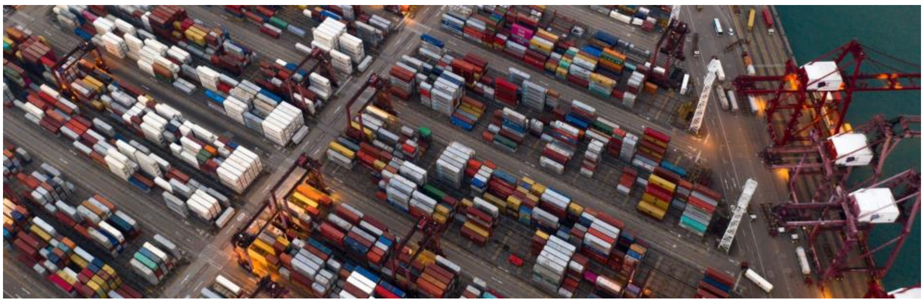


Figure 309: Container Terminal (Image Bellergy in public domain)

A lean company can handle a drop in demand much better than a not-so-lean company. Shorter, leaner supply chains mean that you can slow down the flow of material quicker. If your goods arrive by ship from China, you will always have two months’ worth of goods floating on the ocean. They tie up capital, and when they arrive, they need to be stored somewhere. Some ports are running out of space for containers, and have started to use space inland to store goods …

at an additional effort of moving things around. There are even some scams selling nonexistent storage space. The price of some oil futures even dropped to negative $37 per barrel because the oil was pumped, but with nowhere to go. You were paid money to take the oil off their hands.

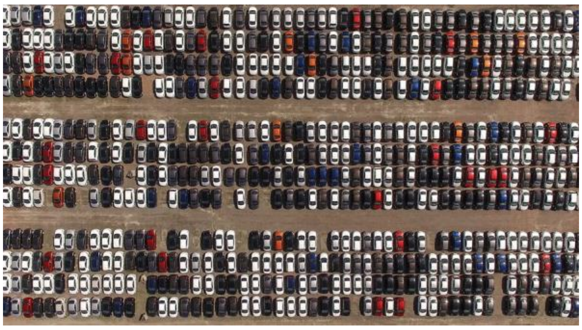


Figure 310: Car Parking of Unsold Cars (Image Alexandr Medvedkov with permission)

Even if you keep producing, you have to put the goods somewhere. The automotive industry rented huge parking lots from (currently unused) stadiums to put hundreds of thousands of unsold cars there. A lean company would have been better at scaling down production to avoid overproduction, which is the worst of the seven types of waste. To take a historic example, during the 1973 oil crisis, Toyota was able to scale production down and later back up much faster than the competition. Overall, **a lean supply chain can handle a drop in demand much better** than a long and slow supply chain.

34.2 Increase in Demand

Figure 311: Toilet Paper Jumbo Roll (Image Axxis10 under the CC-BY-SA 4.0 license)

Many other industries had a huge increase in demand. Many things that are used at home have a much higher demand. Since a lot of people now cook and eat at home, demand for food in the supermarket has gone up. This was most visible with noodles and goods with a long shelf life, where stockpiling was also a factor.

People roughly need the same quantity of food. Anything that they no longer eat in restaurants they now eat at home. Similarly, the food eventually goes down the toilet, and demand on toilet paper also increased. Partially this was due to hoarding, but also because a lot of the "business" that was done previously at work or in restaurants was now done at home.

Now, since the end customer demand on food and toilet paper remained the same, you could think that wholesalers that sold to restaurants now simply sell their food and toilet paper through supermarkets to the end consumer. Unfortunately, despite its very similar end use, the products are very different. Restaurants may buy their products in bulk, but a private home rarely needs a 50-kg bag of flour. Toilet paper may also be different size, and a commercial jumbo roll won't fit in the toilet paper holders at home, even if the consumer would accept the sandpaper-like quality that is often found in public toilets. Hence, both the product packaging and the product specifications make it difficult to convert industrial products to home use.

Figure 312: Corona - Woman with Mask (Image www.vperemen.com under the CC-BY-SA 4.0 license)

Over time, this can often be adjusted, and producers can switch to different packaging sizes, albeit with additional effort. The *invisible hand* of companies trying to survive and make money ensures adjustments are already happening. But not all products can be adjusted. A paper machine that produces the cheapest *sandpaper*-type toilet paper cannot easily be converted to heavenly four-ply. Yet, efforts are underway to switch distribution channels. Here, too, **having a lean supply chain makes things much easier**. You do not need to find customers for your 300 tons of flour in 50 kilo bags, or – even worse – repack them if you don't have 300 tons of flour in inventory to begin with. A lean supply chain can switch faster.

Figure 313: Covid 19 Medical Ventilator (Image palinchak with permission)

Some other products not only had a shift in demand, but indeed a significant increase. Examples here would be face masks (both high quality for medical use and normal for home use), hand sanitizers, protective equipment, ventilators, test kit materials, and many more items needed to combat the disease. In retrospect it would have been good to have these on inventory … but that is the wisdom of hindsight. Other increases are due to customers spending much more time at home. For example, some popular gaming consoles were sold out for quite some time due to the unexpected demand peak.

However, **you cannot stockpile for all eventualities. If you do stockpile, make the most out of it.** Make sure the type and quantity is what is most beneficial for your industry, and that the benefit is worth the effort.

34.3 Supply Problems with Cross-Border Transport

Figure 314: Trucks at Customs Border (Image Aleksei Smolensky with permission)

Another problem for many supply chains is restrictions to cross-border traffic. Many governments tried to prevent the entry of infected people by preventing the entry of ALL people into their country, or at least have a two-week quarantine. However, exceptions are usually made for logistics, since pretty much all countries depend on the global logistic network (except maybe North Korea). Nevertheless, border crossings often became more cumbersome.

Also, companies that used a lot of air freight have problems now if planes are no longer flying. The common air-mail rush orders that are an important source of profit for airlines are now rushing much less. Overall, cross-border traffic has become more difficult. Having suppliers closer to home makes things easier (although you still have to get the stuff to the customer too). Toyota has most of its suppliers within a two-hour drive around Toyota City in Japan. Hence, a short supply chain would have helped here too.

It seems that many companies become more careful about what borders to cross. The effect of the pandemic plays together with other factors like Brexit or the current behavior of the Chinese Government that make companies adjust their supply chains. Supposedly, many companies also actively try to reduce their dependence on China. Foxconn and Apple just invested 1 Billion in India to have an alternative to China. Overall, it is a challenging time for manufacturing and logistics. But every crisis also has opportunities. Now, **go out, seize the opportunities, and organize your industry!**

P.S.: Quite a few people have written about lean and coronavirus. Here is an incomplete list.

- John Shook: Coping with Covid-19: lessons from The Plague
- Michel Baudin: "Herd Immunity" Varies With The Herd
- Michel Baudin: The Math of COVID-19, And Factories
- Lean Enterprise Institute: Lean in Time of Coronavirus (Podcast)

35 Toyota’s Six Rules for Kanban

Christoph Roser, August 25, 2020 Original at
https://www.allaboutlean.com/toyotas-six-rules/

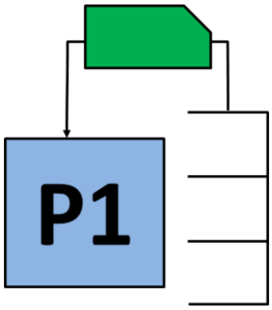


Figure 315: Simple Kanban Loop (Image Roser)

The kanban system is the most famous way to establish a pull system. As part of their guidelines for kanban, Toyota has established Six Rules for Kanban. They can be found, for example, in the 1973 *Toyota Production System Handbook*. This blog post describes these six rules, based on the Toyota handbook. While these rules are all true, they are in themselves not sufficient to establish a kanban pull production. Nevertheless, this post will show you these six rules.

35.1 Introduction

Figure 316: Toyota Logo (Image Toyota for editorial use)

The Toyota handbook lists six rules as prerequisites for a kanban system. These rules are as follows:

- Don’t Send Defective Products to the Subsequent Production Process
- The Subsequent Production Process Comes to Pick Up
- Only Produce the Amount Picked Up by the Subsequent Process
- Reduce Fluctuations
- Kanban Is a Means of Fine Tuning
- Stabilize and Rationalize the Production Process

Please note that often, anything from Toyota is seen as an ironclad rule that must not be violated. These rules do indeed make sense to me. However, I feel that here Toyota mixes up prerequisites with other factors like performance and maintenance of the system. Similarly, there also seems to be some gaps in their rules. An important rule I am missing is, for example, that “*any material in the system must have a kanban card attached.*” Hence, these rules are here more for inspiration, and less a step-by-step guide to establish a kanban system. Anyway, here are these rules and their explanation.

35.2 1 Don't Send Defective Products to the Subsequent Production Process

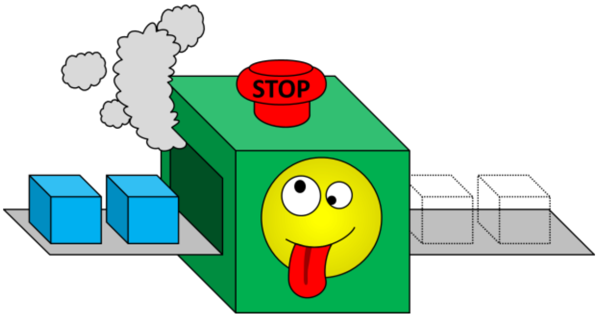


Figure 317: Broken Machine in Jidoka (Image Roser)

The first rule is pretty much a no-brainer. Defects are one of the seven types of waste, since effort goes into production that brings no benefit. The later you find a defect, the more expensive it is. Hence, the goal is to catch defects early. Only good products can be added to the supermarket. This avoids costly subsequent mistakes, and also allows earlier detection of systematic errors. Ideally, every machine at every step should be able to detect defects. This is also known as Jidoka.

35.3 2 The Subsequent Production Process Comes to Pick Up

Figure 318: Supermarket Karlsruhe (Image Roser)

The kanban system needs to know how many parts it has in the system to reproduce more items. Therefore, the supermarket with completed goods is the responsibility of the supplying kanban process. The subsequent process knows best when it needs more material. Hence, it makes sense for the subsequent process to come and pick up the items as needed, so that they can be reproduced by the kanban system. If the supermarket would be the responsibility of the subsequent process, then there would be a risk of information for reproduction coming too late.

35.4 3 Only Produce the Amount Picked Up by the Subsequent Process

Figure 319: Female workers pose with trolleys laden with sacks of flour. (Image Lewis G P in public domain)

This rule is one of the key elements of the kanban system. The idea is only to reproduce or replenish what was consumed. If the next process takes four parts, you produce four more of these parts – not more, not less. This allows you to maintain an upper limit on inventory, which for me is the key feature to obtain the benefits of a kanban system. The combination of rule 2 and 3 makes the material in the value stream flow smoothly.

35.5 4 Reduce Fluctuations

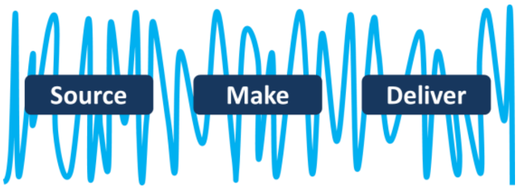


Figure 320: Source Make Deliver Fluctuations (Image Roser)

This step is an important part of lean, often underestimated in the West. The kanban system should be able to reproduce parts reliably within the replenishment time. The kanban system assumes that there is always material in the supermarket for the subsequent process. Large fluctuations mean either occasional lack of material in the supermarket, or much larger inventory levels to cover these fluctuations. Both are not good. The first causes stoppages and subsequent lack of material downstream. The second increases the negative effects of inventory.

Hence, reduced fluctuation, or even some form of leveling, allows for cheaper and more efficient production. Please note that leveling can come in different forms, not all of which are really well suited for your average production system. Especially a longer term pattern is, in my view, one of the hardest things to do in lean.

35.6 5 Kanban is a Means of Fine Tuning

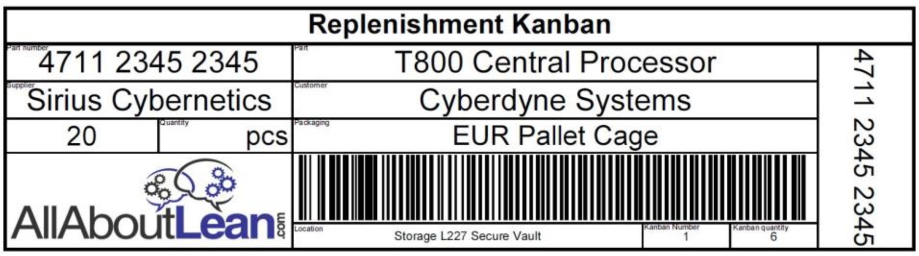


Figure 321: Kanban card (Image Roser)

Over time, the demands on your system will change, as will the system itself. Therefore, you have to adapt the system. Adjusting the number of kanban is an approach to fine-tune your production. If your demand or your replenishment time increases, you need more kanban to cover for this demand (assuming that you do have the capacity to satisfy this increased demand). If your demand or your replenishment time decreases, you may get away with less kanban. This can be easily tracked by monitoring the inventory in the supermarket. If you are often empty, you may need more kanban. If you are never empty, you may get away with less kanban.

35.7 6 Stabilize and Rationalize the Production Process

Figure 322: Network Image (Image World Image with permission)

The last rule aims to stabilize the system. When you establish your kanban loop, you must put forth the effort to debug the newly implemented kanban system, create the standards for the new system, make sure the new standards are actually good, and find problems and resolve them. This is actually the Check and Act of the PDCA circle. See if it actually works; fix it if it doesn't.

The success of a kanban system depends on such good standards. For example, the transport of the kanban back to the beginning of the loop must happen regularly at fixed intervals. If it happens randomly, your replenishment time will fluctuate, and you will either need more cards or run out of material.

35.8 What Is Missing

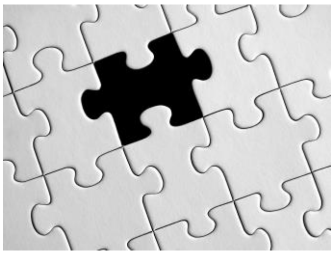


Figure 323: Missing Piece (Image unknown author in public domain)

While these rules are all good, they are in my view not well structured. They are also missing some points I thought would be important. For example, I have learned at Toyota that "*any material in the system must have a kanban card attached.*" If there is material that does not have kanban attached, it is not limited by the number of kanban. The possible overproduction could turn the pull system into a push system.

Lots of other information would be helpful. What has to go onto a kanban card? How should a supermarket look like? How do I determine the number of kanban? Hence, again, these six rules are in my view more of an inspiration and much less actual "rules" as claimed by Toyota.

In any case, I hope this gave you more inspiration and ideas on how to establish a kanban system. Now, **go out, turn your material flow in a pull system, and organize your industry!**

35.9 Source

Toyota Motor Corporation. *Toyota Production System Handbook*. Translated by Mark Warren, 1973. Many thanks to Mark Warren for translating this document.

36 Happy 7th Birthday AllAboutLean.com

Christoph Roser, September 1, 2020 Original at https://www.allaboutlean.com/happy-7th-birthday/

Figure 324: Seventh Birthday Cake (Image unknown author in public domain)

Today, AllAboutLean.com turns seven years old. Hurray! Amazing how fast time flies. Time to look back again on what happened. This is my 370th post on this blog. For seven years I have published a blog post every week going into the details of lean manufacturing and related topics (and once per year a birthday celebration post).

36.1 Most Popular Posts

Figure 325: Top 10 (Image Roser)

The top ten posts for this year were as follows:

- Visual Management
- Good and Bad Ways to Calculate the OEE
- All About Spaghetti Diagrams
- Introduction to Karakuri Kaizen
- What Exactly Is Jidoka?
- How to Measure Cycle Times – Part 1
- Line Layout Strategies – Part 2: I-, U-, S-, and L-Lines
- What Is Your Production Capacity?
- The Seven Types of Waste (Muda) – Now with 24 More Types of Waste Absolutely Free!
- The (True) Difference Between Push and Pull

36.2 Collected Blog Posts Book Series Published

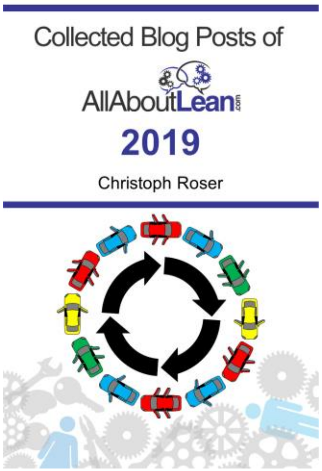


Figure 326: AllAboutLean Collected Post Cover 2019 (Image Roser)

At the beginning of the year, I published my series of collected blog posts books. For each year of this blog, there is one volume containing its blog posts. Hence, we have the following books.

- Collected Blog Post of AllAboutLean.com 2013
- Collected Blog Post of AllAboutLean.com 2014
- Collected Blog Post of AllAboutLean.com 2015
- Collected Blog Post of AllAboutLean.com 2016
- Collected Blog Post of AllAboutLean.com 2017
- Collected Blog Post of AllAboutLean.com 2018
- Collected Blog Post of AllAboutLean.com 2019
- (2020 will come next year)

So, if you want to have all of my blog posts as a book, they are all available. Since my blog is free, the PDF files can all be downloaded for free too here on this blog. If you prefer the Kindle version, it is also available on Amazon for a token amount (I can't make them completely free on Amazon). If you prefer the printed version, you can find them on Amazon too. However, a 300-400 page color print paperback is not cheap. Especially with the free PDF competition, I don't expect to sell many printed collection books. On the plus side, it gave me 344 publications for the internal system at my university, which puts me far, far ahead of any other professor 🙂. Not that I get any benefit beyond the bragging rights, but I just love to test how easy it is to manipulate KPIs.

36.3 Upcoming Book on Pull Systems

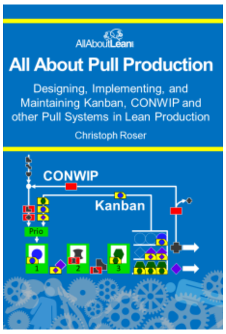


Figure 327: Current Cover Draft (Image Roser)

Besides the collected blog posts, I am also working on a *real* book: ***All About Pull Production: Designing, Implementing, and Maintaining Kanban, CONWIP and other Pull Systems in Lean Production***. I have been promising this to you since quite some time now. But the first draft is complete, and currently under review with other qualified lean people. With a bit of luck, it will be available before the end of the year. In this book I will look in great detail on the different pull systems, which one to use when, and how to set them up, make the layout, implement, and maintain them. The focus is on practical use. It will be probably in excess of 300 pages purely on pull. The top level chapters are:

- Introduction
- Fundamentals of Pull Systems
- Comparison of Different Pull Systems
- FIFO and Other Limited Buffer Inventories
- Kanban
- CONWIP
- POLCA
- Reorder Point
- COBACABANA
- Drum-Buffer-Rope
- Pull System Layout
- Pull System Ramp Up
- Pull System Maintenance
- Summary

I will definitely let you know through this blog and my social media when it comes out. I hope you will like it and that it will help you with your work!

36.4 Faster Website Style

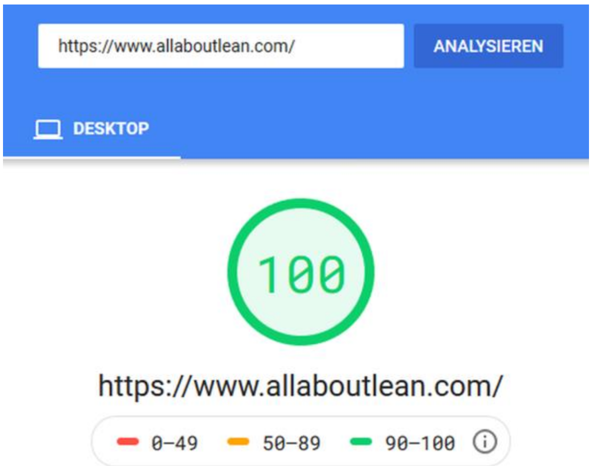


Figure 328: Yes, this webpage is fast! (Image Roser)

After seven years, I thought it was time to change the style of this website a bit. I was still using the 2013 standard WordPress theme, and it was getting a bit dated. Hence, I switched the theme to GeneratePress, with a few new modifications of my own. It is a very lightweight theme and makes for fast loading times. The only element that was slowing it down was the Google Captcha, so I turned it off. The amount of spam has correspondingly increased, but my spam filters are quite good, and very little makes it through. I may switch it back on eventually if the spam gets too much.

But now my website is blazingly fast. It gets the rare 100% at Google Page Speed Insights for desktops, and a still very good 92–99% for mobile phones. There are also now almost no cookies when you visit my blog. I do want to protect your privacy!

Of course, mistakes also happen. I managed to avoid it for almost seven years, but this year I pressed the wrong button and published a post that was not yet done. The second post on workers safety during Corona was pushed into the mailing list about four weeks too early. I of course unpublished the post, but I could not recall the emails. Hence, some of you may have finally seen my beautiful 404 File not Found page ☺. My apologies!

36.5 Awards and Praise

Like every year, I get lots of positive comments on my blog. The LeanLab and the LeanVLog created a video with the top Lean websites, and AllAboutLean.com was included!

The Video by LeanVLog is available on YouTube as "Lean Manufacturing Training - 7+1 Websites to Learn Lean" at https://youtu.be/7QIjzwSqGKU

I also got praise from different people through LinkedIn and other channels:

- *I want to let you know about a great series of articles on the subject of "sequencing": putting the production schedule into the optimum order. Christoph Roser has created a tutorial on how to go about actually doing this. (Richard D. Rahn via LinkedIn)*
- *This AllAboutLean blog post by Christoph Roser contains an extensive list of Lean terminology that goes far beyond any other Lean glossary I've seen. If you need to look up a term, this is the place to go. (Lauren Y. Hansen via LinkedIn)*
- *All these days from 1980 I was specialized in Lean & Lean six sigma as a Professor & CEO having 50 years of experience in industry You article educated me more. (Prof. Rammohun)*
- *Wow, Fantastic write up on the JIS, that starts from the Prerequisite till the post implementation problems & its solution, the person who don't even know what is JIS also can understand, with the given picture illustrations, Great Work..!!! (Vasantha Kumar commenting on my article on Just In Sequence)*
- *Dear Christoph, thanks for the excellent series of articles. (Bernd commenting on Flexible Manpower Lines)*
- … and many more ☺

There were more compliments, of course. This is only a small selection. However, the gods of Google seem to like me less. Instead of 3,000 clicks per day, I get now only around 2,500 clicks per day. Or maybe it is because a lot of my readers are in the home office… ☺. Anyway, I enjoy the writing and will keep on publishing the stuff I know on Lean. Now, **go out, (or stay in the home office), keep on reading, and organize your industry!**

37 When NOT to Balance a Line

Christoph Roser, September 8, 2020 Original at https://www.allaboutlean.com/when-not-to-balance-a-line/

Figure 329: Imbalanced Stones (Image Aleks Simonov with permission)

Line balancing is one of the important methods for improving your production system. The idea is to give every process the same workload so all processes are busy all the time. However, there are cases where it may be better NOT to balance a line. This post will look into when and why you may choose not to balance your line.

37.1 Introduction

Figure 330: Hands Circle (Image Robert Kneschke with permission)

Line balancing aims to give every process a constant equal workload. This will reduce wasted waiting time (*muda*) for those with too little work and overburden (*muri*) for those with too much. Altogether it reduces unevenness (mura). I have written a six post series on line balancing, starting with Line Balancing Part 1 – Data Overview.

The reason we do line balancing is to reduce muda, mura, and muri, as mentioned above. However, there are situations when the negative effects of an imbalanced line are offset by other possible benefits, making an imbalanced line more sensible.

37.2 Automatic Processes

Figure 331: All automatic! (Image Roser)

The first and most common reason not to balance a line is when you have automatic processes. The philosophy at Toyota is that it is very disrespectful to let human workers wait. However, they don't care (too much) if a machine has to wait.

Hence, when balancing a line, it is important to **balance the manual work**. Automatic processes merely have to be fast enough so as not to slow down the rest of the line. In theory, this means the cycle time of the automatic processes have to be equal or faster than the cycle time of the manual processes. In reality, however, it is advisable to have the automatic processes even a bit faster than the manual processes. This reduces the likelihood of the automatic process slowing down the manual ones. Exactly how much faster the automatic processes should be depends on three things:

- **Fluctuations**: The more the automatic OR manual processes fluctuate, the better it is to have a faster automatic process. This reduces the likelihood of making the manual processes wait.
- **Buffer**: Having a large buffer capacity before and after the automatic processes can reduce the effect of fluctuations. Hence, larger buffers reduce the likelihood of having the manual process wait on the automatic one and hence reduce the speed requirements for the automatic processes.
- **Cost**: It would be nice to have a faster automatic process, but you have to watch the cost. If a faster automatic process costs you a LOT more than a just barely fast enough one, you may choose to go with the cheaper process.

Figure 332: All manual (Image olly2 with permission)

Overall, an automatic process that is faster than the rest of the line does not hurt the overall performance of the line. On the contrary, it may reduce the waiting time of the workers on the automatic processes, and hence improve overall performance. It also makes it easier in the future if you need to squeeze more parts out of the line. Manual workplaces are often easier and cheaper to optimize than automatic ones. In the worst case, you can simply create more manual stations and add more workers to speed up the line. However, speeding up an automatic process is often costly. You need probably more hardware, and a programmer that makes everything work again … and again if it didn't work out the first time … and again … and again. In sum, making an automatic process faster often takes more time, money, and effort than improving a manual station. Semi-automates processes fall somewhere in between.

Hence, having a faster machine to begin with does not hurt at all. You may even choose to get a faster machine from the very beginning to future-proof your line if you expect higher demand in the future. Although you would have to balance this with the cost of the faster automatic process. If you have a fast machine sitting around anyway, just use it. If you have a machine custom made, discuss with the supplier the price increase for a faster machine. Under no circumstances should you explicitly slow down an automatic process just to balance a line.

37.3 Processes That Cannot Stop Easily

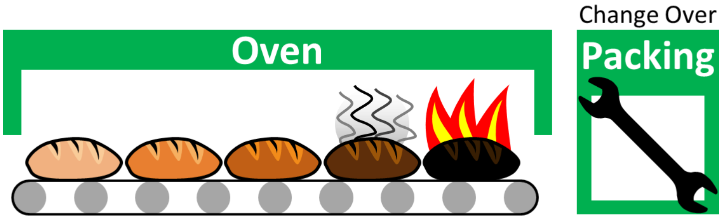


Figure 333: Burning Bread in Oven (Image Roser)

Another example where a line may be better off imbalanced is processes that are difficult to stop. These are often continuous processes. For example, let's take a food processing line. You are baking bread or pizza in a continuous oven. The time in the oven is determined by the speed (and length) of the belt in the oven. You can only stop the oven if it is empty, or you will damage your goods and potentially even start a fire with your (no longer) food stuff. Hence, the stopping of this baking process has the additional requirement that it is empty.

Figure 334: Slightly overcooked pizza. Do you still want it? (Image Slick in public domain)

This additional requirement complicates a lot of things. In a production line with FIFO buffers, one important concept is that the process must stop if the subsequent buffer is full. This prevents overproduction. However, unless we want to throw out all the stuff that got stuck in the oven, you have to stop the oven **before** the buffer gets full. The remaining items still go through the oven and then are buffered. This is possible, although there are two problems.

First, depending on your system, it may still affect quality slightly. Since there is less cold produce entering the oven, the temperature may be a tad higher and the products a tad more well done. Similarly, the first products that go through after the stop may also be slightly overcooked.

Figure 335: Angry Manager (Image Elnur with permission)

Second, you have to stop the oven before the buffer is full. This requires foresight, which may or may not be in plenty on your shop floor. Chances are, every now and then you may miss the cutoff point and end up with defective products. Additionally, there is also often a hesitation of the employees to turn of machinery. Maybe they turned it off before because a problem was coming up downstream, but the problem was fixed faster than expected and no turn-off would have been necessary. Management – with the wisdom of hindsight – may have then yelled at the workers for why they turned off the machine. A good standard can help, but it will only reduce the likelihood of it happening.

It may be much less of a hassle to design the processes before and after the oven faster than the oven itself. This would allow you to manage more fluctuations in the process through additional capacity before and after the oven. Subsequently, the oven has to be stopped less if there is a minor problem. Hence, you turn the oven into an intentional bottleneck, so that the oven does not stop because of other processes.

We can find similar examples in many industries, from steelmaking to paper mills, which are also my examples for the next reason not to balance your line.

37.4 Very High Investment Processes

Figure 336: Nippon Steel Yokohama (Image Roser)

Another situation where a production flow is created intentionally imbalanced is with processes that have significantly higher investment cost than other surrounding processes. A common example here is a paper machine or a blast furnace to make steel. While these are also difficult to turn off as explained previously, they are also a much higher investment that the processes that surround them.

Figure 337: A typical paper mill SCA Paper Mill (Image SCA Deutschland under the CC-BY 2.0 license)

Let's take the paper mill as an example. The machine that actually makes the paper is quite big and expensive. It makes a roll of paper (called a *tambour*) 12 meters (or more) wide and easily weighing 100 tons (or more). This roll is subsequently cut into smaller rolls, which then in turn are cut into sheets of paper, which then are packaged and shipped. If the line would be evenly balanced, it would be as likely to have the cutting process wait on the paper machine as the other way round.

A lost minute at the paper machine is much more expensive than a lost minute at the cutting machine. However, this is a somewhat theoretical calculation of cost accounting. More relevant is that it is much cheaper to create extra capacity at the cutting machine than at the paper machine, increasing the overall output for little money. Therefore, here, too, the paper machine is intentionally the bottleneck, and the value stream is intentionally imbalanced.

37.5 Summary

Overall, there are situations where imbalanced lines are sensible. Please note that when I say "not to balance a line," I don't mean to just throw the process speeds together randomly. You still have to think about it, and select certain workloads or speeds for certain processes. Different from the normal balancing, you just intentionally create an imbalance, and only if you have a good reason for this. Most lines should still be well balanced, and intentionally imbalanced lines are less common. Now, **go out, balance your line (unless you have a reason not to), and organize your industry!**

P.S.: This blog post originated from a small discussion between Prasad Velaga, Erik T. Hansen, and me on LinkedIn.

38 How to Do a Lean Transformation – The Toyota Approach

Christoph Roser, September 15, 2020 Original at https://www.allaboutlean.com/toyota-lean-transformation/

Figure 338: Lean start button (Image Olivier Le Moal with permission)

Companies continuously need to improve to survive. Lean can help them with this continuous improvement, so many companies aspire to become lean. The question is, how do you do that? How do you do a lean transformation, or more generally a change management? In this post I would like to talk about what is needed for a company to start their journey to lean. Be warned, it is not easy, and it does require a lot of support from the very top.

38.1 What Is Lean?

Figure 339: Example of the American culture? (Image vent du sud with permission)

To become lean, you should know what lean actually is. There are many definitions of lean production around, although I find all of them flawed (except the one that says lean is a *different name for the Toyota Production System*, but this does not help you much here). Often, lean is reduced to a set of tools, from kanban to SMED. But this is far from what it actually is. In my view, **lean is a culture!**

This brings up a few problems. First, **how do you define a culture?** This is nearly impossible. How do you define the <*your nationality*> culture? Any attempt soon turns into cliches and subsequently turns offensive. America: Hamburgers, flag waving, and guns? Germany: Wurst, beer, and “*Nein!*“? I think I better stop here before I offend too many of my readers. In sum, it is really hard to define a culture, including the lean manufacturing culture.

Figure 340: Example of the German culture? (Image master1305 with permission)

Second, **how do you measure a culture?** To improve, you would need to know where you are, and how much you have improved. Let's use the example of your nationality again. On a scale from 0 to 100, how <*your nationality*> are you? What criteria did you use to measure this? Again, it is pretty much impossible to have a quantitative measurement of a culture, although there are a lot of qualitative opinions.

Finally, **how do you change a culture?** This is very tricky. However, with lean we have it a bit easier than if we would like to change the <*your nationality*> culture. A corporate culture is often less diverse than the culture of a nation. If you enter, for example, a car company, the mindset of the employees is more aligned than if you would randomly pick people from the streets. It is still quite diverse, however, and the task at hand is not easy.

38.2 How Does Toyota Do It?

Figure 341: Toyota Headquarter Sign (Image Roser)

Before we discuss how to change your corporate culture, let's have a look at Toyota does it. Initially, the culture was homegrown. Hence, Toyota does not need to change its overall corporate culture. However, they often open new plants, many of them overseas, and they have to convey their culture, including the Toyota Production System, to the new location.

38.2.1 The Transformation of a Foreign Plant

They do this by shifting around a lot of workers. Large groups from the new location are brought to Japan to be immersed in the Toyota culture. Toyota sent hundreds of employees to Japan to learn lean. This includes not only bigwigs, but also a lot of frontline operators. The workers work in a Japanese Toyota plant to learn and understand how Toyota ticks. Such a stay is often four weeks, maybe more.

When these workers move back to their home country, even more Japanese workers come along. Most native managers in the new plant will have a Japanese "shadow" to coach and mentor them on how things are done. Toyota sends out hundreds of coaches from Japan to other locations. Many Japanese frontline workers will work alongside their foreign colleagues to also transfer the culture to the new location.

Even then, it does not always work out. Between 2000 and 2010, Toyota may have expanded too quickly, which may have lead to the frontline scandal with their gas pedals. CEO Akio

Toyoda admitted that growth at Toyota “may have been too quick” (but he may have been more worried about the technical side). But overall, their approach works. Toyota plants overseas often have much better quality and efficiency than the plants of the native competitor.

38.2.2 GM–Toyota Joint Venture NUMMI

Figure 342: NUMMI GM Toyota (Image Ellen Levy Finch (Elf) under the CC-BY-SA 3.0 license)

The famous example is NUMMI in Fremont, California, a GM-Toyota joint venture. It was originally a GM plant, and it was the worst of all GM plants. Even the unions said so. The culture was hostile, and everybody was miserable. Eventually the plant was closed. Two years later, it reopened as NUMMI together with Toyota. They even hired their workforce mostly from the previous GM employees. Many were worried about a repeat of the hostile culture. However, Toyota was able to turn it around, making NUMMI a place the employees were proud of. Quality and efficiency were on par with Japanese plants, and far, FAR better than any other GM plant. Absenteism went from 20% to 3%.

38.2.3 Why the Toyota Approach Does Not Work for You

Figure 343: Say hello to your seasoned lean experts! (Image Brussels Airport under the CC-BY-SA 2.0 license)

If you are reading this, trying to find out how to transform your own plant, it feels impossible. You would need a plant that already has this culture to learn from. You need hundreds of people of all ranks who have their lean culture deeply engrained. I don’t mean knowing how to SMED or kanban, or having a Six Sigma black belt. It means to live and breathe lean. From your point of view, it just looks like cheating, because Toyota has all of this but you don’t. Toyota sent six hundred employees from NUMMI to Japan for a month of training, and another four hundred coaches from Japan to NUMMI for months. Clearly, this is not a viable option for you.

38.2.4 Why You Probably Can’t Afford Toyota’s Approach Either

Figure 344: Piggy Bank (Image Ken Teegardin under the CC-BY-SA 2.0 license)

Before I go into the options you actually have, and before even an example on how NOT to do it, I would like to talk about the effort Toyota takes to bring its culture across. You have multiple larger groups visiting Toyota in Japan. Six hundred people from the USA all spend four weeks in Japan. While they do work and generate value, it is probably less than they would working normally at home. They also need coaching, mentoring, and training by Japanese employees. This includes frontline workers who train their foreign colleagues. You surely know that when you hire a new person, the first few months it will cost you more than what you get. Often, after six months or so, the performance is good enough to be comparable to a seasoned worker. It is somewhat similar when Toyota trains foreign workers in Japan.

I estimate that including the additional work for the Japanese hosts, it is similar to having six hundred workers for a month getting paid but bringing no benefit … all of this while on a business trip to Japan. Later, when additional Japanese workers and managers are sent to the foreign country to help the natives, they are also not quite as efficient as at home. Having a shadow for most managers is particularly expensive. Four hundred Japanese coaches stayed in the USA for months, or even longer than a year.

Just do the numbers in your head. The salary of six hundred people for one month, half of another four hundred people for a year, including many expensive managers, plus travel or expat expenses for all of them … it is a lot of money! Even if you had access to four hundred lean experts, you probably could not afford it. I do this calculation to show you how much it is worth to Toyota to transfer its culture to a new plant. And, yes, it does cost Toyota a lot too!

Figure 345: Sneaky Consultant $ to Cent (Image bramgino with permission)

Hence, you need cheaper options. This is possible, although it will take longer. However, it will still be quite an investment in time and money. If done right, it should pay off through better quality and efficiency. See it as a large development project. Of course, if the price is your main issue, you will be able to find consultants that promise you lean for cheap. "Just take two lean experts, preferably freshly graduated from university since they are cheaper, and give them the task to transform your one-hundred-fifty-location-worldwide corporation with 50 percent of their time." If you believe that, then I can't really help you.

But I will show you better in my subsequent posts. Since I am a fan of learning from mistakes – preferably the mistakes of others – I will first show you how it will NOT work. Until then, **go out, do lean where you can, and organize your industry!**

39 How NOT to Do a Lean Transformation – A Case Study of GM

Christoph Roser, September 22, 2020 Original at https://www.allaboutlean.com/failed-lean-transformation/

Figure 346: Failed Rocket Launch (Image gualtiero boffi with permission)

Becoming lean is an aspiring goal for many companies. In my first post I showed you how Toyota does it … and why this may not work for you. In this second post of this series I will show you how NOT to do a lean transformation, and try to highlight common mistakes. In a subsequent post I would finally like to show you possible options you have for your lean transformation. Read on!

39.1 How NOT to Do a Lean Transformation – The GM Case

Figure 347: GM Logo (Image General Motors for editorial use)

There are plenty of failures of lean transformations in industry. Most of them are known only to insiders, which usually are subject to confidentiality. Hence, I can talk about many failures only in abstract terms. However, there is one well-published example (also in my own book Faster Better Cheaper) that I can talk about: General Motors. They were able to train a lot of people in lean at the very source through their NUMMI joint venture with Toyota, but then squandered it all away. They had dozens of mid-level people well trained in lean, and hundreds of workers that believed and trusted lean, but they were unable to transfer this knowledge to their other plants. It is pretty much a textbook case on how NOT to do it. Many other companies also failed with lean transformations, but none failed from such an excellent starting position.

39.2 The Initial Situation – NUMMI

In the early ’80s, Toyota wanted to open its first major plant in the United States. To mitigate the risk they decided to do a joint venture. They first approached Ford, since they learned a lot from Ford before. However, Ford declined (and probably regretted it afterwards when lean became popular). They then approached GM, resulting in the New United Motor Manufacturing Inc. in Fremont, California, better known as NUMMI. The GM Fremont plant was by far the worst and most miserable plant at GM, and probably the worst in the USA. Eventually it was closed in 1982. When it reopened in 1984 together with Toyota, it quickly became not only the best plant of GM, but produced comparable quality and efficiency as the Toyota plants in Japan, despite having mostly the same workforce.

Figure 348: NUMMI GM Toyota (Image Ellen Levy Finch (Elf) under the CC-BY-SA 3.0 license)

This then was the golden opportunity for GM. They had a (joint venture) plant that excelled in lean manufacturing. Lean had the support of the staff, managers were familiar with the lean culture, and many people knew how to do lean properly. When other companies want to do a lean transformation, one major problem is always where to get a lot of people familiar with lean. GM got this handed on a silver platter. They did not have to learn "lean" from scratch, but merely transfer it to their other plants. And that was where they messed up big time.

39.3 Using Threats and Force to Do Lean

Figure 349: Motivating the employees? (Image kopitinphoto with permission)

GM decided to roll out lean in steps … which by itself is a smart thing to do. Two plants were selected to be transformed into lean plants, Van Nuys near Los Angeles and Norwood in Cincinnati. The sensible approach would then be to start with a few small projects within these plants, trying to have the people open up to lean, and build success stories to motivate. This would then build the base to spread lean throughout the plant.

But GM management had a better idea to motivate people. **Let's have them fight each other to the death!** Yes, you heard that right, they wanted a death match where only one (plant) could survive. They set up a lean competition, and the winner did NOT get closed, whereas the losing plant would be shut down. They used the threat of losing their job to force the workers to do lean. Obviously, right from the start, the employees of both plants were very suspicious of lean, and not motivated for lean at all. I wonder why …

39.4 Using Lean to Eliminate Labor

Figure 350: Fire 25% or fire 100%? (Image Roser)

So, the winning plant would not be closed. But, to GM, this of course did not mean that everybody kept their job. Oh no, **the goal was a 25% headcount reduction!** Hence, the GM workers had the choice between getting everybody fired by closing the plant, or getting one out of four fired. Talk about attractive options …

In effect, they were asking their workers for help to make themselves redundant. Unsurprisingly, the workers were very reluctant to fire themselves, and resistance against lean hardened. Unions called lean "the most dangerous scheme ever conjured up by GM to rob workers of their union."

39.5 Lack of Top Management Attention

Finally, and probably one of the biggest factors, was the lack of top management attention. Toyota managers are always very interested in all the details, wanting to truly understand how things work. Obviously, as a manager you cannot go into every detail, but Toyota focused much more in depth on a few examples, whereas GM managers were more interested in a shallow but wide view. Even then, GM managers did the equivalent of a "five-minute flyby," instead of spending real time with the situation. GM looked for methods and tools, but missed the big picture.

Figure 351: There is more to a culture than the clothes! (Image Hassan Abdel-Rahman under the CC-BY 2.0 license)

In my last post in this series, I described lean as a culture, using examples of different cultures. GM did the equivalent of dressing their workers in a kimono and pretending that they are now Japanese. Lean is so much more than just its tools. To use another example, buying the best paint and brushes you can get won't turn you into a Michelangelo. GM managers did not get that. A Toyota manager said that GM understood the process "as far as the hardware and the plant layout are concerned. But I'm afraid that GM upper management doesn't understand the basic concept."

39.6 Delegating Lean

The managers at GM were always looking for a magic bullet that they then could give someone else to use. They delegated the idea of lean to others, who further delegated it. There were people who knew lean well through NUMMI, but they were unable to initiate a transformation against the disinterest of the management and the opposition of the workers. They were also dispersed into small teams or individuals, and too small of a group to act effectively, even if there would not have been so much disinterest and opposition.

39.7 The Outcome of the Competition

Figure 352: Site of the former Norwood Plant in 2011 (Image Ohio Redevelopment Project under the CC-BY 2.0 license)

So, what happened to the competition? After all, it was Van Nuys against Norwood. Norwood rejected the idea of lean from the beginning, and not much happened. The workers at Van Nuys also rejected it, but management forced some lean tools on them, although they rarely worked as intended. You cannot do lean against the opposition of the workers. Even worse, the negative attitude affected other plants, and anything coming from NUMMI was resisted at by other plants. The skills learned by the GM people at NUMMI fell on dry and barren ground, and nothing came out of it.

Figure 353: "The Plant" mall, formerly GM Van Nuys (Image Cbl62 in public domain)

Since Van Nuys did at least pretend to do something, they looked better than Norwood, which did not do any lean at all. Hence, Norwood was closed in 1987. However, Van Nuys survived only five more years, before also being closed in 1992. It is now a shopping mall, aptly named "The Plant."

So overall, it was a mess. Lean did not take off at GM. They were not only unable to transfer the culture from NUMMI to other plants, but the other plants actively resisted lean. As so often, it was a failure by the management. To their defense, since then they have improved their Lean abilities, although it is still mostly tool-based and without much mindset change. Now, **go out, learn from mistakes instead of repeating them, and organize your industry!**

40 Key Points for a Lean Transformation

Christoph Roser, September 29, 2020 Original at https://www.allaboutlean.com/key-points-lean-transformation/

Figure 354: Lean Illustration (Image UncleFredDesign with permission)

In my last post, I showed you a good example of all the things you can do wrong during a lean transformation. Learning from these mistakes gives a list of points that are relevant for a lean transformation. Let me show you what is important for a successful lean transformation.

40.1 You Need to Convince Your People!

Figure 355: Skeptical Worker (Image Krakenimages.com with permission)

Lean is not a tool but a culture. Hence, you have to convince your people that lean can help them. This is also often called a mindset change. This is fundamentally different from installing a machine or developing a new product. Those you can simply buy or develop. Once the machine or product is there, your people can't undo it (or at least it is very difficult for the workers to have a product or machine removed).

Not so with lean manufacturing. Even many of the individual tools in lean manufacturing require cooperation and support by the people. If you want your people to stop the line if there is a problem, then they have to do it every single time. If you want to level your production, it needs constant attention by the people doing this task. The overarching concepts of PDCA and continuous improvement die on the spot if the people are not actively behind them. Hence, again, **you need to convince your people!**

Also, you do not need to convince everybody. This is impossible. If you randomly pick ten employees, there is probably at least one who is against the new idea in particular, and maybe even against the company in general. But you would need the support of the majority of your people.

40.2 How Do You Convince Your People?

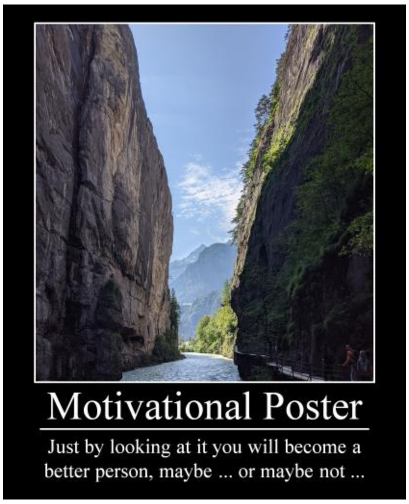


Figure 356: Fake Motivational Poster (Image Roser)

So now the question is, how do you convince your people? As we have seen in the last post, pressure, threats of unemployment, and a plant death match are not well suited to convince people of your ideas. This should be obvious, but apparently it is not always to all managers. Another popular approach is to simply tell your people that it is important. Maybe even put up some posters or similar. Or even hold a motivational seminar convincing your people of the new ways.

Unfortunately, this rarely works either. Many workers in industry have long since learned to ignore the background noise, ignoring what the bosses say, and instead look at what the bosses do. Managers sometimes overestimate the weight of their words. Hence, such verbal emphasis usually has little effect. At best, such talks or posters could have a minor supporting role; at worst, they could turn the people against it, based on the outcome of the last program that was advertised by such phrases. If the previous three *grand programs* always made the mess bigger, then a poster announcing the fourth will meet with resentment.

The more trust management has with their people, the easier it will be. A company that uses management by fear will have more difficulties in a lean transformation. But even if your management only has a mediocre respect among the workers, a lean transformation can still be done. Done well, it even could increase the reputation of the management.

40.3 Start Small

Figure 357: Strawberries Small Medium Large (Smaller strawberries Dllu under the CC-BY-SA 4.0 license, large one AnRo0002 in public domain)

The above is quite a challenge. Luckily, there are things that make it easier. At the beginning, you do not need their conviction, but it suffices if they are willing to give it a try. Hence, try to get them onboard on an improvement project to test the waters. Make sure you pick a case that is both relevant to the workers and has a high chance of success. For subsequent projects you can build on this success. The more successful projects you complete, the more the people will trust in the method.

40.4 Involve Your People

Figure 358: Ask us! (Image Cherie A. Thurlby in public domain)

Another VERY important part is to involve the workers in the lean transformation that affects their area. This has two main benefits. First, the chances of success are higher. Nobody knows the shop floor as well as the workers who work there every day. Access their knowledge to ensure the improvement actually works.

Second, the workers will have a higher level of trust if they were involved in the change. They distrust solutions that rain down from above without their involvement … and this distrust is often justified.

Of course, you cannot involve all employees in a lean transformation project. Depending on the topic, I find a group size of five to twelve people good. This should include representatives of different stakeholders, like management, engineering, maintenance, and especially the operators. As for operators, in most plants there are a few alpha males or alpha females who can shape the opinion of the group. Having them on the team and letting them help to develop a working solutions will make wonders toward the mindset of the whole plant.

40.5 Speak Their Language

Figure 359: Blah Blah Blah (Image studiostoks with permission)

So, now let's do a *vertical-approach heijunkaing and jidokaing by getting the buy-in of the empowered stakeholders leveraging our core competency by thinking outside of the two bin kanban*. I wrote this sentence, but, frankly, I don't even know what that means! You need to speak a language the people understand. While buzzwords, consulting lingo, and Japanese vocabulary may (or may not) impress the management, it will definitely turn off the workers.

While I do have a good Japanese vocabulary, I actively try to avoid using this when doing workshops. Use plain English (or whichever language you are working in) whenever possible. Some of the positive feedback I get after trainings is that I did not use a single Japanese word during the entire day.

40.6 Make It Benefical for Them

Finally, the projects should be beneficial for the workers too. GM thought it would be beneficial to GM to fire 25% of the people, but for some reason, the workers disagreed, and the projects floundered. Especially at the beginning, select projects that have a positive impact on the shop floor.

40.7 Management Committment

Figure 360: Management Comittment (Image DDRockstar with permission)

Finally, you need management committed. Managers are used to delegate tasks to others. After all, this is their primary job description, to *manage* others. However, you cannot delegate changing the corporate culture! While others can assist with some aspects of a lean transformation, it needs management support, not only passively allowing it, but actively driving it.

Figure 361: Trumpf Logo (Image Trumpf for editorial use)

Successful lean transformations as with Trumpf or Porsche had top-level managers that had not only the freedom to change but actively pushed their company in the right direction. At Toyota it was Taiichi Ohno, and at Trumpf, it was Mathias Kammüller. The latter learned lean through an extensive stay at a Bosch joint venture in Japan. He used this experience with lean to subsequently change Trumpf.

Hence, the manager at the top also needs to learn lean. This doesn't mean a theoretical knowledge of kanban, but actively leading lean projects. Lean is learning by doing. Like riding a bicycle, you can learn it only by actually … well … riding a bicycle. Books don't help you much here. The more a manager understands and acts the lean culture, the more he or she will be able to help and drive a lean transformation.

On the opposite end, management by cost accounting is more likely to hinder lean. Often, the benefits of lean projects are hard to calculate. Anything that cost accounting can't calculate is usually set to zero. If you believe this "zero," then lean has no benefit, even though in reality it does.

Overall, there are many requirements to start a lean transformation. Lean is a culture, and it requires a mindset change, a change in culture. People are not machines (even though managers occasionally like to see them as such). Every person is different, and hence every plant has a different culture. What may work for one plant may not work for others. It is not like flicking a switch, but is a constant work on improving the culture. In my next post, I will talk more about how to structure such a lean transformation. Now, **go out, convince your people of lean, and organize your industry!**

41 How to Roll Out a Lean Transformation

Christoph Roser, October 6, 2020 Original at https://www.allaboutlean.com/lean-transformation-roll-out/

Figure 362: Lean (Image Wrightstudio with permission)

The goal of a lean transformation is to shift the culture of an organization toward lean. In my last post I discussed a lot of prerequisites. In this post I would like to discuss how to actually do it. Be warned, there is no magic bullet. There is no simple trick that just turns lean on. It is a lot of hard work.

41.1 It Is Bottom Up

Figure 363: Top Down Bottom Up (Image Asmati with permission)

Top-level managers love to do things top down. After all, that is what they are getting paid for. However, you cannot make your organization lean through a top-down decree. At the same time, there is not enough manpower to change the entire organization bottom up at the same time (unless you have hundreds of lean experts available like Toyota). Hence, you have to start somewhere.

If your area of responsibility is small, then that’s where you will start. If, however, you want to transform a large enterprise with multiple plants, you have to pick one plant, or even one department within a plant where you should start. Since these projects serve to convince people as well as training them in lean, you should pick an area and topic where the chances of success are high, and where it matters to the operators. This would also mean … and I don’t really like saying it so bluntly but it is that way … to pick a location of your cultural background. You need to work with people a lot, and bringing cultural differences into the project makes it more difficult. Maybe do the foreign (to you) plants later.

Also, having one successful project is not enough. From the point of view of the operators, once is a fluke. After completing three successful projects, they are more likely to trust lean. They also know more about lean at that point. Once the lean spirit is strong enough to survive on its own, you can focus on other departments or plants. But make sure that the environment allows them to continue doing lean. It requires time, maybe even some invest, and people often only do it if management is watching at least every now and then.

41.2 You Need Capability Building

Figure 364: Training (Image Gerd Altmann in public domain)

The purpose of these lean projects is to not only motivate people for lean, but to also build capability. Lean is a lot of learning by doing. Your people need to practice lean to become good at it. Doing projects is the best way. Trainings and simulations can help them understand the theory behind it, hence you may also invest in some training. But again, the focus is on real projects on your real shop floor.

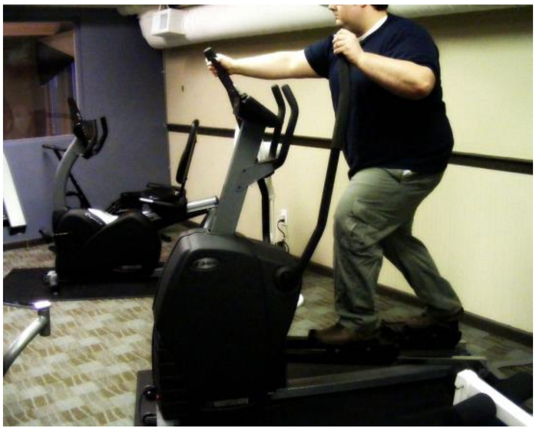


Figure 365: Can’t delegate that… Exercising Weight (Image Robert Anthony Provost under the CC-BY 2.0 license)

Did I say building capability of your people? What about yourself? Or your boss? Depending on your skills in lean, you should participate or lead at least a few lean projects yourself. Similar to the operators, leadership also needs to learn about lean. Again, lean is a culture, and a culture starts from the top. If the top executives have only a theoretical knowledge of lean, then it will be difficult. It is hard to support a culture if the person is not part of that culture. If the lean culture starts only half way down the hierarchy, chances are that the top may neglect or accidentally even harm the lean spirit. It is a bit like losing weight … you can’t delegate the exercise and dieting to others.

Depending on the lean capabilities you have in-house, or the lack thereof, you may benefit from an external coach that can help you with lean. Such an external support could take part throughout the entire transformation, although due to the cost many companies opt to use this help only during the initial stages of the transformation.

41.3 Check and Review

Figure 366: Blue Collar Meeting (Image style-photographs with permission)

Projects should be reviewed regularly by management and other stakeholders. Often this happens in a meeting room with presentations, which I find not so useful. An alternative is a meeting room with A3 reports, which is better. Best is of course to do it on the shop floor directly where the processes are. This does not mean PowerPoint presentations on the shop floor (I have seen those!). It means looking directly at the machine as much as possible. Depending on your circumstances, a weekly review is often chosen.

41.4 It Is a Long-Term Process

Figure 367: Observing the completion of his lean transformation… (Image Krakenimages.com with permission)

A lean transformation to change the corporate culture will take time. Probably more than you want. It is also hard to schedule this ahead of time. Projects are not necessarily completed with the due date, but are done if the C&A of the PDCA are completed. I understand the desire of management to schedule it ahead of time, but due to the nature of lean projects it will be tough to schedule one project, let alone a sequence of projects. The more lean experts you have, the more projects you can start. But don't spread them too thin. It is easier for them to work in small groups rather than with a standalone expert on its own. Also, once you have trained some experts yourself, you can send them to other locations to support the lean transformation there.

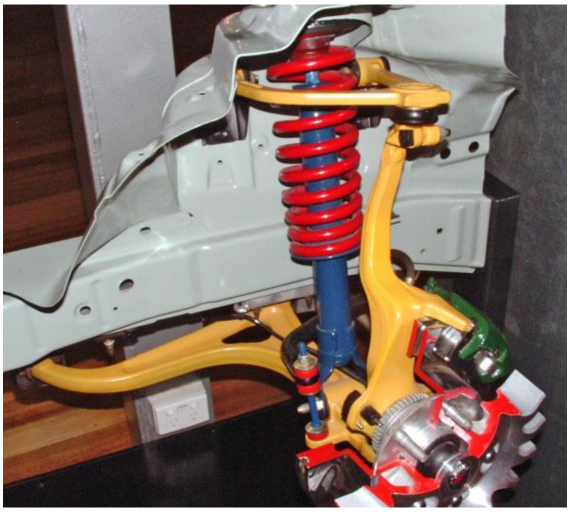


Figure 368: Steel or aluminum? (Image RB30DE under the CC-BY-SA 3.0 license)

This long-term process should also go into the same direction. Let's take a counterexample. In automotive there are frequent projects to reduce weight, especially around the wheels. The engineers dutifully replace steel struts with aluminum. Four years later there are similar projects to reduce cost. The engineers then dutifully replace aluminum struts with steel. Another four years later the priority is weight again and the struts are aluminum, only to be followed by another project four years later that replaces them again with steel to save cost. Overall, the company is not moving forward, but turning in circles. After a lot of work you end up where you started. Then you put in even more work to go there again.

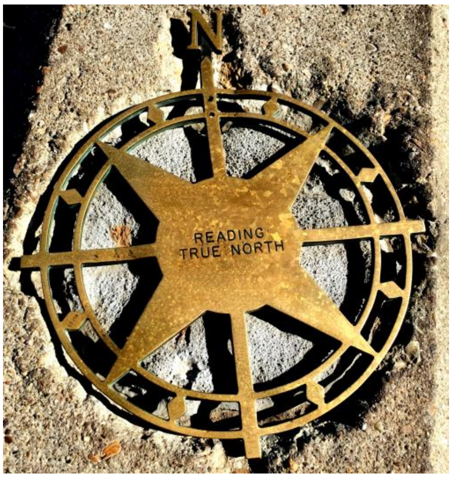


Figure 369: True North (Image Hike The Monicas under the CC-BY-SA 4.0 license)

Obviously, it is much better if there would be a consistent direction. This is often called True North. But it is not that easy to have a good true north. Often, everything is important (usually cost, quality, and time), sometimes with different priorities on different weeks. Even if you (or your boss) has a good idea of where you want to be, it may not survive the next change in command. One of the great things of Toyota is that they were able to drive the company in the same direction for 50+ years, across multiple generations of management.

Again, a lean transformation is not easy. It is based on lots of smaller individual lean projects, hopefully changing the culture of your company over time. Now, **go out, get the lean transformation going, and organize your industry!**

42 Why Are Fluctuations So Bad?

Christoph Roser, October 13, 2020 Original at https://www.allaboutlean.com/bad-fluctuations/

Figure 370: Abstract Wave (Image galinadvorak with permission)

Fluctuations are bad for manufacturing. In lean, unevenness is one of the three evils, besides waste and overburden. In this post I will give you an introduction to fluctuations. One option to handle fluctuations is decoupling, but this addresses only the symptoms and not the cure. In my next post I will show you how to actually reduce fluctuations.

42.1 Introduction

Figure 371: Descending into chaos… (Image NASA in Public Domain)

Fluctuations are part of all production systems. Fluctuations are actually part of everything. According to the second law of thermodynamics, entropy (disorder) can only increase in a closed system. Over time, everything, the whole universe, drifts toward chaos. Unfortunately, this includes your shop floor. It takes energy to reduce the chaos on your shop floor, but as soon as you stop taking care of your shop floor, chaos will increase again. Even with your best efforts, you cannot eliminate chaos completely, only reduce it. Hence, keeping fluctuations in check is a never-ending task on your list of to-do's.

Figure 372: Car Crash (Image Thue in public domain)

Fluctuations usually happen randomly. A machine breaks. A delivery is late. A customer buys a product (which, in itself, is not bad, but the irregularity in which it happens can cause problems). Other fluctuations are not random and may be, for example, cyclic like seasonality, or even planned like a not-leveled production plan. Any deviation from perfect monotony is a fluctuation. You won't be able to avoid all fluctuations. Even with lot size one, you will produce different products, whose different requirements and needs are a fluctuation.

Figure 373: Waves in a Pond (Image unknonw author in public domain)

The big issue with fluctuations is, unfortunately, that they do not stay in place. If you throw a stone in a pond, there will be a local splash, but also a wave that goes across the pond. Similarly, in a production system a fluctuation will run through the value stream, both upstream and downstream. A machine breakdown will empty inventory downstream, subsequently cause machine stops, and can eventually lead to a missed sale or a late delivery. The same breakdown fluctuation also travels upstream, filling up inventory, subsequently also stopping preceding processes, and even could lead to canceling an order with your supplier.

The ripple doesn't stop there. Both your customer and your supplier will be impacted by your fluctuations through the delayed or canceled order. Hence, this simple machine breakdown fluctuation can travel quite far in both directions of the value stream, even if the original cause may no longer be visible. Systems outside the value stream may also be affected. The machine breakdown may require additional efforts by maintenance, which may lead to a postponed planned maintenance somewhere else, which in turn may cause other problems.

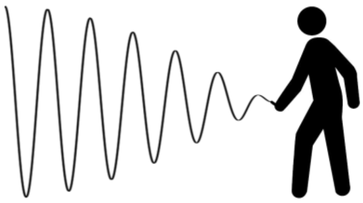


Figure 374: Bullwhip effect (Image Thwongterry under the CC-BY-SA 3.0 license)

Even worse, in some cases the fluctuation may increase. The affected systems try to manage the fluctuation, and inadvertently make it worse. Along supply chains this is known as the bullwhip effect. Overall, fluctuations are not good, but fluctuations traveling up and down (and sideways) on your value stream are really bad. A lot of the fluctuations you have on your shop floor originate from outside of your shop floor (although, don't worry, you also create fluctuations for others and give them a headache, too).

Figure 375: Three Evils of Manufacturing (Image Giuseppe Canino and flydime under the CC-BY-SA 2.0 license)

In lean language, this is one of the three fundamental evils in manufacturing. You probably know waste (無駄, muda). But there is also overburden (無理, muri) and – relevant here – unevenness (斑, mura). While overburden is considered the worst, unevenness is the second most important evil to fight. Mura can be translated as unevenness, inconsistency, erraticness, irregularity, or lack of uniformity.

It may not sound exciting, but you want your shop floor to be boring! In most cases, the fewer fluctuations you have, the better your system will run. (An exception where monotony would be bad is, for example, perfectly stable customers that consistently never order anything.) While some people live and breathe firefighting, not having to firefight in the first place is actually much better.

42.2 What About Decoupling?

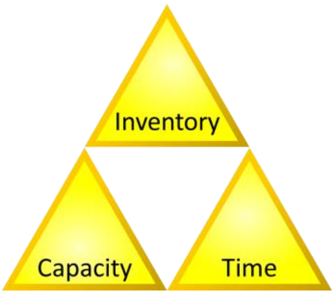


Figure 376: Triforce Inventory Capacity Time (Image Roser)

Fluctuations are much worse since they travel up and down the value stream. Hence, one possible way to work with fluctuations is decoupling. While the fluctuation still exists, decoupling will reduce the impact of the fluctuations on other parts of the system. In a way, you reduce the impact of fluctuations on others. In the best case you may even isolate the fluctuation to its origin, and have no other systems affected.

Sounds good, right? Well, you are already doing it to some degree. There are three fundamental ways to decouple fluctuations. For more, see my post on The Three Fundamental Ways to Decouple Fluctuations. The best known is **inventory**. You buffer fluctuations through inventory. If there is a disruption, buffers may keep other processes working by filling up or emptying, depending on the location. The larger the buffer, the better its ability to decouple fluctuations.

The second way to decouple fluctuations is **capacity**. You change the work time of your machines and workers to match the changes in demand. This is also done to some degree, but requires more effort and ideally an advanced notice.

The third way to decouple fluctuations is **time**. This is usually the default fallback if the other two approaches were insufficient. In effect, machines, workers, or customers wait until the issue is resolved. If you do nothing, time will take care of your fluctuations. Like ripples on a pond, they will eventually stop. Unfortunately, this is often the least desirable outcome. You usually don't want your machines and workers standing around doing nothing.

Sooo … if buffers decouple fluctuations … why don't I just put big buffers everywhere? Problem solved, right? Well, unfortunately no. Big buffers will decouple fluctuations in the material flow, although possibly not all. However, they come at a cost. There is the tied-up capital and the used storage space. But there are many more negative effects of inventories, including an increase of the lead time, administrative overhead, delay in the information flow, handling, aging and subsequent crapping and obsolescence, and more.

Figure 377: Extra capacity (Image zhaubasar with permission)

Similarly with just having tons of capacity available. Having extra machines and workers for the occasional fluctuation is also expensive, and hence it is done sparingly. Firefighters spend a lot of time waiting, but you don't want to run out of firefighters in an emergency. But for most manufacturing systems, this is only a limited option.

Overall, while you can decouple fluctuations, it does not address the problem, but only the symptoms. It also costs time and money. Lean is known (among other things) for reducing inventory. The idea is to reduce it to the inventory you need to decouple (most) fluctuations, and then to reduce the fluctuations itself so you can reduce the inventory even more. Hence, reducing fluctuations is more important than reducing inventory.

After this lengthy introduction on why fluctuations are so important, my next posts will look into how to reduce these fluctuations. But, please, don't expect miracles. Reducing fluctuations is a difficult, grueling, and never-ending effort. They are also a myriad of different causes of fluctuations. Now, **go out, get those fluctuations under control, and organize your industry!**

43 Structure for Reducing Fluctuations

Christoph Roser, October 20, 2020 Original at https://www.allaboutlean.com/reducing-fluctuations-structure/

Figure 378: Abstract Wave Molecule (Image Drevynskyi Maksym with permission)

This post looks at how to reduce fluctuations (mura) in manufacturing. It is a continuation of the previous post that looked at why fluctuations are so bad. Be warned, tackling fluctuations is often a tedious task that never ends, but it one of the important fundamentals for lean manufacturing. After all, the more stable a system runs, the more efficient it is. Leveling is one major method to reduce fluctuations that focuses on the production schedule. Line balancing is another one that focuses on the work content.

43.1 How to Tackle Fluctuations

The process of reducing fluctuations follows a certain schema. I will go into more details of each of them later on. The illustration below also visualizes this approach. And again, it is tedious work!

- First, you would have to find the fluctuation to tackle.
- Next you have to check where it originates. If it originates outside of your area of responsibility, congratulations, you have found the probably most difficult problem. Not only do need to find the root cause, a solution, and implement the solution, but you also have to convince the person in charge to do so.
- If it is within your area of responsibility, it is a bit easier. You have to distinguish between random fluctuations like machine breakdowns, and predictable fluctuations like seasonality. If it is random, you have to find the root cause before developing and implementing a solution.
- If the fluctuation is predictable, then you have to distinguish between unplanned fluctuations like seasonality, or planned fluctuations like your production plan. The easiest case is probably a planned fluctuation, because (in theory) you could reduce it merely by changing your plan. In any case, you still need to develop a solution, implement it and check if it worked.

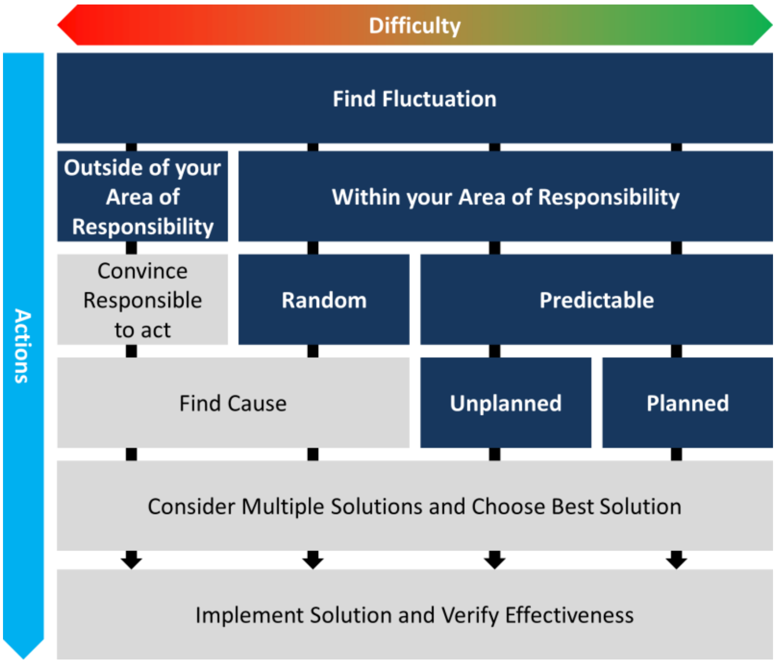


Figure 379: Fluctuation Structure (Image Roser)

However, please note that due to the large number of possible reasons for fluctuations, this guide is only a rough outline. There are still plenty of things for you to analyze and decide on.

43.2 Select Fluctuation

Figure 380: Which wave to tackle? (Image NOAA under the CC-BY 2.0 license)

The first question is which fluctuation you want to tackle. This is not an easy question. There will be lots of sources of fluctuations on your shop floor. It will feel like a ship in a stormy ocean, trying to decide which wave to investigate. It may be that you don't even have much time to investigate a wave in more detail, since you are just trying to survive a wave. After this wave has passed, you are just trying to survive the next one, and so on. Switching this metaphor to the shop floor, you are constantly firefighting but not changing any of the fundamentals. You need to find time to reduce the size of the waves hitting you!

Figure 381: Calm seas (Image marekssteins in public domain)

Maybe you are in the lucky situation that your waves are already much smaller. You are no longer in constant fear of drowning, but try to optimize yourself and make the waves even smaller. While this is probably much more profitable than a stormy ocean, it still leaves you with the problem which wave to tackle. And again, this is not an easy question. Toyota does quite a bit of monitoring to detect fluctuations, so it can act upon them.

Anyway, regardless if the waves are crashing over your head or just gently rocking your boat, you have to pick one to look at in more detail. Chances are that you have certain types of recurring problems. Those that give you the biggest headaches are potential candidates for improvement. Select a few of them for further consideration.

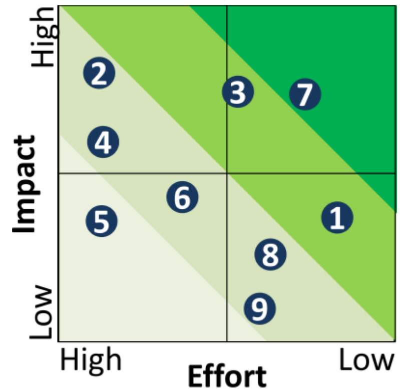


Figure 382: Impact effort matrix (Image Roser)

Like most improvement projects, the trade-off is between the impact and the effort of getting the impact. As explained in a previous post How to Manage Your Lean Projects – Prioritize, this is easiest done in an impact-effort matrix. Please note that both the impact and the effort are guesstimates. You probably don't have any hard values, but take your (or your people's) best guess.

43.3 Fluctuations Originate Outside Your Area of Responsibility?

Figure 383: Man on Island (Image sabelskaya with permission)

Fluctuations can have a multitude of reasons. Your next steps depend on a couple of questions as described above. The first question you should ask is if the fluctuation originates within your area of responsibility, or not. If it is within your area, you have good control of the possible actions. It will be more difficult if it is from outside of your area. For example, if your supplier's quality is rather unpredictable, then you have to work with your supplier to improve quality.

The frequent problem with fluctuations originating from outside your area is the challenge to motivate others to work on the fluctuation. Hopefully, your supplier is actually willing to work on what is essentially your problem. Depending on your connection to the supplier and your influence on the supplier, the supplier may or may not be interested in the additional work to reduce fluctuations. In the worst case, you will get empty promises and no results. This can happen especially when you're only a small customer for the supplier.

However, do consider that even though you think the fluctuations come from the supplier, they may actually originate with you! For example, if the deliveries of the supplier are somewhat chaotic around the desired delivery date, check if you don't actually order just as chaotic on short notice from the supplier. There are probably other fluctuations that caused the fluctuations of the supplier, and it rarely originates only from one location.

Such situations can quickly turn into a blame game. You blame your supplier, your supplier blames you or someone else, who then again blames someone else. Soon, the week is over, everybody is frustrated, and nothing has improved. Don't go down that road; nothing useful will come out of it.

It is much better to address fluctuations originating from your own area of responsibility. These you can actually improve yourself … although it may be more work than just blaming someone else.

43.4 Random or Predictable Fluctuation?

Figure 384: Random events (Image spass with permission)

The next question you have to ask yourself is if the fluctuations are random or predictable. Predictable ones are easier to understand, because you probably already know why the fluctuation is happening. Seasonality is a common, predictable fluctuation. More difficult are random fluctuations. They happen with no warning. Common examples are machine breakdowns. Often with random fluctuations you first have to find out why the fluctuation is happening. This will feel like a detective work. You have to collect clues (data) to understand the situation and to catch the killer (the fluctuation).

Actually fixing it may often be quite simple. I had plenty of situations where a machine was behaving erratically and messing up the material flow just because a sensor came loose over time. Simply tightening the screws fixed the problem.

43.5 Planned or Unplanned Fluctuations?

Figure 385: Electrical Engineer (Image NACA in public domain)

The final question to ask is if your fluctuations are planned or unplanned. Many fluctuations are unplanned. Some are at least predictable like seasonality, but others are almost impossible to predict like machine breakdowns. However, some other fluctuations are actually planned! This sounds counterintuitive, because why would you plan fluctuations? However, by setting up a production plan, a work schedule, or an imbalanced line, you actually plan fluctuations! Planned fluctuations are hence often easier to understand, since they are … well … planned. To reduce them you just have to … well … plan better. Key examples here are leveling or line balancing. In my next post I will talk a bit more on the difficult topic of reducing fluctuations. Now, **go out, tackle those waves, and organize your industry!**

44 Reducing Fluctuations Upstream

Christoph Roser, October 27, 2020 Original at https://www.allaboutlean.com/reducing-fluctuations-upstream/

Figure 386: Abstract Wave Water (Image Lotus_Studio with permission)

This post will list a number of tools that can help to reduce fluctuations. They can reduce fluctuations in the material flow, including its inventories and the durations and lead times. Since reducing fluctuations (mura) is an underlying important idea throughout lean manufacturing, a lot of tools can help. And, depending on how you interpret tools, this list is not even complete.

44.1 Source – Make – Deliver

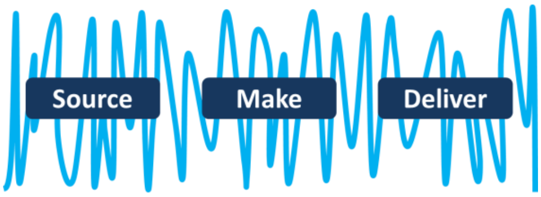


Figure 387: Source Make Deliver Fluctuations (Image Roser)

Fluctuations can happen anywhere along the value stream, or even outside it if a support process acts up. But most commonly it happens in the value stream before your area, in your area, or downstream of your area. Hence I have listed selected methods from the lean toolbox along source, make, and deliver. The source may be your suppliers, but also could be production systems in house that supply your area with material. In general, it is upstream of your area. Similarly, deliver could be your customer, or a production system in house that takes your material. In general, it is downstream of your area.

I have grouped these tools where they have the largest impact, although many of them have a positive effect on the entire value stream. Leveling is one example that can reduce fluctuations both downstream and upstream. Most of these tools can be done within your area to have a positive effect somewhere else in the value stream, which in turn will again benefit you.

44.2 Source

44.2.1 Reduce Part Variants

One way to reduce fluctuations is to reduce part variants. It is general wisdom (and also accepted science) that larger parts volume fluctuate proportionally less than smaller part volumes. The product you make only a few times per year will be much more random than the product you make every day. Hence, reducing part variants will reduce your fluctuations.

Below is a structure on how to decide if you can remove a part. However, I can tell you by experience that reducing a part variant is an uphill battle. It feels like Sisyphus work. You put in a lot of effort to reduce three part variants, and at the same time thirty new part variants are introduced. To change part variants, you need support from design and development. Unfortunately, design and development lives to create new stuff, not to eliminate old stuff, and hence they may be less enthusiastic about it. For more on how to reduce part variants see my posts on Design for Assembly Questions Part 1 and Part 2.

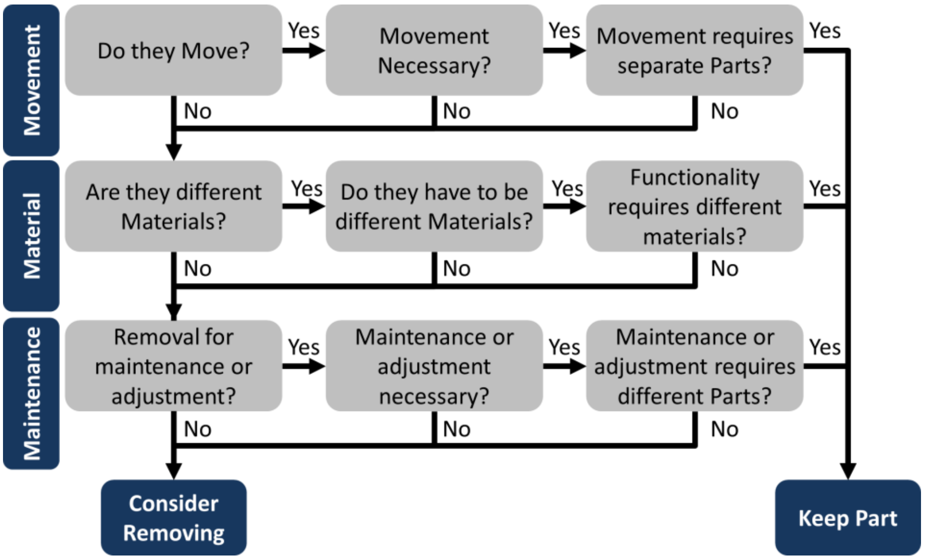


Figure 388: DFMA Logic Tree Remove Part (Image Roser)

44.2.2 Local Suppliers

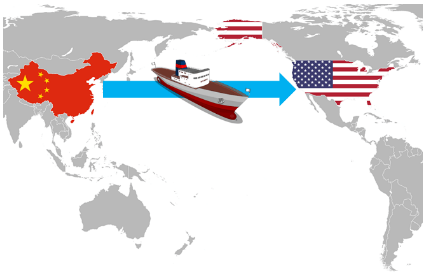


Figure 389: Long-distance supply (Image Roser)

Another option is to use more local suppliers. The farther away your supplier is, the longer it takes for material to arrive. Any adjustments or changes need time to pass through the value stream before they are effective at your location. Similarly, but usually underestimated, the distance also makes the information flow more difficult. Long distance communication is possible, of course. But a lot more information can be conveyed and faster if you just visit your supplier or vice versa.

This delay in material and information flow increases fluctuations, as it takes time to work against them. If your sales go down and you want to reduce production, tough luck. You still have three months of goods in the supply chain from overseas. You either produce and store completed goods, or store excess parts. Chances are also that you may overreact and tell the overseas source not to produce anything, since you have three months' worth of inventory that you don't need. When the market improves again, it will take three months to get parts again. What I just described you is the well-known bullwhip effect. We had exactly this situation during the 2007 financial crisis, and will have the same situation during COVID-19.

Many automotive plants try to have local suppliers. Seat makers especially are often literally next door or even on-site at the car plant. Toyota in Toyota City has the majority of its suppliers within a two-hour truck drive, making it so much easier to deliver just in time.

44.2.3 Leveling

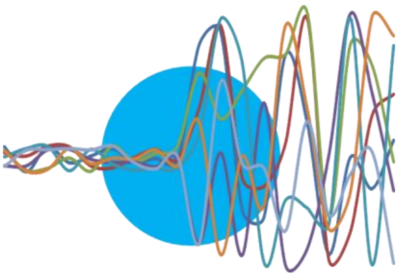


Figure 390: Leveling (Image Roser)

Leveling is a major tool to reduce fluctuations. I listed it here under "Source," but it also has a large effect on the "Make" part. I.e., it will not only make life easier for your supplier, but also for you.

Please note that there are different ways to level. I am all in favor of sequencing your lot sizes every day as evenly as possible. This should be feasible for pretty much everybody, regardless of lot size.

Figure 391: One Piece Flow (Image Roser)

I am very hesitant to use a longer pattern. Often, leveling is seen as a multi-week pattern, where the entire production plan is defined weeks in advance. The major (!) problem is that due to other fluctuations, very few companies can actually follow a production plan that was set up weeks ago. Most companies can't reliably produce on Wednesday what they planned on Monday! Being forced to change the multi-week plan on short notice will increase the fluctuations, not reduce it. Hence, such a multi-week pattern often has the opposite effect of **INCREASING** fluctuations!

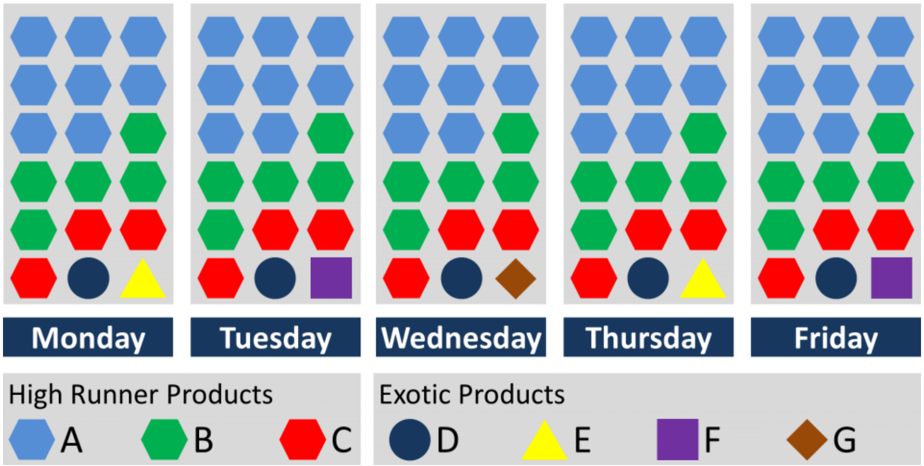


Figure 392: Leveled Example (Image Roser)

You can find more on leveling in my series of posts starting with Why Leveling (Heijunka) Is Important, including the good approach Introduction to One-Piece Flow Leveling Part 1 and Part 2, and the not-so-good approach Folly of EPEI Leveling in Practice Part 1 and Part 2.

44.2.4 Reduce Lot Size

Figure 393: What is your lot size? (Image otsphoto with permission)

Finally, you can reduce fluctuations simply by reducing your lot size. This will also have beneficial effects on both your source and your own area. The perfect lot size is one. However, not every company can achieve a lot size of one right away. However, reducing a lot size is in general beneficial, as long as you can still produce what you need within the given time including change overs. And, always remember, change overs can be optimized using SMED! Any reduction in changeover time is usually best invested in more changeovers and a reduction in lot size. For more, see my series of posts starting with How to Determine Your Lot Size. For some inspirational examples, look at Toyota's and Denso's Relentless Quest for Lot Size One.

In my next post I will look at tools that can help you with reducing fluctuations in your own area, in "make." Now, **go out, reduce your source fluctuations, and organize your industry!**

45 Reducing Fluctuations on Your Shop Floor

Christoph Roser, November 3, 2020 Original at
https://www.allaboutlean.com/reducing-fluctuations-shop-floor/

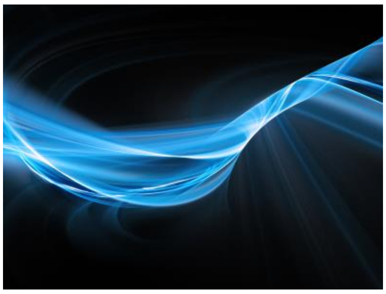


Figure 394: Abstract Wave Blue (Image Hisoka with permission)

Fluctuations can also originate within your area of responsibility. In my previous post, I looked at how to reduce fluctuations coming from upstream. In this post I look at your shop floor. Using the source-make-deliver structure, this post is about reducing fluctuations at "make."

45.1 Make

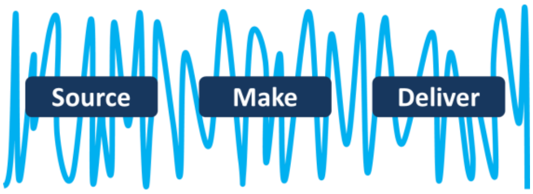


Figure 395: Source Make Deliver Fluctuations (Image Roser)

There are a lot of possibilities for reducing fluctuations in the "make." Some are of technical nature, like line balancing and preventive maintenance. Others are organizational, like flow shops and pull production. Please note that besides the methods listed in this post, there is also leveling and lot size one, as explained in my last post.

45.1.1 Line Balancing

Figure 396: Hands Circle (Image Robert Kneschke with permission)

Line balancing is having all your stations produce at roughly the same speed, ideally the customer takt. This reduces fluctuations in the work content. While it may not be obvious, this is also a source of fluctuation: it fluctuates the workload of your workers. Alternating between idle and working are fluctuations (mura), which in turn can create both waste (muda) and overburden (muri). Balancing your line reduces such fluctuations, and improves your system performance. For more details I have a six-post series only on Line Balancing.

45.1.2 Preventive Maintenance

Figure 397: Repair with Barrier (Image dashadima with permission)

Preventive maintenance, or even maintenance in general, can reduce the tricky fluctuations of machine breakdowns. However, this is often tough, since you may not know why the machine broke down in the first place. Even if you do, there may be many different reasons why a machine breaks down. Identifying the main reason for the breakdowns is tricky and may take some time. However, it is worth it. The solution is often surprisingly simple.

I have many examples of such problems. For example, one machine that tested some tubing had an O-ring wear out every two weeks. The number of defects increased, not because the product was faulty but because the testing machine was. This led to a loss of a couple thousand euros worth of products every two weeks until the O-ring was fixed. The simple solution was to replace the O-ring not after it wore out but before. Instead of fixing it every two and a half weeks when defects increased, it was automatically replaced every one and a half weeks, before it wore out. The O-ring cost around 0.03€.

Another example is a machine component that counted sheets. Unfortunately, there were frequent miscounts, and maintenance could not find out why. Eventually someone figured out that the screws attaching the component to the machine were loose. The component was simply wobbling and hence miscounted. The fix was easy: just tighten the screws, and maybe add some adhesive so the screws didn't come loose by themselves again.

There are plenty of other examples where something broke and the problem went away after it was fixed. A shaft bearing was broken, creating more faulty products. An air ventilator was clogged, causing the machine to stop due to overheating. A cable was not plugged in, leading to wrong data. Once you find it, the fix is not that difficult.

45.1.3 Flow Shops

Let's start with the fact that I love flow shops! They make a lot of things so much easier. Efficiency, visual management, control, productivity – almost every important KPI improves in a flow shop compared to a job shop. And this of course includes fluctuations!

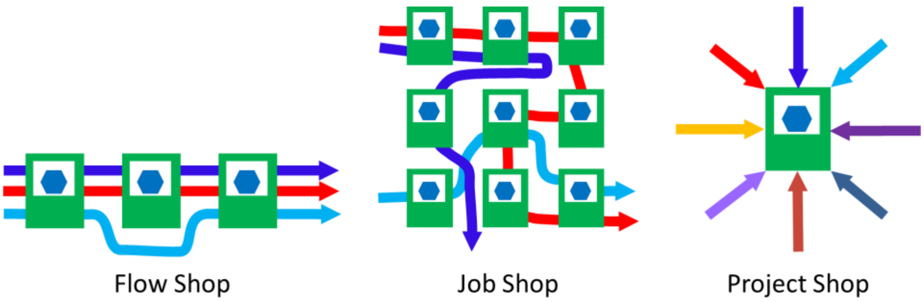


Figure 398: Flow Shop, Job Shop, Project Shop (Image Roser)

Job shops usually have an irregular material flow, which sometimes put loads on one process, sometimes on others. It is hard to balance the workload, it is hard to keep a steady flow, and it is hard to keep the inventories under control. All of this is much simpler in a flow shop, where you can balance the workload more easily, define clear inventory buffers, keep all processes working at the same time, and have a steady and stable stream of material coming out. If it is in any way possible, try to convert a job shop into a flow shop. For more info, see my posts Why Are Job Shops Always Such a Chaotic Mess? and How to Convert a Job Shop into a Flow Shop.

45.1.4 Pull

Figure 399: Children Tug of War (Image Christian Schwier with permission)

Pull production is another way to reduce fluctuations. The basic concept behind pull is to have an upper limit on your inventory. Whenever an item leaves the system, another job is started. This avoids the clumping together of jobs and makes production much more smooth. It also avoids the dreadful bullwhip effect, where fluctuations can increase along the supply chain.

The best known approach to implement pull is kanban, but there are many others like CONWIP, POLCA, or reorder point methods. I have written many post on kanban, so look at my list of post for kanban-related topics. A book on pull production is currently on the final stages of editing. Of my many posts on pull, I especially recommend The (True) Difference Between Push and Pull and Why Pull Is So Great!

45.1.5 Just in Time, Just in Sequence, and Ship to Line

Figure 400: Relay Race Hand Over (Image tableatny under the CC-BY 2.0 license)

Just in Time (JIT), Just in Sequence (JIS) and Ship to Line (STL) are a few related tools that streamline the material flow both inside and outside of the plant. Toyota even considers Just in Time as one of the two main pillars of their Toyota Production System (along with Jidoka; see next heading).

The underlying concept of Just in Time is that material arrives when it is needed, where it is needed, in the right amount and in good quality. Too much, too little, too early, and too late should be avoided. But be warned, Just in Time is not easy and requires already a system with few fluctuations. I have seen plenty of plants that showed me their Just in Time inventories … worth 3 days of production or more …

Just in Sequence is the idea of having parts arrive in the right sequence as they are needed at the assembly line. This makes sense only for expensive or big parts. It is often used for seats in automotive. Finally, Ship to Line is the idea of moving material directly from the loading docks to the line, without any warehousing in between (but possibly with a shuffling area). Any Ship to Line system is also Just in Time, as you can't have any inbound warehousing for your goods. Therefore it also requires an already pretty stable system with few fluctuations.

45.2 Jidoka

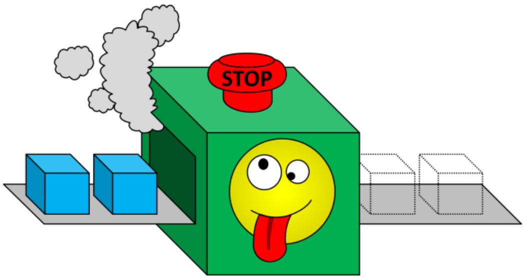


Figure 401: Broken Machine in Jidoka (Image Roser)

Finally, the second pillar of the Toyota production system is Jidoka, also known as Autonomation. The idea is that a machine detects abnormalities by itself. Such abnormalities could be quality issues, process issues, or lack of material. If such an abnormality is detected, the machine stops automatically.

This may sound counterintuitive. If you want to reduce fluctuations, why do you stop your machine? Well, because if you don't, the fluctuation later on to fix the mess will be much larger than if you did not stop your machine!

There are probably even more methods or tools to reduce fluctuations on your shop floor. Most lean tools are connected to reduction of fluctuations. But for now, these should suffice. In the next post I will talk about how to reduce fluctuations on the customer side of your value stream. Now, **go out, get those pesky fluctuations under control, and organize your industry!**

46 Reducing Fluctuations Downstream

Christoph Roser, November 10, 2020 Original at https://www.allaboutlean.com/reducing-fluctuations-downstream/

Figure 402: Abstract Wave Dots (Image INGA RA with permission)

This last post of my series looks at fluctuations that originate downstream from your location. In other words, how to reduce fluctuations originating from your customer. Granted, this often is the most difficult one, as you usually have not so much influence over your customers (unless you have a monopoly). Let's have a look.

46.1 Intro

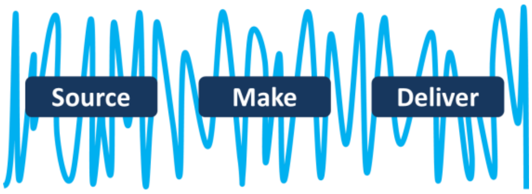


Figure 403: Source Make Deliver Fluctuations (Image Roser)

Again, following the source-make-deliver structure, we now look at "deliver." This is your customer. It may be the end customer; however, it could also be simply the next stage in the value stream, which again is your customer.

As always, there is the possibility to decouple using buffer inventories. Or you could adjust the capacity to better match the customer demand. However, these two approaches address only the symptoms and not the cause of the fluctuations.

46.2 Deliver

Figure 404: Deliver! (Image nullplus with permission)

Your overall goal in reducing fluctuations originating from your customer is to have your customer order more regularly. Unfortunately, you usually don't have enough influence in simply telling the customer when to order. However, even then there are some methods that nudge your customer to order more regularly.

46.2.1 Sales Promotion

Figure 405: 15% OFF (Image Roser)

One popular method is a sales promotion. You reduce the price to increase sales. Similarly, you could also increase the price to reduce sales. By adjusting the price, you can change the customer behavior. However, this also affects profit. Maybe you sell more items but with lower profit, or less items but with higher profit, in any case it has an influence on the profit. If it helps you to make more profit, then you should have done this already just for the money. If it reduces profit, you have to be careful that the cure of lower profit is not worse than the disease of less fluctuations.

A similar approach that keeps the price stable is a marketing campaign. You do not change the price, but merely motivate more people to buy your stuff. But be aware that marketing is a bit of a magic black box that does not always work.

These approaches have some delay between the implementation and the change in the behavior. Hence, it is more for longer-term fluctuations. It is also helpful if you can predict a change in demand beforehand. A key example is seasonality, but it may also be an upcoming legal change, or an increase or decrease in the sales tax. In any case, by carefully adjusting these levers, you may be able to reduce the magnitude of fluctuations.

This does require coordination between sales on one side and production and/or logistics on the other side. I was on the receiving end of a very successful sales and promotion campaign that hit my shop floor with increased orders when we were not even able to satisfy the initial demand. It increased the fluctuation and led to many delayed deliveries, but sales looked good because they sold stuff. Anyway, poor coordination can lead this to backfire.

46.2.2 Expand Markets

Another example to counteract fluctuations is to expand markets. This can work in multiple ways. In general, the larger the sales volume, the smaller the fluctuations compared to the sales volume. Hence, if you sell more, your fluctuations grow slower than the output. And, management usually does not mind if the profit grows along with the increased sales.

Figure 406: Your anti-cyclic customer (Image Donald Hobern under the CC-BY 2.0 license)

If it is a seasonal fluctuation that you want to reduce, you should try to expand into new markets that have an anti-cyclic behavior. Skiing gear usually is highly seasonal, but in Australia the skiing season is July and August. Unfortunately, there are only 25 million people in Australia, plus another 5 millioon in New Zealand. Don’t you wish Australia and New Zealand would have more people?

46.2.3 New Product Variants

Figure 407: Your anti-cyclic product (Image Malcolm jarvis under the CC-BY-SA 3.0 license)

There may also be a possibility to introduce new products that have an anti-cyclic seasonal behavior. If you are making ski sticks, consider expanding into hiking sticks. The whole idea of Nordic Walking originated from the desire to have a product that you can sell in summer.

46.2.4 Reduce Product Variants

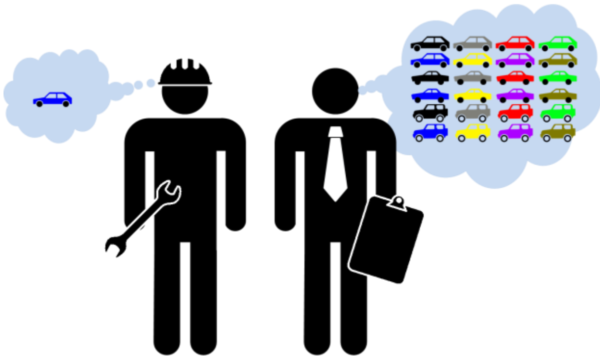


Figure 408: Sales and Manufacturing Dream (Image Roser)

Another option is to reduce product variants. This may be confusing, since the previous suggestion was to add new product variants. However, the additional variants were for anticyclic markets. The reduced variants are for the "normal" market.

This works in two ways. First, reducing product variants will (hopefully) increase sales of the reduced variants. Higher quantities mean automatically a more stable demand.

Figure 409: One of the many variants for glove compartments… (Image Tim under the CC BY-ND 2.0 license)

Second, it means less components and products to track. You also get higher demands for fewer components. A common example is cars. If you buy a Toyota, there are a few model variants, with few options. Most Western car makers have many more options, which increase the fluctuations and subsequently the overall cost. An Audi A6 has over 150 variants for the glove compartment alone, and 18,800 variants for the door cover. Think of the logistic nightmare of having 150 different glove compartments for the same car! Reducing some of these variants will have a lot of benefit, one of which is the reduction of fluctuations.

Be aware that you may face a lot of resistance from sales and management in general when you want to reduce product variants. Their argument is that having more different products allows you to capture more market niches. They are, of course, also correct. Normally you would do a cost-benefit analysis, but in this case there is probably no hard data neither for the extra market niche nor for the reduction in fluctuation. Such situations where you have to argue based on opinions rather than facts can quickly get messy.

So, as you can see, there are some options for reducing fluctuations on the customer side. Of course, these require effort and may also cost some money. You have to decide which one is worth the cost. Also, I never said it is easy. Overall, it may be easier and better to start reducing fluctuations with “source” or “make” rather than “deliver.” Nevertheless, I hope this gave you some inspiration. If I forgot anything that you think can also help, please let me know. Now, **go out, reduce your fluctuations, streamline your system, and organize your industry!**

47 The Impact of Brexit on Supply Chains

Christoph Roser, November 17, 2020 Original at
https://www.allaboutlean.com/brexit-and-supply-chains/

Figure 410: Brexit Banner (Image bennymarty with permission)

On December 31, 2020, the transition period will end and United Kingdom will be out of the European Union. Brexit will be complete. But I fear the mess will be only starting. In this post I want to look at the impact of Brexit on supply chains. It won't be pretty.

47.1 Background

Figure 411: The decline and fall of the British Empire? (Cameron unknown author under the Open Government Licence version 1.0, May Tomasz Ostrowski under the CC-BY 2.0 license, Johnson EU2018BG Bulgarian Presidency under the CC-BY 2.0 license)

A political gamble by British prime minister David Cameron in 2016 led to a non-biding referendum on the European Union membership of the United Kingdom. Amid much disinformation, 51.89% of the people of the United Kingdom voted to leave the European Union. David nope'd out of his own mess and resigned. His successor, Theresa May, formally triggered the withdrawal process known as Article 50 in 2017. This process allowed for two years to negotiate the future relationship, which didn't happen. Theresa also resigned from this mess in 2019, and Boris Johnson took over. He signed the withdrawal agreement in 2020.

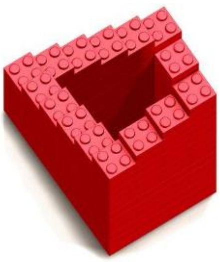


Figure 412: Step after step, moving … nowhere? (Image Claus Lunau under the CC-BY-SA 3.0 license)

However, this withdrawal agreement only covered the very basics, like the "divorce bill," citizens residence rights, the border in Ireland (where Northern Ireland sort of stays in Europe and the border is in the Irish Sea), the European Court having the final say on EU-UK disputes, and a transition period that ends December 31, 2020. It included not much on the flow of goods, stating only that items that were sent out before the deadline should be delivered, even after the deadline.

There has been lots of time for negotiating the future relationship. Politicians frequently announced another "step forward," but apparently they were going in circles. As of now, it looks like there will be a no-deal hard Brexit at the end of the year. This is sometimes euphemistically called an “Australian-type deal” … but the EU doesn’t really have a deal with Australia. Trade would revert to the rules of the World Trade Organization.

47.2 What Will Happen on January 1, 2021?

Figure 413: Happy New Year 2021 … or not (Image New Africa with permission)

On January 1, 2021, Britain will be, for all legal purposes, outside of the European Union. It looks like there will not be any trade agreement between the EU and the UK. Britain does not have many trade agreements with other countries either. The only deal I know of is with Japan, and it is not any better than the deal the EU had with Japan. With trade, Britain is to the EU the same as Palau, Somalia, Sudan, or the Vatican. Trade between the EU and the UK falls back to WTO terms. This means taxes and paperwork.

But before normal taxes and paperwork come into play, something else will happen: **Confusion!** When your markets change, they usually do so over time, and companies can adjust. Legal changes, however, will be abrupt. When the clock strikes midnight on New Year’s Eve, a whole new set of rules comes into play. In theory, they are known beforehand. In practice, however, they are complex and hard to understand, and it will take time for the people to learn these rules. Specialized software tools are programmed to help with this paperwork.

For example, Her Majesty’s Revenue and Customs (HMRC) developed a Customs Declaration Service (CDS), at a cost of around £100 million. It is claimed that this software is ready, but I believe on January 1, it will be at best only an alpha test. Have you ever seen a custom made software that worked right from the start? I believe it will be a mess. This software also communicates with other software at retail and industry, and it seems many of these interfaces will not be ready in time, let alone working reasonably well. There is also a lot of training to be done for the people to use these tools correctly.

Figure 414: The Bottleneck in Kent (Image Nilfanion, modified by Roser under the CC-BY-SA 3.0 license)

In sum, **people who have little understanding of the legal framework and little training will use an alpha version of a software that cannot communicate with the other software tools. What could go wrong?** I expect at least three months, but probably six months or more, of chaos. After six months, a resemblance of normality may come, but only because trade has dried down to a trickle and the available workforce has had more time to sort out every individual declaration. There may also be similar problems on the EU side, but I expect them to be fewer, since the EU seems to be a bit better organized. The UK expects large delays, and is building gigantic overflow parking lots. They even created an artificial internal border, and you will be able to enter Kent (where most goods pass through) from the rest of the UK only with a permit. The UK likes taking control of their borders so much, they created some more, I guess…

47.3 What Will Happen Once Normality Resumes at Customs?

Figure 415: Trucks at Customs border (Image Aleksei Smolensky with permission)

Probably around the second half of 2021, British Customs may look normal again, albeit with a much smaller volume. Custom declarations may take around one hour of paperwork for most goods, and the shipment delays will be probably less than half a day, especially if the Customs forms have been prepared beforehand. But now there will be import and export taxes. These are also very confusing. Importing live horses into the UK has a tariff for 10%, unless they are for slaughter, which has no tariff. Asses are taxed at 6%. Ducks, geese, and guinea fowls all have different rates that depend on the weight of the animals. Cars have 10%. Besides tobacco products, the highest rates are for grape juice, with 40% (Source). Tariffs also apply to import into the EU. Overall, it will be costly!

47.4 What Is the Impact on Industry?

Figure 416: Burning Money (Image www.tOrange.us under the CC-BY 4.0 license)

Brexit will have a lot of negative impacts on industry due to the new Customs regulations in both directions. There is the **cost**. Both the paperwork and the tariffs will increase cost and reduce profitability. If you build a Ford engine in London-Dagenham, send it to Köln in Germany to make the car, and then sell the completed car to the EU, Customs will be paid multiple times. Industry hates costs!

Even worse than the cost is the **lost time**. Modern supply chains are often tight. Obviously, freshly cut flowers won't do well if they spend an extra day in the truck. But non-perishable products are also often part of just-in-time supply lines, where a delay can lead to an expensive stop of a plant. Industry hates lost time!

Industry can, if necessary, factor the delay into their supply chains. However, the **fluctuations of the delay** will also increase. Sometimes it will work well, but sometimes someone will forget a check-mark on a Customs form, resulting in an extra day or two until the paperwork is sorted out. This will make any kind of just-in-time delivery impossible. Industry hates fluctuations!

And, at least currently, worst of all is the **uncertainty**. Will Customs work? Will my supplier survive? Is it still economical to ship across the channel? Trading between the EU and Britain has a lot of uncertainty. Industry hates uncertainty!

47.5 What Can Industry Do?

Figure 417: Distracted Boyfriend Meme (Image AntonioGuillem with permission)

In most cases, trade across the channel becomes significantly less attractive. It may often be faster, better, and cheaper to avoid trading across the channel. Industry will look for alternatives—and is already actively doing so. European industry has it easier, as the alternatives include all of the EU and many other countries worldwide. British industry is limited to… well… Britain (and not even the full United Kingdom, as Northern Ireland will be sort-of EU).

European firms are already doing this. New supplier contracts are much less likely to be involve the UK. Decisions on production locations also rarely involve the UK. New investment in Britain is falling.

47.6 What Will Be the Impact on the EU and the UK?

Figure 418: Post-Brexit Full Menu? (Image Roser)

Brexit will hurt the EU. Ten percent of all EU imports come from the UK, and 14% of all exports go to the UK (Source). **It is much, MUCH worse for the UK**. Forty-three percent of the goods exported from the UK go to the EU, representing around 7.7% of British GDP. Fifty-one percent of the UK imports come from the EU. Within the EU, it will probably hurt Ireland, Belgium, and the Netherlands the most.

It will also not hurt all companies equally. There are even some winners, where companies benefit from the Brexit. But it will hurt many companies, especially on the British side. Many smaller companies won't survive the chaos of the first few months of Brexit. Goods could be delayed for weeks. Perishable goods may not even survive the trip (and I already feel sorry for the trailers full of cattle and other livestock).

Even reasonably healthy companies that just survived the COVID-19 pandemic may be killed off by Brexit. Even companies that have little or no international trade may be collateral damage from this.

Figure 419: Mediocre Britain One Ounce 2025 (Image Roser)

Food prices will rise. A comparable example happened with Hurricane Katrina in 2005. The storm closed three ports that trade 45% of America's agricultural goods. As a result, food prices in the USA rose by 3% (Source). With Brexit, they will rise more, and not only for food. Unemployment goes up. GDP goes down. Inflation will go up, as Britain tries to attract more trade through lower prices. All of this is hard to estimate.

And this does not even cover the impact on other sectors like finance, services, travel. Even political unrest at the border to Northern Ireland is possible. Scotland and Northern Ireland may leave the union to join the other union. Overall, Brexit is an awful idea. Taking control of your borders feels good, but if the other side does the same, it will be much worse. It is an "act of self harm," and little good will come out of it. I sincerely do hope that I am wrong, but my best expert estimate is looking terrible for the UK. **Now, go out, brace for the storm, and organize your industry!**

48 How to Learn Lean

Christoph Roser, November 24, 2020 Original at https://www.allaboutlean.com/how-to-learn-lean/

Figure 420: Smiling Manager in a Warehouse (Image mavoimages with permission)

Lean manufacturing can help you and your company greatly. But how do you learn lean? Of course, there are plenty of Six Sigma lean black belts and other certificates available online, but do they really make you understand lean? In this post I have some suggestions on how to learn lean. These can befollowed by people with access to an actual shop floor to work on. However, I have also included suggestions for people, e.g. students, that do not have access to a shop floor. In this case, you can do … let's call it "*Home Improvement*". Let's have a look at some suggested actions for learning how to do lean!

48.1 On Online Courses and Certificates

Figure 421: Get your lean certificate here! (Image Nancy Wombat under the CC-BY 2.0 license)

There are a myriad of online courses available that claim to certify you in lean. Six Sigma courses seem to be especially popular. The cheapest one I found will certify you to be a *Lean Six Sigma Black Belt* for £59, although they claim that it takes six months. If you want it faster, you can get a $99 *Certified Six Sigma Black Belt* course with 50 questions in 60 minutes. (If you want to know where these are, I am NOT linking that crap … google it yourself). If that is still too expensive to you, just make up and print a certificate yourself. After all, the term is not protected.

Figure 422: Only 5 more clicks to become a certified master SCUBA diver! (Image kjekol with permission)

Anyway, I don't have much trust in online lean certificates, even though there is quite a demand for theses on the market. Doing an online course in lean is like an online SCUBA diving course. No matter how good the course is, it is not going to make you a proficient diver. Similarly, reading a really good book on how to drive a car won't prepare you for at all for driving a car. Theory, of course, does have its place in learning lean, but it is more of a supporting role.

48.2 Learning by Doing!

Figure 423: That's how you become a diver! (Image Joakant in public domain)

In my view, the most important part of learning lean is to actually do it! As with learning how to drive or learning how to SCUBA dive, the most important part is to actually do it! Go out there and practice lean by improving your system.

Of course, if you are a beginner, you should look for easy cases first. Just like when you learn to drive, you do not start out with a Ferrari during rush hour in a snow storm in New York City. You need a safe and easy playground for lean. Try to work on an area where **a mistake won't break the company** but is something that can be easily fixed. Also, try to take an area where you can have **quick improvement cycles**. If any change has a six-month delay because you need new tools manufactured, then it will be difficult to learn.

Figure 424: Triangle Kanban for my A4 Paper (Image Roser)

These quick improvement cycles are also easier if you **improve a process that happens frequently**. If you want to improve your annual inventory taking … well … it happens only once per year. It helps if the improvement is **easy to see and understand**. If you need an hour of analysis just to see if something has changed, then it will be difficult to learn. For all of those reasons, try to **avoid anything related to your ERP system** when learning lean. Changing your ERP software usually needs a programmer, is hard to see, takes time, and can break the company if it does not work. Please note that these limitations are for learning only. Later on, you eventually may have to also tackle problems that are risky, slow, infrequent, difficult to see, or (*shudder!*) involve your ERP system.

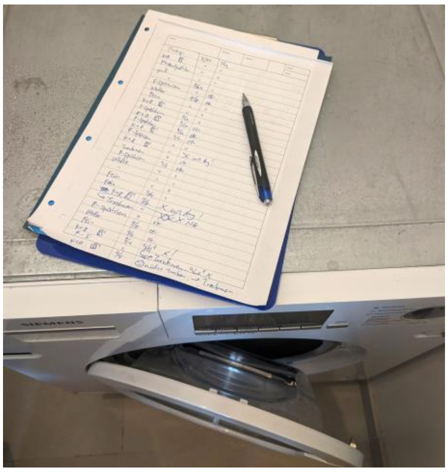


Figure 425: Washing machine data (Image Roser)

You will certainly be able to find a problem in your company that needs improving, and does fit the criteria above. Even if not, you can always practice lean at home. After all, at home you also have plenty of frequent processes like doing the laundry, restocking consumables, cleaning the room, and many others. Can you do a FIFO for your dinner plates? Can you establish a simple pull system for consumables? We have pull systems for paper and printer ink, among others. Can you collect data on a trickier problem? For example, our washing machine has the habit of stopping sometimes, but infrequently. About a month or so ago, we started tracking washing cycles on paper and wrote down when it stopped and when not, to find out the cause of the problem.

The advantage of practicing lean at home is that you ~~are in full control~~ … only have to coordinate with your spouse and children. The risk is manageable, the cycles are quick, it is easy to understand, and your home probably doesn't use an ERP system ☺.

48.3 Theory

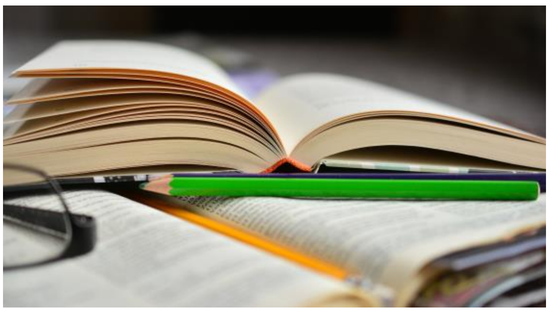


Figure 426: Book for Studying (Image Pixabay in Public Domain)

Learning lean is learning by doing. Merely studying the theory won't help. However, the theory is important to help with practicing. You learn driving in a car, but it is supplemented by classroom study. You learn how to SCUBA dive in the water, but there are also theoretical lectures. Similarly, when doing lean, the experiments in your lean playground should be supplemented by theory.

But again, you should start with an actual improvement project on which you practice your skills. Hence, the theory should match your needs for the improvement project. If your improvement involves changeover optimization (SMED), there is little need to study value stream mapping at this point, although it may be of interest for a later problem. So find yourself good sources on how to do lean. I have even heard there is a website that is *All About Lean* … gosh, I wonder where I saw that …

48.4 Simulations

Figure 427: Bottleneck Walk training in Poland (Image Lean Poland with permission)

A popular way to learn lean is to do simulations and games. John Bicheno has written a whole Lean Games and Simulations Book filled with lean games, most of them for groups. Many institutes that offer courses in lean and related methods use simulations and games. Depending on your improvement project, different games may help you to understand the behavior of manufacturing systems and their people better.

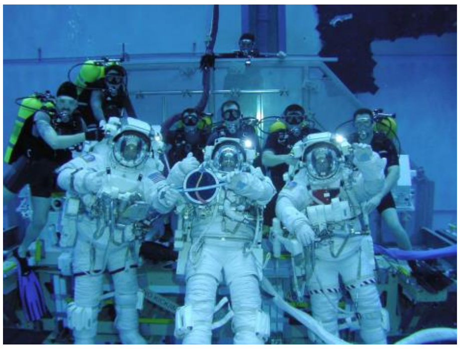


Figure 428: NASA Astronaut training in a water tank (Image NASA in public domain)

Yet, here too these simulations and games are only an aid. No matter how elaborate the simulation is, it is only a pale copy of reality. Even fancy training factories lack the details of a real production system running under cost and time pressure. To make a realistic simulation requires more resources than what is normally available. Think NASA training astronauts. You can’t fly to the moon and figure out the details on the way. But even then, the simulations are not as good as reality. Therefore, simulations can help, but can in no way substitute practical experience.

48.5 Coach, Mentor, Buddy, and Other Support

Figure 429: Coaching (Image unknown author in public domain)

What can help you, however, is another person to work with. Ideally, this other person has more lean experience than you (i.e., a coach or mentor). Your path to lean can be accelerated by the knowledge of this mentor. However, don't expect the coach to have all the answers. On the contrary. In my view, **a good coach should never give you the answers, but should ask you the right questions!**

If you are lucky, there is a coach or mentor around that has time to work with you. But just as likely, you may not have such a support. Even then, it helps to work together with someone else. Even if that person does not know more about lean than you, you can ponder problems together. Hence, seek to partner up, or even make a small group of study buddies to learn from each other. While none of you may have the complete answer, all of you may have some puzzle pieces for the solution.

Regardless of how many coaches you have, you should always work together with the people using the system you are improving. They may not know as much about lean as you do, but they probably know much more about the system than you. Hence, you can definitely learn from them too.

Finally, if you are already more experienced and are coaching or mentoring someone else, you can also learn from them. You remember when I said "a good coach should never give you the answers, but should ask you the right questions"? The mentee may answer the questions in a way you may expect, but very often the answers are something you did not think about yourself. When I mentor or coach others, I also learn from them.

48.6 Summary

Learning lean is not a task for a weekend. It is a long journey. It is like learning another language; it takes time and practice to become fluent. Depending on the skill level you want to achieve, the learning never ends. It is lots of practice by doing improvement projects. It is (often) a series of trial and errors and trial again until you succeed. Now, **go out, learn by doing, and organize your industry!**

48.7 References

Bicheno, John. The Lean Games and Simulations Book. Buckingham: Picsie Books, 2014.

49 The Baton Touch Flow Line

Christoph Roser, December 1, 2020 Original at https://www.allaboutlean.com/baton-touch/

Figure 430: Relay Race Hand Over (Image tableatny under the CC-BY 2.0 license)

The baton touch is probably the easiest way to do multi-machine handling in a line. This ease-of-use makes it a very popular approach for the assignment of the operators in a line. An operator is in charge of a fixed set of processes. The operator always repeats the same loop of processes. Multiple operators, each with their fixed assignment of processes, work on a production line together. It is quite simple.

49.1 Introduction

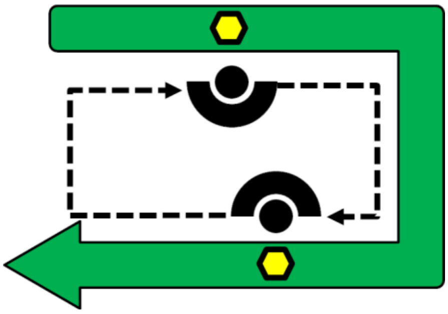


Figure 431: Animated lean rabbit chase. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

The baton touch is one of the different ways to man a production line with fewer operators than you have processes. The other options are the rabbit chase and the bucket brigade. Most of them are better suited for an U-line, to reduce the time needed to walk back. In a rabbit chase, the workers keep on working on one part through all the processes in the sequence. For more details, check my post on [The Lean Rabbit Chase in a U-Line]().

Closer to the baton touch is the bucket brigade. Workers process a part through the series of processes until they meet the next worker coming back or the end of the line. Here, they hand over the part and walk back until they meet the previous worker or the beginning of the line. For more details, check out my two post series on the [Lean Bucket Brigade](). In any case, they take the part and process it. The number of processes a worker handles depends on the speed of the worker.

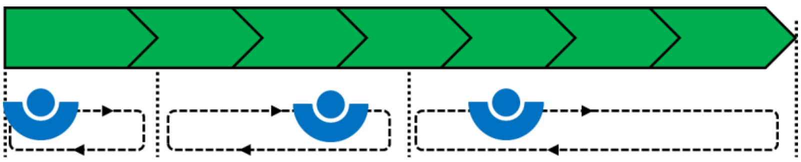


Figure 432: Animated bucket brigade loops. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

49.2 The Basics of the Baton Touch

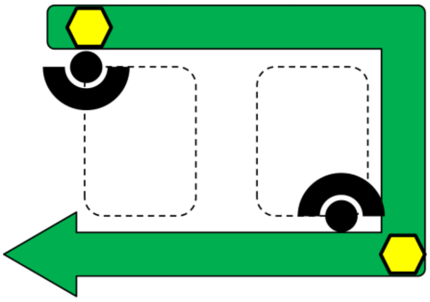


Figure 433: Animated baton touch. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

The baton touch is very similar to the bucket brigade, but with a fixed set of processes for each worker. Like in a relay race where each runner has to cover a fixed distance, each worker has to handle a fixed number of processes. This has the advantage that each worker has a fixed number of processes assigned, which makes it easier to train the workers. It also avoids the somewhat less-structured hand-over of the bucket brigade. On the downside, it does not include an auto-adjusting for the worker's speed. While in the bucket brigade the faster worker covers more ground, in the baton touch the faster worker has to wait for the slower one.

49.3 Organization of the Baton Touch

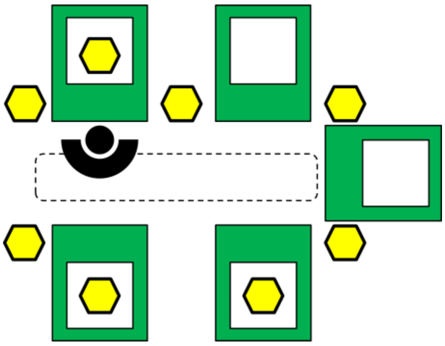


Figure 434: Animated chaku-chaku line. The original image can be found at https://www.allaboutlean.com/flexible-manpower-lines-4/. (Image Roser)

The baton touch line can be completely manual or semi-automated. In the latter case, it is often called a chaku-chaku line, for which the baton touch is one popular option (others being the rabbit chase or the bucket brigade). One common feature of the chaku-chaku line is that the operator inserts the part in a process and starts the process. When the process is completed, the part is ejected automatically.

Like with any semi-automated process, it is recommended for the process to be faster than the worker. In lean philosophy, it is impolite to let the worker wait for the machine. The other way round is perfectly acceptable, and the machine can wait for the worker.

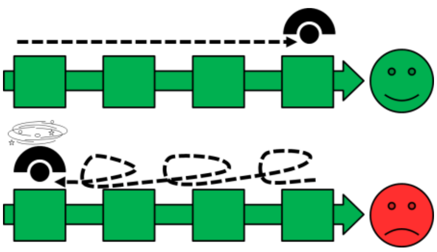


Figure 435: Direction of Chaku Chaku (Image Roser)

It is highly recommended to have the workers walk in the same direction as the material flow. This makes it much easier to transport the material along. Walking in the other direction would either require tracking back frequently to get the parts, or an automated transport system.

49.4 On Buffers

In manufacturing, you need buffers to decouple fluctuations. With the baton touch, the machine is waiting for the operator anyway. Hence you do not need much buffer between the processes for the loop of one operator. If the machine ejects the part automatically, you just need space for one part to be ejected.

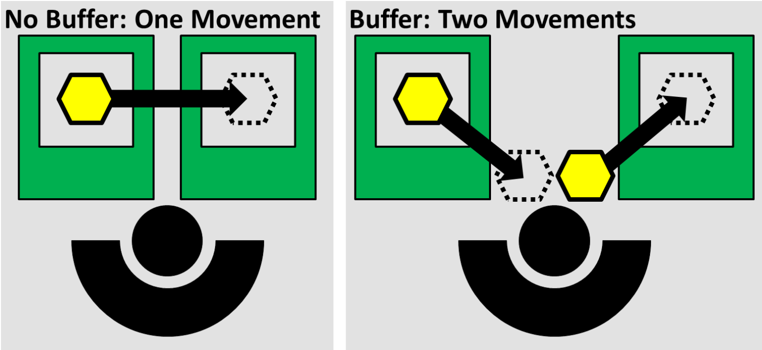


Figure 436: Chaku Chaku Buffer (Image Roser)

If the operator removes the part by hand, you do not need any buffer at all. Here, a buffer may even be worse than no buffer. The operator needs to touch the part for removal. If the same part goes directly into the next process, we save time since the operator does not need to grab the part again. However, if there would be a buffer in between, the worker would have to put the first part down and grab the second part to put it into the next machine. Hence, no buffer may be a better solution here.

However, it makes sense to have buffers between the loops of the operators. Ideally, the work of the operators is well balanced. But even then, sometimes a worker may be slower or faster than usual, or a problem at a process took a bit more time (part was stuck, reset button needed to be pressed, …). Hence, a (small!) buffer between the operators can improve the overall performance of the system.

49.5 Number of Workers

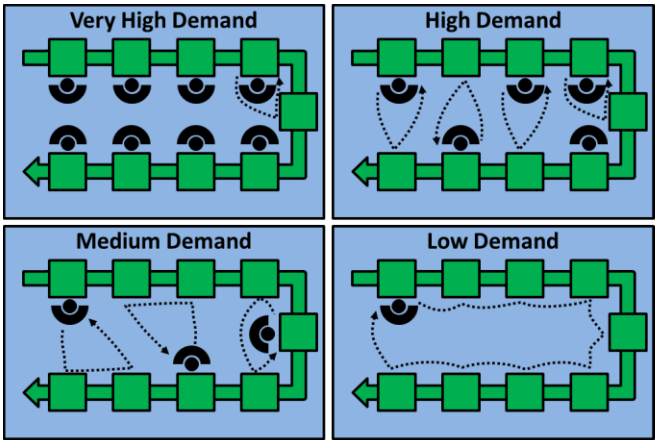


Figure 437: U-line-flexibility (Image Roser)

Often, the number of workers is adjusted depending on the demand. If you have a high demand, you add a lot of workers. For lower demand, you man the line with fewer workers (or run it for shorter times). With the baton touch approach, you would assign a fixed sequence of processes to every worker based on the number of workers in the system. I recommend using the Toyota Standard Work approach to assign the stations to the different number of workers.

With multiple workers and multiple stations, you also need to keep track of which worker is qualified for which station. This is ideally done with a skill matrix. A skill matrix is a simple table with one row for each worker and one column for each process. It tracks the qualification of each worker for each process. You can even distinguish on multiple qualification levels (e.g., untrained, basic, fully qualified, and trainer). Make sure an operator has at least a basic qualification for all assigned processes.

49.6 Summary

Overall, the baton touch is a very common method to organize your workers in a flow line. Alternatives are fully staffed lines where each process has one operator, the rabbit chase, and the bucket brigade. While the latter two may sometimes have a slight advantage in performance, the bucket brigade is much easier to organize and manage. Now, **go out, structure the operators assignment in your flow line, and organize your industry!**

50 What Is True North in Lean?

Christoph Roser, December 8, 2020 Original at https://www.allaboutlean.com/true-north/

Figure 438: True North (Image Hike The Monicas under the CC-BY-SA 4.0 license)

Lean manufacturing often talks about true north. This is the direction in which your operations should move to become better. Sometimes that may be a bit fuzzy, so let's have a look at what true north could include.

I am fully aware that reaching true north in all aspects is unrealistic. If you actually reached true north, there would be nothing left to improve… which goes against my beliefs in manufacturing. You can always get better! Hence, **achieving the list below is not realistic**. But hey, as I am writing this, it is almost Christmas, and it is okay to make a wish! I hope that this unrealistic list helps you to get closer to true north in at least some aspects.

50.1 Introduction

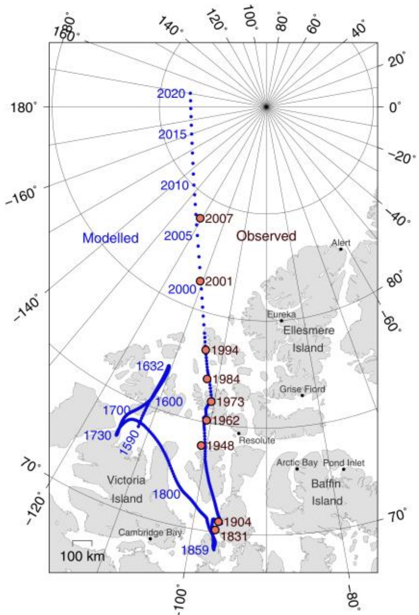


Figure 439: Magnetic North over Time (Image Cavit under the CC-BY-SA 4.0 license)

In navigation, true north is the geographic north pole. It is at the axis around which the earth rotates (the other end would be the geographic south pole). Hence, if you want to go to the north pole, you just have to keep going north. The easiest way is using a compass with a magnetic needle. However, the needle does not point to the geographic north pole, but to the magnetic north pole (which, coincidentally, is a south pole in magnetic terms).

Furthermore, the geographic north pole does not move much (only a bit due to earth-wobbling and plate tectonics). The magnetic north, however, moves quite a bit over time. Hence, your magnetic needle will point in the wrong direction, the closer you come to the pole. If you actually are at the north pole, the needle would point south, and you would be going the wrong direction. Good maps include information on this difference, and also on how it is expected to change over time. Lean (and others) use this true-north analogy to describe the direction your company should really be going. If you don't know your true north, you may as well be going in circles.

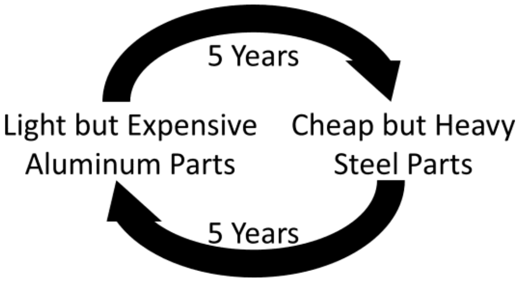


Figure 440: Steel and Aluminum Parts Automotive (Image Roser)

Let me give you an example from the automotive industry. There may be a push to reduce weight in cars for better performance. Hence, steel parts will be replaced with lighter but more expensive aluminum parts. Five years later, the drive is no longer weight, but cost. Aluminum parts will be replaced with cheaper but heavier steel parts. Another five years later, the drive is toward weight again, and the steel parts are replaced with the aluminum parts again. This cycle seems to repeat every five or so years. There is lots of movement, but it's going in circles.

To me, a good company is a company that's able to follow its true north even across multiple generations of leadership. Toyota, for example, pushed SMED for multiple decades to reduce the changeover time. So let's look now at what true manufacturing in Lean could include.

50.2 Material Flow

The ideal material flow is in **lot size one**. This is also with a **changeover duration of zero**. In a world perfect for manufacturing, there would also be only one part type. However, this is not the goal for the entire company, and you probably would not want to drive toward a single-product company. However, **the number of product variants should be a good trade-off between the effort of making multiple products and the benefit of making multiple products**. In my experience, most companies have a lot of product variants in very small quantities whose continued existence should be seriously questioned. **The production sequence of these different part types should be a perfect mix over the working duration**. Distribute all part types as evenly across the day as you can.

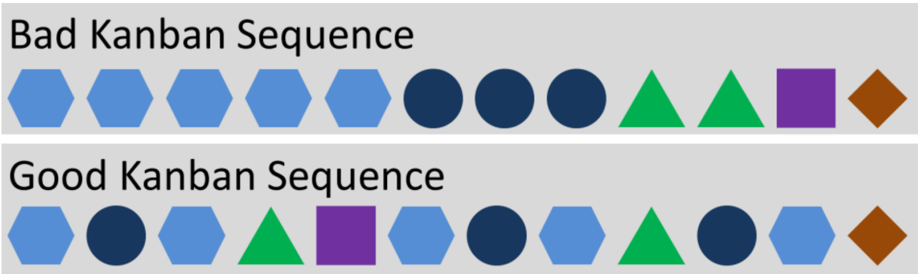


Figure 441: A good sequence mix example (Image Roser)

The distance between the different processes should be zero, or as close to it as possible. Ideally, the machines are right next to each other. Do not ship parts around the world and back.

50.3 Inventory

Figure 442: Inventory (Image Axisadman under the CC-BY-SA 3.0 license)

Lean is legendary for reducing inventory. However, you can't reduce the inventory to zero. You need parts that are worked on. You have parts in transit. But there should be **no inventory except for the parts that are actually either moving or being processed**. This requires Just-in-Time, Just-in-Sequence, and Ship-to-Line.

50.4 Information Flow

Figure 443: Worker in Factory making a Phone Call (Image Standret with permission)

The information flow should be **instantaneous**, and **without any loss of information** or miscommunication. **All required information should be available**. However, there should be **no excess information**, since it requires effort to gather and store, and it may hide the actually relevant information.

50.5 Fluctuations

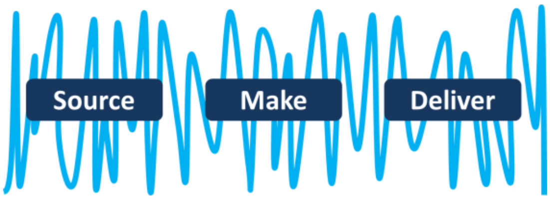


Figure 444: Source Make Deliver Fluctuations (Image Roser)

Simply said, there should be **no** fluctuations (mura) whatsoever. The customer orders regular like a Swiss clockwork, and suppliers and production deliver parts and products with equal regularity. Nothing of source-make-deliver should fluctuate. The production should be a **flow shop**, and **the line should be perfectly balanced** without any waiting time.

50.6 Quality

Figure 445: Ball Bearing (Image Roser)

The perfect requirement for quality is simple: **Zero defects and zero rework!** Nothing should ever be defective or reworked. If there is a defect (which of course never happens), the processes should detect the defect automatically and the process should be stopped. This is the idea of **Jidoka**, or autonomation.

50.7 Waste

There should be **no waste (**muda**)**. You surely know the seven types of waste. These should be eliminated.

Figure 446: Seven types of waste (Image Thomas Söllner with permission)

50.8 Overburden

Figure 447: Stiff Shoulder Worker (Image sunabesyou with permission)

There should also be no overburden of the workers (muri). First and foremost, this requires a **perfect safety record**. It would also require the work being neither too difficult nor too easy, but just right without being monotonous. **All employees and other people should be treated with respect**. **The workers should have a positive attitude toward work and the company**.

50.9 Continuous Improvement

Figure 448: Kaizen Word Bubble (Image PixelsAway with permission)

If you have achieved true north, then there would be nothing left to improve. Nevertheless, on the way to true north, continuous improvement is an important part. Hence, you should have **continuous improvement**, or kaizen. This is not assigned to a continuous improvement specialist, but is engrained with all employees (including the CEO) and supported by management. **Improvement follows the Plan-Do-Check-Act (PDCA) sequence**.

50.10 Where Paradise Meets Reality

True north is not realistic. True North is a dream… but you never should stop dreaming! The idea is not necessarily to reach true north (do you actually want to go to the north pole every time you pick up a map?). But it should help you to find the right path.

You will also find that there are contradictions in the above list. For example, there should be no fluctuations, but work should also be not monotonous. Or, the effort of achieving zero defects may not be worth the cost. The closer you get to these different true norths, the more contradictions you will find. Luckily, most companies, possibly even including yours, still have a looong way to go before they even get close to true north.

Furthermore, you won't be able to push everything toward true north at the same time. And that is where this laundry list of industrial paradise above may be helpful. Pick your focus areas! Which areas from the long list above are most relevant to your company? Where are you, and where do you want to be? If safety or generally overburden of the workers is unsatisfactory, it should be high up on your list, as should be quality. Continuous improvement is the actual process that helps you to go toward true north, wherever it may be for you. Overall, you have to decide which direction is most relevant for your company in the long term. It may not even be on this list, since I make no claim for completion. But you should know where you want to go. Otherwise you will be just wandering around aimlessly. Now, **go out, pick your direction, and organize your industry!**

51 Reducing Lead Time 1 – Inventory

Christoph Roser, December 15, 2020 Original at https://www.allaboutlean.com/lead-time-inventory/

Figure 449: Supermarket Checkout (Image Robert Kneschke with permission)

Lead time is a key factor for customer satisfaction, especially with make-to-order production. Hence, many companies want to reduce this lead time. In this blog post I show you the basic levers that influence your lead time, and a few more that may also apply to some cases. You have to find the combination of these levers that works best for you. This is the first post in a series of four posts on how to reduce lead time. Most of the series focuses on production, but the last post looks into reduction of lead time in development.

51.1 Introduction

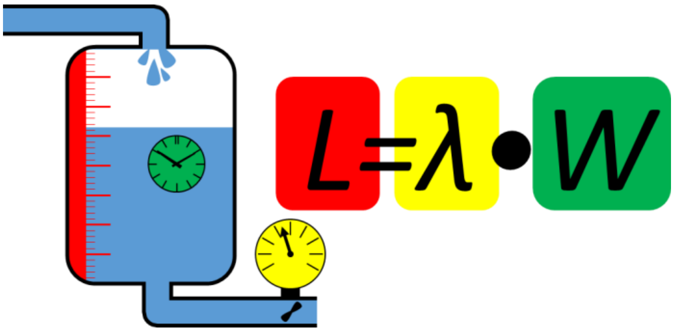


Figure 450: Water tank example of Little's Law (Image Roser)

The lead time is the time between a part or job entering the system and the time the completed product leaves the system. For make-to-order, this may also include other elements like development or purchasing. For make-to-order, the lead time defines the waiting time of the customer for his goods. For make-to-stock, it is slightly less relevant, since the goods are (ideally) already on stock. It may still make sense to reduce the lead time, however, for a faster information flow within the value chain. Since make-to-stock tries to reduce the inventory anyway, a reduction in lead time is often a nice side benefit.

The easiest way to determine your lead time is Little's Law, as shown below. You simply divide your inventory (measured in pieces) by your throughput (measured in pieces per time) and get the lead time. Little's Law is quite accurate and valid for pretty much all systems as long as they are somewhat stable. The inventory for Little's Law includes not only the waiting inventory, but also the items that are currently processed. For more details, see my Eulogy for Little's Law.

$$LeadTime = \frac{Inventory}{Throughput}$$

The lead time is significantly influenced by the utilization and the fluctuations of the system (arrival and processing fluctuations). While there is no accurate mathematical formula for real-world cases, the Kingman Formula is a good approximation of the waiting time for a single process with a single product type and a single queue. The formula is shown below, but for more details check my article on The Kingman Formula.

$$E(W) = \left(\frac{p}{1-p}\right) \cdot \left(\frac{C_a^2 \cdot C_s^2}{2}\right) \cdot \mu_s$$

51.2 The Different Ways to Reduce Lead Time

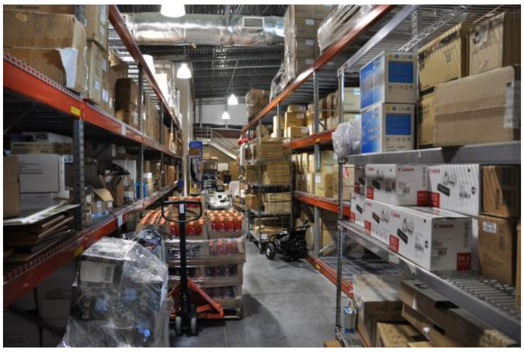


Figure 451: Messy Warehouse (Image Christin Michaud in public domain)

Overall, we have a couple of different ways to influence our lead time. Many of these are somewhat connected, so changing one may have beneficial side effects for another one too. One option is to reduce the **inventory**, which I will discuss in this blog post. My next post will look at the effects of **fluctuations** and the **utilization**. A third blog post will look at **throughput** and **lot size**. The final post in this series will look at the development process, where many of these effects are found again.

This blog post starts by looking at inventory, because this is the primary tool to reduce lead time. Even many of the other levers like fluctuations, utilization, and lot size reduce the lead time by reducing the inventory. This crucial role of inventory on lead time (and many other factors) is why lean pushes so hard to reduce inventory. Even the name *lean* comes from an inventory reduction.

51.3 Reduce Inventory

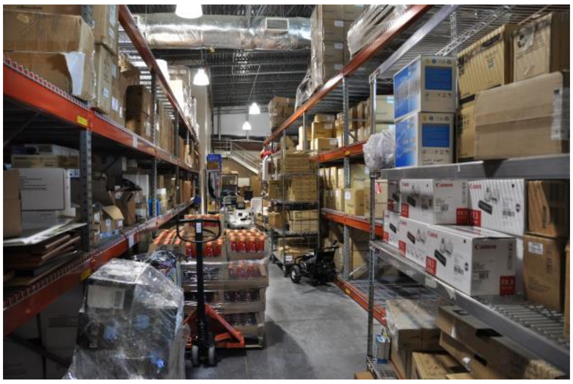


Figure 452: Warehouse worker checking the inventory (Image WavebreakMediaMicro with permission)

Looking at Little's Law, the best way way to reduce the lead time is to reduce the inventory. Sounds simple enough, but unfortunately it is not. Inventory does have a purpose in manufacturing, the biggest of which is to cover fluctuations. Others are to actually have a part to work on, and sometimes you can reduce cost by buying in bulk. For more see my post Why Do We Have Inventory?.

Figure 453: Not enough inventory? (Image Roser)

Anyway, you can't just reduce your inventory. If your inventory can no longer cover the fluctuations, you will be missing material more often, your utilization goes down, and your lead times may increase again. However, many companies have much more inventory than what they need to cover the fluctuations. Your first step is to figure out how much inventory you actually need … which is unfortunately not a precise science. To cover all fluctuations, you would need an infinite inventory, which is impossible. The inventory level is therefore always a trade-off between what fluctuations you want to cover and how much inventory you want to have.

This, in turn, is related to the importance of the utilization, fluctuations, lead time, and product availability. In general, make-to-stock systems have a higher inventory to ensure a high material availability. Make-to-order systems usually have a trade-off between the lead time and the utilization. In any case, you need to figure out your target inventory level.

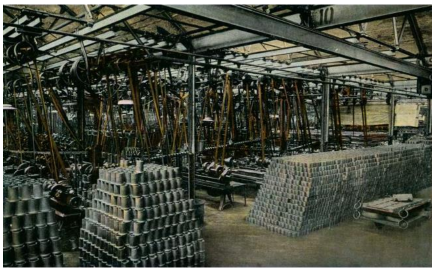


Figure 454: Too much inventory? (Image Ford in public domain)

Since this is an imprecise science, this is best observed in your real system. What material is always plenty in supply? Can you reduce it? What material is often out of stock? Should you increase it? Pull systems can help you both with determining a good inventory level, and with keeping your inventory at that level. If it would be a kanban system, you should determine how many kanban you need, and set up a kanban system.

Hence, your first step in reducing the lead time is to figure out how much inventory you actually need for your system. Subsequent steps addressing fluctuations, utilization, and lot sizes enable you to get away with even less inventory. But you should not have more inventory than what you actually need.

I hope this brief introduction to reducing the lead time by reducing the inventory to the actually required levels was helpful for you, although chances are you already suspected this relation. Nevertheless, I like to be thorough and start with the basics before going into more details in the next posts. Now, **go out, reap the enormous benefits from reducing inventory, and organize your industry!**

P.S.: This series of posts is based on an inspiration by Rajan Suri, and also chapter 7 of his book *Quick Response Manufacturing* and chapter 3 from his book *It's About Time.*

- Suri, Rajan. It's About Time: The Competitive Advantage of Quick Response Manufacturing. 1 edition. New York: Productivity Press, 2010. ISBN 978-1-4398-0595-4.
- Suri, Rajan. Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times. Portland, Oregon, USA: Taylor & Francis Inc, 1998. ISBN 978-1-56327-201-1.

52 Reducing Lead Time 2 – Fluctuations and Utilization

Christoph Roser, December 22, 2020 Original at https://www.allaboutlean.com/lead-time-fluctuations-utilization/

Figure 455: Airport Waiting (Image mazzzur with permission)

This second post in a series on how to reduce your lead time looks deeper at the effect of fluctuations and utilization. Improving these will reduce your inventory and hence, as per Little's Law, reduce your lead time.

52.1 Reduce Fluctuations

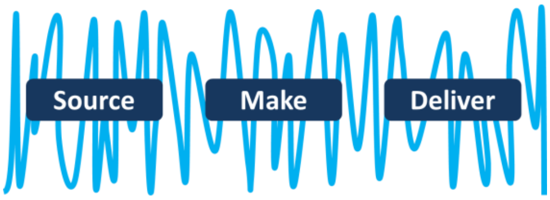


Figure 456: Source Make Deliver Fluctuations (Image Roser)

Your inventory helps you to cover fluctuations. The next step would be to reduce fluctuations (in Japanese "mura"). This is also not easy. I recently did a multi-post series on how to reduce fluctuations in the source, make, and deliver side of your value chain. It is a Sisyphean task that never ends, since fluctuations always tend to increase unless they are actively reduced. The Kingman formula which I showed in the last post includes the fluctuations for the arrival and processing times, but this is a simplified model. In reality, you have multiple part types, multiple processes, and multiple queues. On top of that, the arrival of parts is often initiated by the departure, as in a pull system the departure of one part initiates reproduction. Hence, fluctuations in the demand pass through to fluctuations at the arrival.

Overall, it is hard to say how beneficial a reduction in fluctuations will be, but it will be beneficial. Hence, reducing fluctuations is an very important but underrated aspect of lean manufacturing.

Figure 457: VIP Label (Image Roser)

One fluctuation that affects the lead time especially is prioritization. If you have a priority "VIP" queue, the jobs in the VIP queue are prioritized and have a shorter lead time. This, however, comes at a cost of longer lead times of the non-VIP jobs. As long as you prioritize no more than 20%–30% of the work, the negative impact on the non-VIP jobs is negligible. However, the more jobs you prioritize, the worse the effect on the non-VIP jobs. Eventually, the non-VIP jobs may have a lead time approaching infinity.

With make-to-order, reduction in fluctuations help primarily with reducing lead time. With make-to-stock, the primary goal of reducing fluctuations is to reduce inventory, and a reduction in lead time is a nice side effect with additional benefits.

52.2 Reduce Utilization

Figure 458: Overworked worker (Image Roser)

Another major factor in the Kingman equation is the utilization. As the utilization approaches 100%, the waiting time approaches infinity. The utilization is – indirectly – another way to manage fluctuations. There are three ways to decouple fluctuations, inventory, capacity, and time. Having a utilization of less than 100% gives you a capacity buffer to decouple fluctuations. If you want to have high utilization, you need lots of inventory in the system to reduce the chances of running out of material. Lots of inventory – you guessed it – means a long lead time. Hence, **100% utilization is a really bad target for a production system!**

For one, your production system is not balanced perfectly, and some processes are needed more than others. It is absolutely normal and okay for non-bottlenecks to have less than 100% utilization. Even bottlenecks have less than 100%, since the bottlenecks usually shift. It also depends on how you measure utilization. Is it the percentage of the time a machine is scheduled for production? Or is it the ratio of the actually produced good parts to the maximum number of parts that could theoretically have been produced in the same time? This is better known as the OEE. Aiming for a 100% OEE is unrealistic (unless the number is fudged, and I have seen plenty of OEE claimed to be above 100%). Just as a reference, Toyota aims for around 90% OEE.

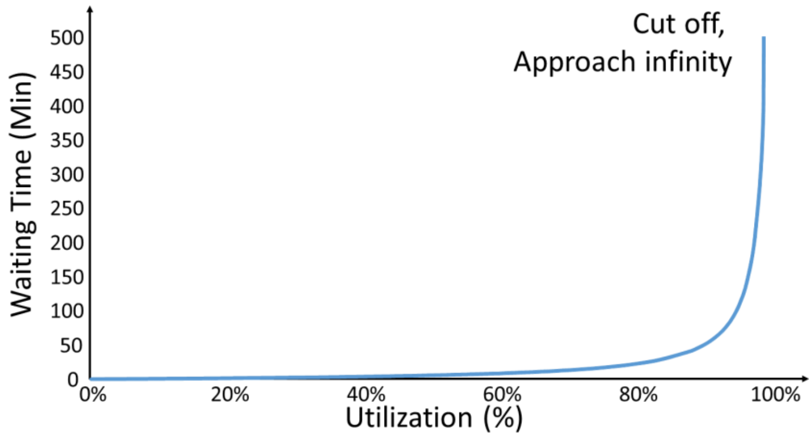


Figure 459: Utilization and waiting time according to the Kingman equation (Image Roser)

In any case, a utilization of less than 100% gives you a capacity buffer to handle fluctuations. You could also use inventory to decouple fluctuations. However, a capacity buffer does not increase your lead time, whereas inventory does. On the downside, a capacity buffer with workers and machines waiting for parts costs you too. The question is a trade-off between unused capacity and additional inventory. Furthermore, this trade-off is not linear as shown in this graph based on the Kingman equation. The closer you get to 100% utilization, the more inventory you need to cover even the smallest fluctuations. For an utilization of 100% you need – in theory – an infinite inventory. Please note that the graph measures only the waiting time for a simplified system with one queue and one process, but similar behavior can also be found in more complex systems.

Hence, reducing utilization a bit below 100% will save a lot of inventory and hence a lot of lead time. **A sweet spot is often around 80%–90% utilization**, although it depends on the details of your system. Reducing the utilization further has much less impact on the inventory and hence the lead time. For example, if you reduce your utilization from 60% to 40%, the impact on the inventory and lead time is negligible, but now your workers stand around even more, which costs money.

Figure 460: Illustration for shift patterns (Image Roser)

The Kingman equation gives a nice relation between utilization and lead time. But again, the Kingman equation is a simplified model of the real world. Regarding utilization, it assumes a round-the-clock non-stop working system. Such systems exist in reality. However, most systems do not work twenty-four hours a day seven days a week. Instead, you may have one shift or two shifts four, five, or six days per week. This gives you another way to use capacity for handling fluctuations, namely with overtime. Overtime where you call people in when you need them is cheaper than having them waiting around if there is no work. On the downside, overtime requires a bit of preparation, and hence can cover medium- or longer-term fluctuations like seasonality. Overtime can also handle fluctuations whose short-term effects were buffered by inventory. If you see your buffer inventory going down, you may schedule overtime.

Figure 461: Clocking out at the end of the shift (Image Ministry of Information in public domain)

But keep in mind that even with overtime, your utilization will not be 100%. Overtime cannot cover short-term fluctuations unless you have inventory. Trying to reach 100% utilization will again blow up your inventory and lead time. In sum, it is okay to aim for getting the most out of your system. But keep in mind that it will not have a 100% OEE, and that is okay. Also keep in mind that if you run your system around the clock like a paper mill or similar, you need an additional capacity buffer (a lower utilization) if you want a short lead time or a good product availability.

Hence, **reducing fluctuations in general and utilization to a reasonable level will reduce your inventory and hence your lead time**. Now, **go out, reduce your fluctuations, manage your utilization, control your lead time, and organize your industry!**

P.S.: This series of posts is based on an inspiration by Rajan Suri, and also chapter 7 of his book *Quick Response Manufacturing* and chapter 3 from his book *It's About Time*.

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- Suri, Rajan. Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times. Portland, Oregon, USA: Taylor & Francis Inc, 1998. ISBN 978-1-56327-201-1.

53 Reducing Lead Time 3 – Throughput and Lot Size

Christoph Roser, December 29, 2020 Original at https://www.allaboutlean.com/lead-time-throughput-lot-size/

Figure 462: Traffic Jam (Image B137 under the CC-BY-SA 4.0 license)

Two more factors for reducing your lead time are the throughput and the lot size. However, the throughput has a smaller effect – although with other benefits that are often larger than the reduction in the lead time. The reduction in the lot size can have a huge effect, although usually only for make-to-stock production. Nevertheless, both are worth looking at if you want to reduce the lead time.

53.1 Improve Throughput

Another possible approach to reduce lead time is to speed up the system (i.e., to improve throughput). You simply crank out more parts in the same time.

Figure 463: Four empty green wine bottles (Image Roser)

My apologies, did I say *simply*? Unfortunately, it is not quite that. If you just randomly improve the speed of your processes, you may waste a lot of effort. The output of a system is defined by the bottleneck. Hence, you need to find the bottleneck. This is complicated by your bottleneck shifting between different processes. I spent a lot of time developing two methods to detect shifting bottlenecks, the Active Period Method and the Bottleneck Walk. Once you found the possible bottlenecks, you need to improve them. While you may think first about technical solutions, there are also organizational solutions to improve bottlenecks. For more details, see my series on bottleneck management. But somehow, you have to improve your throughput.

In practical terms it may be easier to measure this as the line takt, which is the inverse of the throughput. You can also see this as the line cycle time plus the average losses. How long is the average time between the completion of a product? Reducing this will improve your lead time (all other things being equal). If we replace the throughput with the line takt, the lead time equation in Little's Law changes can be rearranged as shown below.

$$LeadTime = Inventory \cdot LineTakt$$

This is now a linear relationship. If you shave one second off your line takt, you will shave one second off your lead time … for every part in the system. Hence, with 1,000 parts in the system, a one-second reduction in the line takt will give you a lead time reduction by 1,000 seconds. The easiest way to see this is as a percentage. **Shaving x percent of your line takt will shave the same x percent of your lead time**.

Figure 464: Wine Bottling Line (Image David Herrera under the CC-BY 2.0 license)

Improving throughput feels natural to most people on production. Hence, chances are, the speed of your system has already been looked at many times before. Further improvement potential certainly does exist, but may not always be easy or cheap. It depends on your system if the effort of reducing your line takt is worth the benefit of an improved lead time. Don't forget that there are also other benefits, like a reduction in production cost through reduced labor and machine invest. In fact, most often when improving throughput, the main goal is to either increase capacity or to reduce cost or both. A smaller side benefit may also be that faster lines may fluctuate a bit less in absolute terms than a slower line, but don't expect huge benefits from this side benefit. Overall, **reducing your line takt (increasing your throughput) will lead to a proportional reduction of the lead time, although this is often less important than other benefits of this change**.

53.2 Reduce Lot Size (for Make-to-Stock)

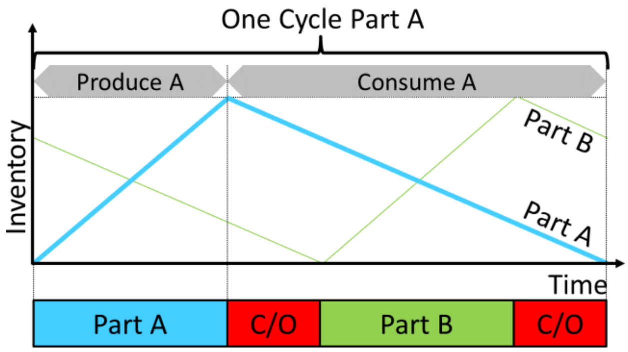

Figure 465:Inventory subject to changeover: two parts, one cycle (Image Roser)

Finally, you can reduce your lead time by reducing your lot size. However, this is most useful for make-to-stock production. In make-to-stock production, the lot size influences the inventory you need to cover the time until the part can be produced again. This is shown below in a simple example with two part types. The inventory over time are the blue and green lines for the respective part types.

If you reduce the changeover time by half, you can reduce the lot size. The new inventory over time is also reduced as shown below. Using Little's Law, this will also reduce the lead time. Both graphs are examples from a longer post on "What to Do with SMED: Reduce Lot Size or Increase Work Time?"

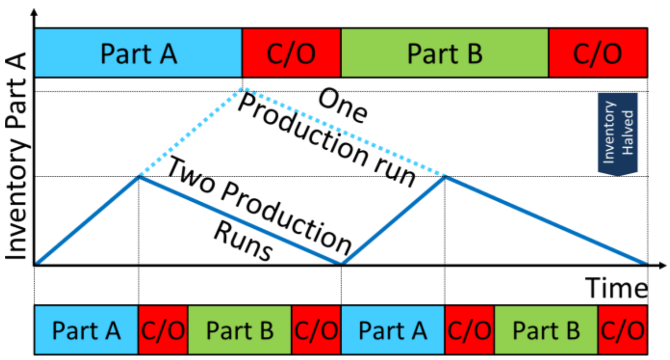

Figure 466:Inventory subject to Change Over Two Parts Two Cycles (Image Roser)

Hence, for make-to-stock, reducing the lot size can proportionally reduce the inventory and subsequently lead time. The exact numbers depend, among other things, on the number of parts. **This massive effect on reducing the inventory is one of the main reason that lean is pushing hard for smaller lot sizes!** The reduction in inventory will have significant cost savings. The reduction in lead time, however, usually makes no difference for the customer, since the material is "in stock" anyway. It does, however, make a difference for the speed of information flow within the system too. Quality problems will be detected earlier and fixed easier, product changes will be faster, and overall you will run a much tighter ship. Hence, **while the main reason for a reduction in lot size is savings related to inventory reduction, the reduced lead time will also have some benefits, although it will make less difference for the customer**.

Figure 467: Bespoke Suit (Image SummerWithMorons under the CC-BY-SA 4.0 license)

Unfortunately, this method does not work quite as well for make-to-order. The lot size in make-to-stock provides inventory (stock) to cover the time until the parts are produced again. Since there is no stock to cover with make-to-order, a reduction in lot size will only distribute a larger job over a longer time. It can be done for make-to-order products too, although it does not reduce the average lead time. It does make it easier for the suppliers to provide material as it levels the production a bit more. It also allows you to fit in more urgent jobs between the smaller lot sizes of the formerly larger job. But to significantly reduce the average lead time, you would need to convince your customer to order smaller quantities more frequently, although in this case producing make-to-stock may be better anyway.

This is the last post of this series looking at the lead time in production systems. **Inventory, fluctuations, utilization, throughput, and lot size** are the most important levers you can influence if you want to reduce your lead time. The next post will close this small series on the lead time by looking at product development. Until then, stay posted, and **go out and organize your industry!**

P.S.: This series of posts is based on an inspiration by Rajan Suri, and also chapter 7 of his book *Quick Response Manufacturing* and chapter 3 from his book *It's About Time*.

- Suri, Rajan. It's About Time: The Competitive Advantage of Quick Response Manufacturing. 1 edition. New York: Productivity Press, 2010. ISBN 978-1-4398-0595-4.
- Suri, Rajan. Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times. Portland, Oregon, USA: Taylor & Francis Inc, 1998. ISBN 978-1-56327-201-1.

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Figure 468: 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.