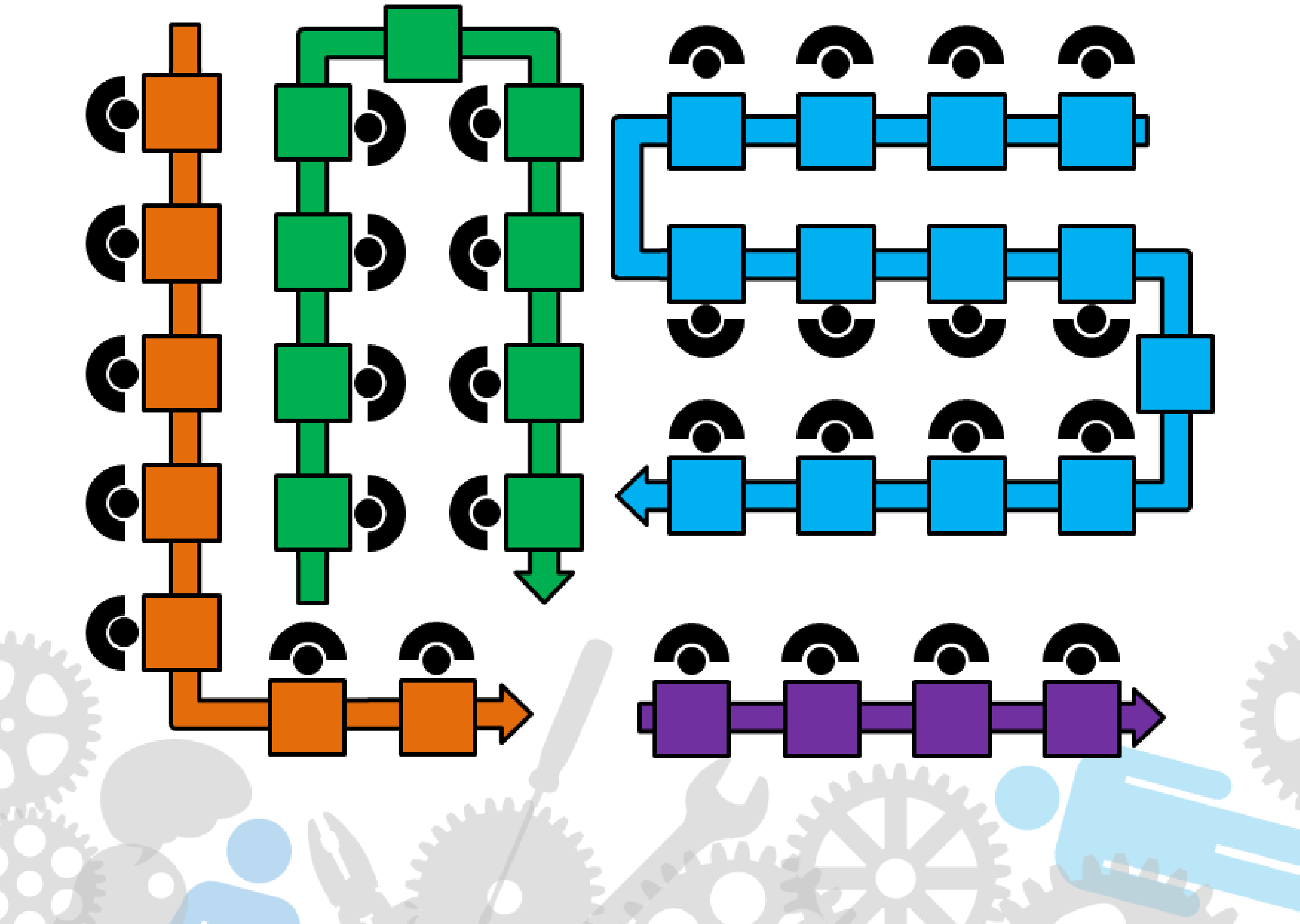
Collected Blog Posts of AllAboutLean.com

2016

Christoph Roser



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Other Books by Christoph Roser

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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)

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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.

Table of Content

1 Taiichi Ohno's Chalk Circle

Christoph Roser, January 05, 2016, Original at https://www.allaboutlean.com/chalk-circle/

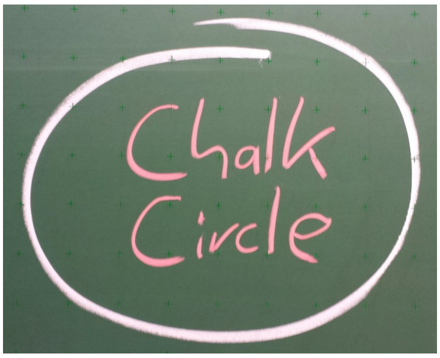


Figure 1: Chalk Circle (Image Roser)

One of the famous teaching methods by Taiichi Ohno is the chalk circle. The method itself is simple. A circle is drawn on the shop floor near a point of interest. A disciple is put in the circle and told not to leave it until he is picked up again by the teacher.

In this post I will explain a bit about the chalk circle, how to use it for teaching, and how to use it for yourself.

1.1 Taiichi Ohno's Chalk Circle

Figure 2: Taiichi Ohno, Father of the Toyota Production System (Image unknown author in public domain)

Taiichi Ohno is one of the main drivers behind the Toyota Production System, and hence by proxy, lean production. One of his famous methods was the chalk circle. On the shop floor in an area of interest (but not in the way of the workers) he drew a circle using chalk. A disciple that had a problem to solve in this area was put in the circle. The instruction given to the engineer was simple: **"Watch!"**

And watch he did. After a while Ohno came back and asked him what he had seen. If the answer was unsatisfactory, the disciple had to watch more. Often, a disciple stood in the circle for hours before Ohno was satisfied. This exercise is also known as *circle exercise* or *standing in the circle*.

1.2 The Human Mind on the Shop Floor

Figure 3: Brain with Gears (Image Roser)

When observing the shop floor, we have a few issues. First, the capacity of the human mind to take in information is limited. If we visit a shop floor, most of us will remember only a disconnected bunch of machines, parts, and people. Only a few details can be recalled.

Secondly, not everything happens at the same time. Even with a perfect attention, you will only see what is happening right now. Unfortunately, a lot of events on the shop floor develop only over time. The regular processes repeat every cycle time. Failures and breakdowns, however, will be much less common.

Overall, you need to focus on a small part of the shop floor for a longer time to really understand what's going on. Hence, it is quite tricky to really understand the actual situation. Usually, the understanding goes through different levels.

- The first level would be simply **walking through the shop floor**: The person knows there is a shop floor and may remember some disconnected details. By the way, this is great to hide real problems from visitors (for detail, see my post How to Misguide Your Visitor – or What Not to Pay Attention to During a Plant Visit!).
- The next level would be **observing a few cycles**, usually no more than 30 to 45 minutes. This is also when the average engineer or manager gets bored. The manager thinks he understands the process, but he understands only a bit and only about the regular process. He still has no idea of the problems that can happen.
- One step up would be **observing an entire shift**, or from 4 to 8 hours. Now the observer gets a deeper understanding of the process, including the problems. This is a good starting point for an improvement process.
- The last step is **observing multiple days**. Usually, this is doable only for the people who work there, although for tricky problems it may also be necessary for managers and engineers to do multiple observations.

Figure 4: It's all in the details! (Image Mentalitanissarda under the CC-BY-SA 3.0 license)

Overall, you need a lot of detail to improve a process (see also Pay Attention to Details – Operator Training at Toyota and Scania). The chalk circle exercise is to get these details, to teach others the value of these details, and to train them into seeing these details. There is even a Japanese word for this *ability to notice*: Kizuki (気付き, Awareness, Realization).

1.3 How to Use the Chalk Circle for Teaching

The chalk circle is a good tool for teaching the value of details.

1.3.1 Selection of Area

Figure 5: Great view (Image petcharapj with permission)

The exercise should be related to a problem the trainee is trying to solve. This works best if the problem or the process is limited to a small area. Find this area, and find a spot with a good view that is not in the way of workers or logistic processes. Sometimes there is a raised walkway overhead. Overall, the spot should have a good view of the area of interest, but should not be in the way of the work. You should also inform the workers why the observation is taking place, and it helps to have a rough idea yourself of what to expect from the area.

Figure 6: Follow me … (Image Katarzyna Kobiljak in public domain)

In some cases the process of interest is mobile (i.e., a vehicle or a worker). In this case you can follow the process along. If it is a truck, you can ride with the trucker. If it is a worker, you can follow the worker. The only thing I'm still struggling with is forklifts, as they are usually only one-seaters ☹. Observing forklifts usually involves a lot brisk walking.

1.3.2 Selection of the Trainee

You should also select a suitable trainee. Who can benefit from observing the process? This is not a cheap Kung-Fu movie where the disciple follows the master's every word. Especially in the Western world, depending on the mentality, not everybody is willing to observe a process for potentially hours on end. There is a risk of the trainee becoming upset about this "*waste of time*," and mentally blocking himself from observing or using the time to fiddle with his smartphone. In this case, it can help to explain the "why" of the exercise rather than simply telling him, "Watch!"

1.3.3 Start of the Exercise/Observation

The trainee is placed on the spot from where he should observe. In my view, a chalk circle is not always needed. Probably not on carpet in an office. Definitely not in a clean room! In any case, the trainee is then left on his own with the instruction to watch. Oh, and tell him that bathroom breaks are okay ☺.

1.3.4 Progress Updates

Figure 7: What did you see? (Image Tyler Olson with permission)

After one or two hours, visit the trainee again. Ask him what he has seen and observed. Ideally, you have an idea yourself of what could have been seen. The great thing about this is that the trainee will probably have seen more than you, yet by adding a few additional comments you can make it look like you knew it all beforehand and are just checking on him. Of course, if we do the exercise together, I have *seen and understood everything*, I am just not telling you ☺.

Even more important than what the trainee sees is that he learns to see. With this exercise, the trainee gets a better understanding not only of the process observed, but also – and more importantly – of how to observe!

1.3.5 End of the Exercise/Observation

The above update is ideally repeated until you feel the problem is thoroughly understood. It may also be ended if the shift or the trainee's working hours end. If for any reason the problem is understood rather quickly, it may be of interest to observe a bit more just to see what happens.

If you have not yet told the trainee why you are doing this exercise, now would be a good time. Try to drive home the value of detailed observation for problem solving. If it is a lean trainee, now by the latest he should hear words like Gemba, Genchi Genbutsu, Genjitsu, etc.

1.4 How to Use the Chalk Circle for Your Own Problem Solving

The value of the chalk circle is not only for trainees. It can also help you to understand a problem in more detail. The process is similar; pick an area and observe. Expect to invest multiple hours for a true understanding.

For example, a while ago I volunteered my time for a project Lean for Refugees, where we try to improve the processes related to the refugee crisis in Germany/Europe (without any political agenda). To understand the registration of new refugees, we observed the processes in detail. I spent around half a day for an overview of the process, followed by a full day for one sub-process (others watched other sub-processes). This helped me to understand not only the normal process, but also the multitude of problems that come with it.

1.5 A Shortcut – Contextual Inquiry

Figure 8: Ask us! (Image Cherie A. Thurlby in public domain)

We are always short on time. The chalk circle, however, is quite time consuming. Luckily, there is a shortcut. You pick the brain of a person who has already observed the process for a longer time – the worker! He has spent literally months with the process and knows a lot of the problems. You should simply ask him while observing. This way you will get a lot more information than you could ever see in a day. It even has a fancy name: **contextual inquiry**.

A few things are important for this contextual inquiry to work:

- It works only where workers have the time to answer your questions, e.g. if they are working on their own pace or have slack time between processes. A closely balanced line does not give the worker time to answer your questions. In any case, **you must not interrupt their work.**
- You still need to observe the process. Ask only whenever something is unclear.
- Everybody sees the world through their own eyes. Hence, what may be significant to the worker may not be to you, and vice versa. Take everything with a grain of salt.
- It still takes time. We are talking maybe four hours for the contextual inquiry instead of eight for the classical chalk circle. For one thing, it is to establish a relation of trust with the worker. For another, you can verify and understand what he tells you if you see it happen.

1.6 Summary

Overall, there is great value and insight in a prolonged observation. Many problems that are near impossible to solve become quite easy to understand if watched in detail. If you are into lean, you should know already the value of going to the shop floor, or Genchi Genbutsu. **The chalk circle is the essence of Genchi Genbutsu.**

Naturally, it works not only for shop floors but also for administrative processes, logistics, and many others. As long as you can observe it, it can help your understanding. Now go out, speed up your improvements by standing still, and **organize your industry!**

1.7 See also my Academic Writings

- Roser, Christoph. "Der Kreidekreis von Taiichi Ohno: Beobachten – Verstehen – Entscheiden – Handeln." Yokoten 5, no. 2 (2016).
- Roser, Christoph. "Taiichi Ohno's Chalk Circle in the Office." In Proceedings of the European Lean Educators Conference. Buckingham, England, 2016.

2 The Problems of Cost Accounting with Lean

Christoph Roser, January 12, 2016, Original at [*https://www.allaboutlean.com/accounting-and-lean/*](https://www.allaboutlean.com/accounting-and-lean/)

Figure 9: Calculator and Money (Image unknown author in public domain)

Accounting is one of the cornerstones of the modern economy. Cost accounting in particular helps in decision making with the goal to maximize profit. Many decisions are based on these numbers. Unfortunately, **cost accounting usually does a really poor job of capturing the essence of manufacturing in general and lean manufacturing in particular**.

2.1 The Historic Development – Where Did It Go Wrong?

Figure 10: Give me your numbers… (Image Jacopo de' Barbari in public domain)

Accounting itself can be dated back to the beginning of civilization. The beginning of modern accounting and also cost accounting is usually attributed to Luca Pacioli (1447–1517). He was inspired by Venetian merchants, who were also the primary customers of his books.

For merchants, cost accounting is rather useful. The idea behind it is simple: buy cheap, sell expensive. To maximize your profits, you should use your limited resources (money) for activities that give you the best return on your investment.

Manufacturing, on the other hand, was usually less concerned with bookkeeping. With the different materials coming in and products going out, tools needed, and time used, it would have been difficult to keep track of it all. Historic manufacturers probably used more of a gut-feeling approach and experience to set their prices. Besides, their goal was often not profit maximization, but merely to have a good life. As Daniel Defoe observed: "*There's nothing more frequent, than for an Englishman to work till he has got his pocket full of money, and then go and be […] drunk, till, tis all gone.*"

With this attitude, it is no surprise that merchants became wealthier than craftsmen. Soon, merchants started what we would nowadays call a vertical integration: they included craftsmen in their supply chains through a *putting-out system*. Merchants contracted craftsmen for creation of products. They provided the craftsman with raw materials, and often also with the tools and even the workshop, and the craftsman labored for the merchant.

Hence, the merchant had little knowledge of the manufacturing process. He did not know and did not care about the details of the process, its efficiency, and the possibilities for improvement. He was merely interested in the cost and quantity of the raw materials, the value and quantity of the finished goods, and the expenses for the craftsman. And that is even nowadays still a fitting description of the relation between manufacturing and cost accounting.

2.2 What is Cost Accounting?

Cost accounting aims to understand the cost of the products or services of the company. It is used to help with decision making. It uses a number of different KPI, based on input values like direct labor cost, direct material cost, sales price, quantity, overhead ratio, etc.

- **Variable cost**: Costs that change in proportion with the number of products made (i.e., labor cost based on the wages and the time to make the part, material cost, etc.).
- **Fixed cost**: Costs that are independent on the number of products (i.e., the cost to purchase a machine).
- **Profit Margin**: How much more the customer pays you compared to your own expenses. Should obviously be positive, and for manufacturing usually up to 10%, although there are lucky companies that get more out of it.
- **Return on Investment (ROI)**: How long it takes to get your money back. Anything less than two years is usually desired.

Ideally, cost accounting helps managers decide where to invest and where to save money. The quite valid goal is to the the biggest bang for the buck.

2.3 The Flaws of Cost Accounting Approach

Figure 11: Burning dollar (Image Nik_Merkulov with permission)

However, cost accounting reduces the process of manufacturing to a few simple numbers to make decisions. Even if the numbers were correct (see Lies, Damned Lies, and KPI), it misses out on a lot of information. A lot of things cannot be reliably determined using accounting. Below is an incomplete list of important factors in manufacturing that are ill-covered in accounting.

Speed: Everybody knows that speed gives you an advantage over the competition. No matter if you are first in a market or deliver a product faster, it will improve your competitiveness and hence your revenue. However, it is nearly impossible to determine this advantage quantitatively. How much does it get you to be in the market 7 days earlier?

Fluctuations (Mura): One big thing in lean manufacturing is to reduce fluctuations, or at least to have the **flexibility** to handle these fluctuations. The more even your system works, the more profitable you will be. However, it is difficult to measure these fluctuations, even more difficult to determine the impact of an improvement on fluctuations, and hence nearly impossible to calculate the monetary benefit of reducing fluctuations. For example, do you know what it costs you if your customer always orders at the end of the month rather than throughout the month? Pretty much the only thing that can be calculated are inventory costs, and even these are usually flawed (see The Hidden and not-so-hidden costs of Inventory). Yet, inventory is only a small aspect of the benefit of reduced fluctuations. Overall, cost accounting usually considers a static situation.

Overburden (Muri): Often overlooked in Western-style lean is overburden. What are the costs associated with overworked employees? What is the monetary benefit of training? How much additional cost is caused by each frustrated worker, and how much would it cost to un-frustrate them? What is the quantitative advantage of having clean and well-maintained toilets on the shop floor rather than the biohazards I often see?

Figure 12: Priceless! (Image vadymvdrobot. with permission)

Customer Satisfaction: Yet another thing in lean is customer satisfaction, often described as *value to the customer*. But again, what is the monetary damage if a delivery is delayed, if a product breaks, if service is slow, or if your people are unfriendly? It is nearly impossible to know. Even more difficult to determine is how improvement measures will actually influence the above. How much does it cost you to provide a better service, how will this influence customer satisfaction, and what is your benefit from this?

In the above examples, the investment expenses are usually known rather well. The monetary benefit, on the other hand, is incomplete and fuzzy at best, and often even completely unknown.

On a side note, above I listed *Mura* (unevenness) and *Muri* (overburden). You may have wondered what happened to Muda (waste). Out of the The Three Evils of Manufacturing, waste is probably the one that can be calculated best. Inventory costs, transport costs, etc. are still difficult to determine, but often you may have a rough idea what these will cost you. Maybe this is the reason that waste reduction is found everywhere in Western lean, whereas the much more important (in my view) reduction of unevenness and overburden rarely pop up.

2.4 How This Leads to Bad Decisions

2.4.1 Bad decisions where to put the money

Industry is driven by profit. Cost accounting helps with the decisions to maximize this profit. There is an understandable tendency to prefer decisions that have a defined cost benefit over decisions that give an unknown return on investment. Even if the cost benefit is incomplete and fuzzy, having a number gives a false sense of security.

Hence, investments often happen where there are accounting numbers. In my experience, to invest in machines is an easy decision. You calculate if the machine is worth the money and then decide if you buy one. Same applies to shop floor workers. Based on quantity and time, you can determine how many you need and what they will cost you.

Investments that have a cost but lack a calculated benefit often get overlooked. Customer service is often understaffed. Toilets are only renovated if a higher-up visits the plant. Health and safety are based on legal requirements. Training for shop floor workers is often lacking. Yet, having no calculated benefit does not mean these measures have no benefit.

2.4.2 Bad decisions where to take money out

Figure 13: Remove redundant instruments and use lowest-cost labor to maximize profit… (Image MITO SettembreMusica under the CC-BY 2.0 license)

Similarly, an incomplete picture of the cost and benefits leads to savings that end up costing more than what they saved.

For example, while the cost of maintenance is well known, the benefit is hard to calculate. As a result, maintenance cost is often reduced more than what would be good for the plant. Same goes for internal support. For example, reducing or centralizing IT support clearly reduces labor cost. On the other hand, the cost of delayed or incorrect troubleshooting is clearly there but usually unknown.

Similarly, since work is measured in time, a young, unskilled worker or temp is usually cheaper than an older, experienced worker. Hence, replacing older workers with younger ones reduces costs. But how does that influence quality or reliability? A robot can also produce cheaper than human workers, but humans can learn and will become better. A robot does not learn. Using only robots, Improvement will slow down. (Toyota sometimes reduces robots and also trains master craftsmen (called Takumi 匠) to learn how to become better.)

2.5 How to Make Better Decisions

There are many more examples where a lack of hard numbers leads to one-sided savings or skipped investments. The question is: How can it be done better?

2.5.1 Why we make bad decisions

Figure 14: Decisions… (Image Carsten Tolkmit under the CC-BY-SA 2.0 license)

Before we go into that, I can't really blame modern managers. Every decision includes the risk of failure. In Japan, a failure causes problem solving and learning from mistakes. In the Western world, a failure all to often causes a search for someone to blame. Understandably, managers are often risk averse, seek security in numbers, and are trained not to stick their neck out.

Of course, it does not necessarily help if the person in charge has an economics background only. To manage a process, it is necessary to understand the process.

2.5.2 Lean Accounting?

There is something called **Lean Accounting**, which aims to rectify these problems and help to make better decisions. But, as far as I can tell, I am not impressed by lean accounting. It tries to include lean considerations in the cost benefit accounting. While it has some advantages over traditional accounting, I strongly believe that many of the benefits of lean cannot be reliably calculated. For example, I cannot possibly see how anybody can reasonably determine the monetary value of a happy employee or customer.

Besides, for my taste it includes too many buzzwords and fancy acronyms. But maybe that's just me. But, also read the comment by Brian Maskell below, with an insider view of lean accounting.

2.5.3 Common Sense and Right Direction

There is one crucial fact important for decision making in lean manufacturing: **Some things are beneficial even if you cant quantify the benefit!** Not all decisions can be based on numbers. Some numbers may be wrong. Others may be missing completely. Nevertheless, a lack of quantitative numbers does not mean the idea is bad. In my view, there are a few things needed to make better decisions and to avoid the traps of cost accounting. While by no means a complete set of guidelines, the following may help:

Use common sense: Decisions should not be made based on numbers alone. Try to keep the big picture in mind. If a decision feels wrong, it probably is. Just because you cannot measure the benefit does not mean there is none.

Figure 15: True North… (Image Hike The Monicas under the CC-BY-SA 4.0 license)

Try to move in the right direction. Lean is a good guideline here. If it reduces fluctuations, leads to happier workers or customers, or generally goes toward a "true north," it may be worth the effort.

Make small steps: Big measures can fail big. Small measures may have smaller failures. By doing lots of little steps you are less likely to have catastrophes. Besides, even with small mishaps you can learn from mistakes.

Avoid the blame game: People make mistakes. It is not important who made the mistake, but that the organization learns from it. Removing the person that made a mistake does not remove future mistakes; it actually increases them.

2.6 Summary

In my view, better decision making is still one of the big potentials in manufacturing. Yet it is difficult to change the management process and the decision making. Toyota is known for its excellent manufacturing system, but in my view, its excellent management is more important. Without this management, the Toyota Production System would have never happened. "**Not**

everything that can be counted counts. Not everything that counts can be counted!" (often attributed to Einstein, but probably more likely William Bruce Cameron). But it was definitely Taiichi Ohno, who said that "**It was not enough to chase out the cost accountants from the plants. The problem was to chase cost accounting from my people's minds**". So, keep your head up, use common sense, try to go in the right direction, and learn from your mistakes. Now **go out and organize your industry!**

2.7 Inspiration

This post was inspired by a recent short German book, Lean auf gut Deutsch: Band 1 Einführung und Bestandsaufnahme, by Mari Furukawa-Caspary. She is a bilingual German-Japanese lean expert, and in her short book she talks, among other things, about the failures of cost accounting in lean manufacturing.

A second inspiration was a question by O. H. on how to use traditional cost calculation in lean manufacturing.

3 The Challenges of Lean Administration

Christoph Roser, January 19, 2016, Original at https://www.allaboutlean.com/lean-administration/

Figure 16: More Work (Image unknown author in public domain)

Lean started with manufacturing, but since then has moved in many other areas of the economy, from lean banking to lean healthcare. One major part of modern economy is administrative processes, which includes things like making offers, procurement, accounting, engineering, research, and many others. By some estimates, **more than half of the cost of producing companies are in administration. Up to 80 percent of the lead time is due to administration.** A lot of the principles behind lean can be used in administration. However, there are also some unique challenges that are less prominent in manufacturing. Let's have a look.

3.1 Lean Principles Still Apply

Figure 17: Lean production Tag Cloud (Image Web Buttons Inc with permission)

The underlying ideas of lean are still good for administration. Below is a selection of these ideas. But please note that I myself do not yet have a good enough grasp of lean in my head to postulate a comprehensive list of lean principles. **Shockingly, I don't know everything about lean. Even more shockingly, I admit it.** The ideas below are just examples of what helps with lean, and they are neither complete nor without overlap.

- Eliminate of Muda, Mura, and Muri (waste, unevenness, overburden)
- Improve quality
- Be nice to people, including those you don't have to be (e.g., your own, your suppliers)
- Don't trust KPI, but go see the people actually working and talk with them
- Try to make a pull system by limiting the WIP
- Division of Labor
- Use visual management
- Pay attention to details

I'm also aware that the points above are rather general. Telling someone to reduce unevenness tells you little about how to do it, and talking is also much easier than doing.

3.2 The Challenges of Lean Administration

While most ideas and tools in lean can also be used for administrative processes, there are some challenges that are more problematic in administration than in manufacturing.

3.2.1 The work content is much less standardized

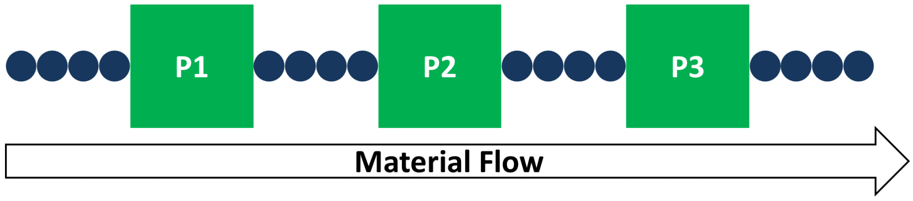


Figure 18: Manufacturing is Standardized (Image Roser)

In manufacturing, particularly in flow production, you can expect every part coming down the line to be all but identical to the previous part. Even with different part variants, they have much in common.

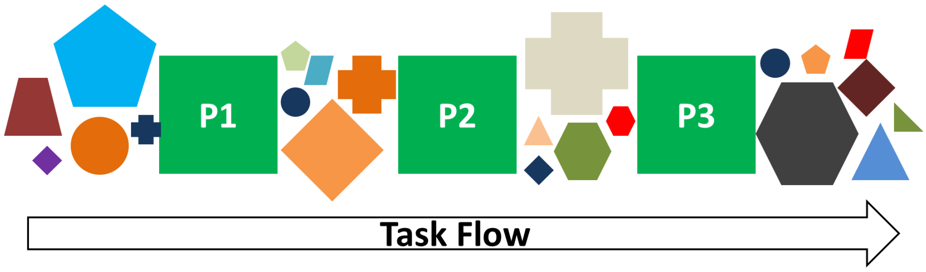


Figure 19: Administration tasks are less standardized (Image Roser)

This is often not so in administration. For example, if your administrative process prepares offers to customers, one offer may be quick and easy, but the next one may be more difficult than ten easy ones. Or take a call center. One customer is happy after 30 seconds of conversation, whereas another customer takes ten minutes and then still wants to talk to the manager. Overall, in administration you never know how much work the next task will be until you actually look at it. In short, you cannot judge the amount of work by the height of the stack of folders.

3.2.2 The flow of the work is less standardized

In manufacturing, if you have a flow shop, all parts follow the same sequence. Even for a job shop, the sequence of the parts is usually well defined even though it may be different for each part. Loops are rare. Once a part goes through a certain process, it is unlikely that this part will be sent back to be processed *again*.

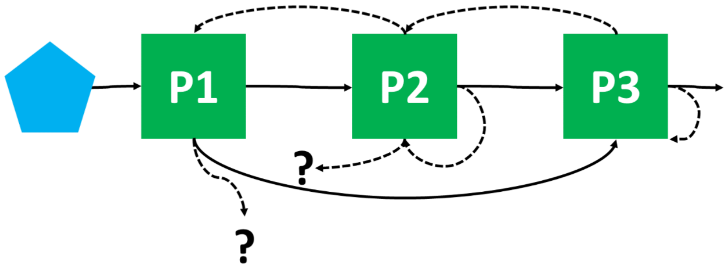


Figure 20: Administration flow is less standardized (Image Roser)

In administration, however, this sequence is usually much less defined. Depending on the task, the sequence of steps may not even be known beforehand. For example, take the process of making an offer to the customer. Depending on the details of the offer, different people may be involved. More than one person could work simultaneously on the same offer. Also, if there are problems, loops are common. The offer may be handed back to the previous process steps for clarification or correction.

3.2.3 It is more difficult to observe the work

Figure 21: Prow lookout aboard USS NASSAU (Image Lt. Wayne Miller in public domain)

For me, an important part of improving a situation is to observe and find the potentials. This often includes an estimate on the cycle times.

For administration, however, this is also more difficult. Modern administration is usually done on a computer. Observing an administration office is seeing a lot of people doing *something* on a computer – and unless you pay close attention, you have no idea if this is actual work or Facebook.

3.2.4 It is more difficult to enforce work standards

When improving manufacturing, it is important that these improvements stick. An improvement is worthless if everybody turns around and falls back into the old style. Standards help with maintaining a new (and hopefully better) way of doing things. Yet even in manufacturing, there is a tendency to fall back to the old ways. In my experience, it helps if the standard is somewhat set in stone. It helps if the standard is enforced through the design of the process. It helps if the process is changed in a way that only the new way is possible, or at least sensible. For example, if you rearrange the sequence of the work by rearranging the machines, it would be highly impractical to do the old sequence with the new layout. We often don't think about this as a way to enforce standards because it is so obvious.

Figure 22: Filling out a form (Image tunedin with permission)

In administration, unfortunately, it seems to be a bit more difficult to enforce standards through the design of the process. This is especially true if it is done by paper. To take an example outside of industry, if you check into a hotel, sometimes you are asked to fill out a registration form. To be honest, I am usually quite sloppy doing so. My address is usually without zip code. If they ask for my e-mail, I just leave this blank. If they want my passport number, I am definitely too lazy to pull out my papers and look up the number, but just write a bunch of numbers anyway. And usually it works. The front desk seems to be more interested in getting a paper than getting correct information. Hence, it is very easy to circumvent the standards.

This is more difficult with mechanical items. If I am too lazy to put batteries in my remote, my remote clearly tells me that this is not acceptable (by not working). Similar examples can be found all over administrative processes.

There may be a tad more standard in software programs, which often work only if something is actually filled out. For example, if registering online, it may work only if there is actually a a valid e-mail address or a phone number added. Yet how do they know if I added the right number? Besides, just because they ask does not mean I want to surrender my phone number. Same in industry. ERP programs often require an input to proceed, but have no quality control if he input is correct. Experienced administrators often know where to pay attention and where just to write something to move ahead.

On a side note, it seems to me that the higher the pay grade, the more difficult it is to make people follow a standard. Hence, when implementing a standard, better-paid white-collar workers may resist more than blue-collar workers.

3.3 Lean Administration Is Still Worth the Effort

All the above problems sound daunting. Administration often is still far behind manufacturing in terms of quality, efficiency, and standard. To me it feels like manufacturing before Henry Ford and his assembly line (i.e., very chaotic).

Yet, difficult does not mean you should not try. For Henry Ford, it was an enormous effort to create assembly lines. This effort, however, created a gargantuan benefit, making Ford the largest car maker of his time.

Figure 23: Low-hanging fruits… (Image andreas_fischler under the CC-BY 2.0 license)

Similarly, there is lots of potential in administration. Since it is more difficult, it often means that fewer people have tried. Hence, there are more low-hanging fruits. It may be near impossible to achieve the efficiency, speed, and quality of a modern assembly line in administration, yet any step in that direction will improve your bottom line.

As mentioned above, most of the ideas and methods behind lean will also work in administration. Some lean tools are even designed specifically for administration (e.g., the swim lane diagrams). In any case, you should not overlook your administrative processes when you work to **organize your industry!**

P.S.: This post was inspired by a question from Veronique Zuber. Name mentioned with permission.

3.4 See also my Academic Writing

- Roser, Christoph. “Taiichi Ohno’s Chalk Circle in the Office.” In Proceedings of the European Lean Educators Conference. Buckingham, England, 2016.

4 Line Balancing Part 1 – Data Overview

Christoph Roser, January 26, 2016, Original at
https://www.allaboutlean.com/line-balancing-1/

Figure 24: Hands in a Circle (Image Robert Kneschke with permission)

Balancing the workload in a manufacturing system helps greatly in improving performance. Most importantly, it reduces unevenness (*mura*) due to different workloads. This in turn will reduce wasted waiting time (*muda*) for those with too little work, and overburden (*muri*) for those with too much. Additionally, I usually find it to be one of the easier aspects of lean manufacturing, since the new standard can simply be enforced through the layout of the machines. This post looks at data preparation, especially the customer takt and the list of tasks. It will be the first in a long series of posts on line balancing. The next post will look at the durations needed for the tasks.

4.1 Introduction

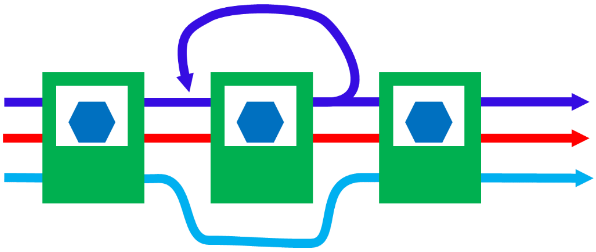


Figure 25: Flow shop (Image Roser)

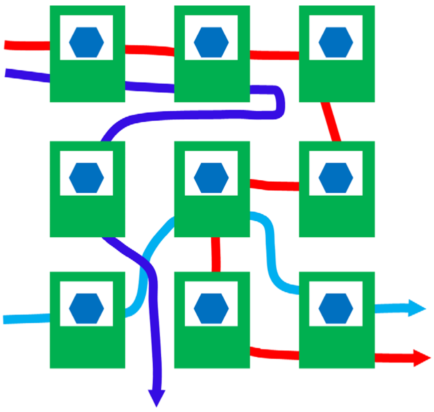


Figure 26: Job shop (Image Roser)

Balancing the workload among the different processes of a manufacturing system is usually straightforward. It is easiest with a flow line where all products are quite similar and go through the same sequence of processes. However, it is also possible for job shops, where the products may have a different workload and a different process sequence. However, since job shops are a bit more complicated, I will cover them in a later post.

4.2 The Product List

Figure 27: Different Screws (Image Ssawka under the CC-BY-SA 3.0 license)

First, you should get an overview of all the products that will pass through your manufacturing system. This list should be as complete as possible. If all your products have the same process steps and cycle times, you may take only one major product. However, this is risky. If you miss one product with a different process step that is relevant only to this product, you end up not being able to produce this product. Best to be on the safe side and have a look at all products to be produced.

4.3 Meet the Customer Takt

Figure 28: The takt for your system (Image Vladimir Voronin with permission)

A manufacturing system has to meet its customer takt (i.e., the average output of the system has to be at least equal to the average demand by the customer). Too little, and you sell less than you could. Too much, and you waste capacity or build up stock. For more details, see my posts How to Determine Takt Times and Pitfalls of Takt Times.

The customer takt is measured in seconds per part including all losses. Please note that I also use the term **line takt** or **process takt** for the corresponding speed of the line or process, also including all losses. Unfortunately this is not standardized, and many others also call this a cycle time, or sometimes even a process time. So, **whenever I talk about a takt, I include all losses (i.e., the gross time). Whenever I talk about a cycle time, I exclude all losses (i.e., the net time).** For more on this, see On the Different Ways to Measure Production Speed.

For later calculations, we need the expected customer takt for each product, or alternatively the expected quantity during a time period. It also helps to have the overall customer takt for all products combined, or alternatively the total quantity of products during a future time period. Please be aware that you cannot simply take the sum of the individual takts; you need to take the inverse of the sum of the inverse.

$$TT_{All} = \frac{1}{\frac{1}{TT_1} + \frac{1}{TT_2} + \frac{1}{TT_3} + \cdots}$$

This also assumes that all parts of the production system are working at the same time and are off-shift at the same time. If you design a production system where some processes work longer (or shorter) than others, then naturally you would need a separate customer takt depending on how long they work. Luckily, if you design a line, it is rare that they have different working times.

4.4 What Do You Have to Do?

Now that you have the target customer takt, you have to figure out what you actually need to do. How much work do you have to put into your product? You need an overview of the workload, its flexibility, and the net working time for each step in the value chain.

4.4.1 The List of Tasks

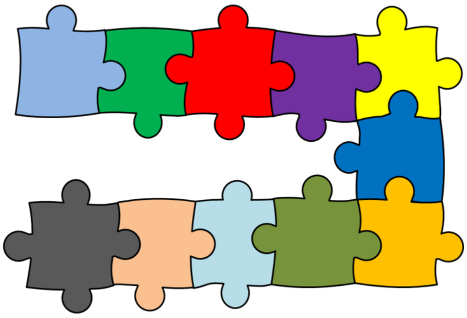


Figure 29: Puzzle Pieces (Image Roser)

You need to get a list of the steps you need to do in your manufacturing system. What are the value-adding actions of your system from the incoming material to the departing products? The steps should be made reasonably detailed. Anything that could be broken into stand-alone sub-steps should be broken into these sub-steps. Anything that cannot reasonably be a separate task should be grouped together.

For example, if you drill three holes of different diameter, it makes sense to have three tasks, one for each hole. However, while you need to pick up the drill, attach the drill bit, and drill the hole, you should not separate these into individual tasks, as they usually have to be together.

Admittedly, this is difficult to explain in theory. However, if you have a real manufacturing system, this usually comes across easily. Even if you later change your mind, **it is always possible to merge tasks again. It is also possible to split one task into two**, although this requires a new estimation of the cycle time of the separate tasks. In any case, splitting the work based on the smallest stand-alone tasks will help you later when rearranging the steps.

Usually, I add these tasks into an excel file. As you balance the line, more and more data will be added to this excel file. This will be helpful later on when you balance the line.

4.4.2 Task Variations Due to Product Variations

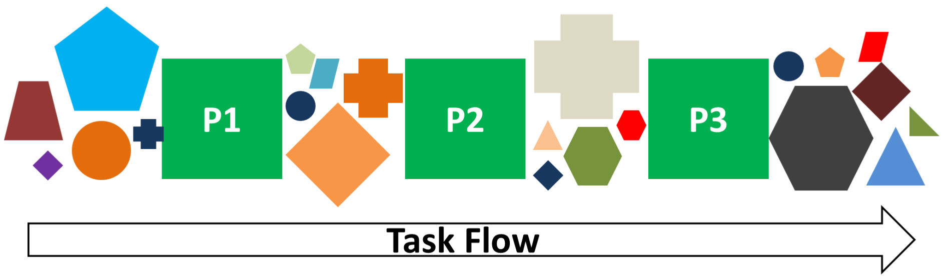


Figure 30: Administration Non Standard Tasks (Image Roser)

The list of tasks is easiest if you have a flow line with very similar products that require identical product steps. In this case you merely need to take one sample product, ideally the one with the highest quantity, and create the task list. Since all products have the same tasks, this list will represent all products.

It becomes more tricky if some products have different tasks. For example, some products may require additional process steps, whereas others may require fewer. The list of tasks must contain all steps that are required for all the products in the production system! If you leave one step out, you may end up missing the task in the final system and hence will be unable to produce. That is the reason I recommended looking at all products going through the system, lest you miss one task for an rarely produced but still needed exotic product.

4.5 Summary

Getting an overview of the products, tasks, and the customer takt is the first step in line balancing. Yet, this just gets us started. In the next post of our multi-post series, we look at the times needed to do the different tasks. If all parts have the same tasks and durations, this is easy. However, if they differ you may need to pull some tricks. So stay tuned, and in the meantime **go out and organize your industry!**

5 Line Balancing Part 2 – Duration of Tasks

Christoph Roser, February 02, 2016, Original at https://www.allaboutlean.com/line-balancing-2/

Figure 31: Hands Pointing in a Circle (Image Robert Kneschke with permission)

In our first post on line balancing, we looked at the tasks that must be included in the line. In this second post of this series on line balancing, we look at the durations for the individual tasks. Of particular interest are different strategies on how to balance a line if the tasks have different durations for different products. A second consideration is if the equipment is already available or is still to be purchased (and hence can be customized more). The next post will look at more details of the losses (i.e., the OEE).

5.1 How Long Will It Take?

Figure 32: On cycle times… (Image unknown author in public domain)

The next step is to determine the duration of each of these tasks. This is relatively easy if all products have the same steps and the same time for each step. The time should be excluding all losses.

If it is a machine you already have, it would be the cycle time (i.e., the time between completion of a part excluding all losses and disturbances). Getting this time usually isn't too difficult, but there are a number of pitfalls. For more details, see my series on How to Measure Cycle Times – Part 1 and Part 2.

For manual work, you can also determine the times needed without losses. See also my post Cycle Times for Manual Processes.

If your system already exists, these times are reasonably well defined. You can measure the cycle times of your machines. You can also measure the cycle times of your manual work. There may be small improvements possible with a new line layout, but there are rarely big changes. Please be wary of data that someone provides you. In my experience this data often turned out to be outdated or incomplete. Make sure you know which data to trust. In case of doubt, do some sample checks.

If you establish a new production system, then this is different. If you purchase new machines, you can usually influence the cycle times. If you need a cycle time of *x*, then you just build or purchase a machine that can meet the cycle time of x. This gives you more flexibility. During the gathering of data for the line balancing, I do not yet set a time, but merely note that this time can be flexible. Later, when I actually balance the line, I pick a time that matches my needs and my budget.

5.2 Task Duration Variations Due to Product Variations

Figure 33: Different Screws (Image Ssawka under the CC-BY-SA 3.0 license)

Having all products with identical tasks and times makes it easier. However, often the products differ, sometimes significantly. The bigger the differences, the larger the troubles. There are three different approaches you can take.

Pick the High Runner

Figure 34: Who is the gorilla in the room… (Image Tiffini M. Jones in public domain and Macinate under the CC-BY 2.0 license)

You design the system based on the product that you need most frequently. Hence, you simply take the times of the high runner for the balancing. This could also be a group of products with nearly identical tasks and cycle times. The advantage is that this is easy and straightforward. It will also give you a good system for the selected high runner. On the other hand, the system may not be well designed for the other products. Overall, this is the easiest approach, and it may still work reasonably well for similar products.

Take the Weighted Averages

Figure 35: Weights for balances (Image Nikodem Nijaki under the CC-BY-SA 3.0 license)

You determine the cycle times for all tasks and products. For each task, you create a weighted average of the cycle time based on the quantity produced. For example, if 80% of your products have a cycle time of 60 seconds, and 20% have a cycle time of 90 seconds, then the average cycle time will be 60s·80%+90s·20%= 66 seconds. This will give you a system that is universally matched for all products, provided you fulfill two requirements:

- **Your batch size must be very small**, ideally a batch size of one. If you have larger batch sizes, it is likely that some processes will be too slow for some products to match the cycle time, while the same process will have lots of waiting time for other products.
- **You need a buffer before and after the processes** with larger variations in cycle time.

Assume you have a process that is slow for some products and faster for other products. For example, a two-door vehicle will have its doors installed faster than a four-door vehicle. Hence, with an average cycle time, the process of installing the door will be too fast for two-door and too slow for four-door vehicles. If there is a good mix alternating between two-door and four-door vehicles with a little buffer before and after the door installation process, then the process can take more time for four doors and catch up with the next two-door vehicle.

However, this works only with (very) small batch sizes. If you make twenty two-door vehicles followed by twenty four-door vehicles, you either need a disproportionately large buffer or you will have waiting times followed by a bottleneck at the same process. **If you take the weighted average times for the tasks together with larger batches and/or insufficient buffer, your system will be too slow and will not meet the customer demand!**

Design for Individual Products

This option is the most difficult one. I would prefer either the high runner or the weighted average. However, if the system is too different and you are forced to have large batch sizes, you may choose to design individual systems.

Figure 36: I am flexible… (Image Beadell S. J. in public domain)

Here we have to distinguish between automatic machine processes and manual processes. You should never design a system where people regularly have to wait. This is impolite, and may also cause slack elsewhere where you don't want it. Letting machines wait is acceptable. You will lose the work time, but it won't be detrimental for the rest of your system. Luckily, people are flexible and the work can be adjusted more easily around manual workers.

Hence, **your machines should be set up so they can match the fastest speed required**. The easy way is to take the slowest cycle time needed for a task. For example, if a machine has one product that needs 30 seconds and another that needs 40 seconds, you should design the system so it can meet the customer takt if the process needs 40 seconds (be aware that we still need to include the losses through the OEE!).

Yet, if your 40-second product is rare, you may end up with a system that is faster than needed, since the 30-second product can now be produced faster than necessary. Balancing this is tricky, since it depends not only on this task but also on the variation of the times of the other tasks. To optimize, you would need to figure out the bottleneck in the system for each product and then design the system for individual products that together match the customer demand.

Figure 37: Just a second … (Image Snyder, Frank R. in public domain)

If this sounds hairy … yes … it is! Solving this problem for a medium-complexity system is probably worth a doctoral dissertation or two. Hence, unless you can wait four years for your Ph.D. to finish the calculations, don't do it. Just take the easy road and have the machines match the fastest speed required, even though as a whole they may be a bit faster than needed.

For your manual work, you have the benefit of adjusting it through the number of people you put in the system. Hence, **for manual work you balance the system separately for each product you produce**, while keeping the process sequence the same. This is also a lot of work, not only in designing the system but also in changing the manpower for each new product. To reduce the required manpower changes, you would need larger batch sizes, and this is in my view fundamentally the wrong direction in lean manufacturing.

Hence, designing a system for each product separately is a lot of work both in design and in operations, and it includes lots of uncertainties. Don't do it!

5.3 Summary

Overall, each task should have a duration. You can boil the ocean and do it in high detail for every product separately, but usually this is quite an effort that is rarely worth it. Much better to use a weighted average or just one sample product. Keep it simple. In the next post I will start with explaining how to turn a cycle time into a takt and vice versa. Hint: We will need the OEE. However, using the OEE has some caveats that you should be aware of. But more about this in the next post. In the meantime, **go out and organize your industry!**

6 Line Balancing Part 3 – OEE Caveats

Christoph Roser, February 09, 2016, Original at https://www.allaboutlean.com/line-balancing-3/

Figure 38: Stacked hands (Image Robert Kneschke with permission)

When balancing a line, it is important to distinguish between idealized times without losses, and times that include all types of losses like breakdowns or missing material. The ratio between the ideal time and the real time is the OEE. This post looks at some of the problems that can happen with line balancing if an OEE is used incorrectly or differently, and is the third post on this series of line balancing. Once we have determined what OEE to use, we will look at how to use the OEE in line balancing in the next post.

6.1 What Are Our Losses – The OEE

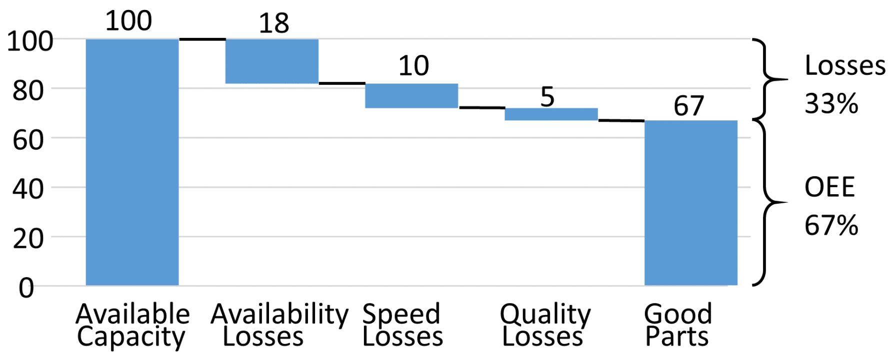


Figure 39: Example of OEE losses (Image Roser)

All the times determined above are without losses (i.e., all the times for the individual tasks are assumed to be in perfect conditions without any breakdowns, missing materials, defects, or other problems). Yet the customer takt you want to meet includes losses. Hence, if your customer takt is 40 seconds between parts, and you design the system to have a cycle time of 40 seconds between parts, even the tiniest breakdown will put you behind and make you slower than the customer takt. Again, for the difference of a takt with losses and a cycle time without losses, see On the Different Ways to Measure Production Speed.

The ratio of the cycle time to the customer takt is, of course, the overall equipment efficiency, or OEE. For more details on how to measure the OEE, see my series of posts starting with What is OEE? – Definition of OEE. Using the OEE, you can transfer a customer takt time into a target cycle time, or alternatively a cycle time in a target line or process takt. Both work. I usually prefer to determine a target cycle time, since the people I work with on the shop floor are more likely to think in cycle times than in takt times.

6.2 Watch Out for How the OEE is Calculated!

Figure 40: Definitely a planned stop… (Image James Salmon in public domain)

Unfortunately, the OEE is often heavily fudged. Often, managers desire the OEE to be as high as possible to look good. I have even seen OEEs above 100%, meaning that the process can produce more than the theoretical maximum. Of course, this is not possible but merely the result of number fudging.

If you use the OEE to calculate the target cycle times, they would have to be reasonably correct. You have to be especially careful if some time blocks are excluded from the OEE. For example, many companies do not include planned maintenance and other planned stops in the OEE. Often, this is also done in a blanket approach.

Let's take an example. Assume you need to produce 480 parts per day, and you have an 8-hour work day. This gives you a takt time of exactly 60 seconds. If your measured OEE is 80%, then you would need a cycle time of 60 seconds · 80% or 48 seconds. Hence, you design your system to have a cycle time of one part every 48 seconds, so that including losses you get a takt time of one part every 60 seconds.

Figure 41: Sneaky Consultant OEE (Image bramgino with permission)

Lo and behold, when calculating the OEE, one hour per day for maintenance was automatically removed. The one hour per day was not defined as a loss in the OEE, but completely taken out of the equation! Hence, the time basis for the OEE was not 80% for 8 hours per day, but 80% for 7 hours. The cycle time of 48 seconds still turns into a takt time of 60 seconds. However, **instead of 480 parts during an 8-hour day, you get only 420 parts during a 7-hour day! Now your calculation is off!** Instead of a takt time of 28800s/480parts = 60 seconds, you now have a takt time of 25200s/480parts = 52.2 seconds. Now you either need a cycle time of 80% · 52.2 seconds, or 42 seconds instead of 48 seconds, or one hour of overtime every day to make ends meet.

Unless, of course, the one-hour maintenance is truly and entirely cheated. If for the OEE calculation, the one hour of pretend maintenance was removed but worked it anyway, then you have the rare instance where two errors cancel each other out. But I would not bet on it.

Overall, **check if the OEE is calculated reasonably**. Look especially at the total time including all losses. If you expect 8 hours per day but get only 7, then you either would have to assume a customer takt that has only 7 hours per day available, or recalculate the OEE with an additional hour of losses to get an 8-hour day.

6.3 Watch Out for Interdependence of Processes

The OEE of an individual process and the OEE of an entire system are rarely the same. A problem in one process can also stop another process through blocking and starving the other process. Hence, if you have three processes with an OEE of 80%, then the OEE of your entire system will likely be less than 80%.

In the worst case, if a problem anywhere in the system will immediately stop the entire system, then the overall system OEE will decrease dramatically. As shown in the image below, if all your processes have an OEE of 80%, then with 10 processes your system OEE will drop to 10%. With 20 processes, there will be only 1% of productive use left.

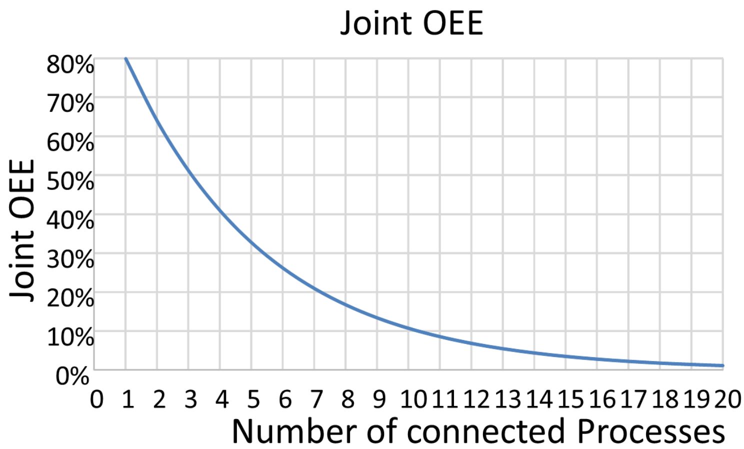


Figure 42: OEE for connected processes (Image Roser)

Luckily, in reality it is not that bad. Processes are decoupled through buffers. Additionally, if you measure the OEE on an existing line, it should already include the downtime due to starving (lack of material) or blocking.

You mostly have to **keep an eye out for this if you buy a new machine** and the manufacturer promises you an uptime of xy%. By this, of course, he means an uptime assuming that there is no lack of material, blocking, a missing operator, or whatever else the machine tool maker considers not his problem. In this case, stay conservative and assume that the OEE will not be as good as the supplier promises (and it rarely will be).

6.4 I Don't Know My OEE!

Figure 43: Question Mark (Image Horia Varlan under the CC-BY 2.0 license)

Getting the OEE is actually not too difficult. You do not need to determine the losses in detail; you merely need the ratio of what you produced to what you could have done under ideal circumstances. For more details, see my series of posts starting with What is OEE? – Definition of OEE.

Of course, this does not help if you do not yet have a system to measure. If you create a new production system, you simply don't know your OEE (yet). The solution is easy: You need an *expert estimate*, also known as a *wild guess by someone who has at least some familiarity with the system*. Look at other similar systems in your company. Your new system will probably behave similarly. Or you could pay me a lot of money and I could tell you for flow shops it is around 80% for manual processes and around 60% to 80% for machines; for job shops it is around 50% to 70% for manual processes and 40% to 70% for machines – terms and conditions may apply.

6.5 Summary

You always have to be careful when using an OEE. Depending on how the OEE is calculated, it can mean something completely different from what you think it does. In the next post we will actually use the OEE. Until then, **stay tuned and organize your industry!**

7 Line Balancing Part 4 – OEE Usage and Flexibility

Christoph Roser, February 16, 2016, Original at https://www.allaboutlean.com/line-balancing-4/

Figure 44: Hands together (Image zest_marina. with permission)

In the previous post we looked at the potential problems when using an OEE for line balancing. Now, in the fourth post on line balancing, we actually use the OEE to create target cycle times (or, alternatively, a target line takt) for our system before we start balancing the system in the next post.

7.1 What to Do with OEE

In any case, now you have the OEE and can calculate the target cycle time based on the customer takt (or, if you prefer it the other way round, calculate the target line or process takt based on the cycle times of the individual tasks). Here again, you have multiple options on how to proceed.

7.1.1 Target Line Cycle Time

Figure 45: Just use the cycle time for the line (Image unknown author in public domain)

The easiest way to do this is to **assume that the losses, and hence the OEE, is pretty much the same across all tasks and parts.** You also assume that the entire system is working at the same time (i.e., either all processes work or all are off-shift).

The target cycle time for all processes is then simply the takt time multiplied by the OEE. If, as in the example above, your takt time is 60 seconds, and your OEE is 80%, then all processes have a target cycle time of 48 seconds.

This is by far the easiest approach. If you can make the assumption above, then your life will be easier.

7.1.2 Target Process Cycle Time

Figure 46: Each process its own target cycle time (Image unknown author in public domain)

Sometimes, you have processes where you know that the OEE is different. For example, in your production system you may have one machine that gives you nothing but trouble. If it is mostly trouble that is bigger than the buffers to the adjacent processes, then this is reflected in the OEE of the other processes anyway. However, if there are lots of little problems, then you may choose to use a different OEE for selected processes.

Yet, you mostly can avoid this. If the OEE differs by less than 10%, I would not really bother too much. In my experience, OEEs are not that precise anyway. Additionally, due to interdependence between processes in a flow line, it is rare that one process is significantly better or worse than the rest of the system. Hence, **unless you absolutely feel the need to treat one process separately, don't!**

7.1.3 Target Process and Product Specific Cycle Time

Figure 47: Product specific? Really? (Image Ssawka under the CC-BY-SA 3.0 license)

Distinguishing the OEE by different processes can even be pushed one step further by also distinguishing by different product types. For example, product A may give you much more trouble than product B. In this case, you could have separate OEEs for different products. But, be warned, you are opening a can of worms that is not easily swallowed (and let me know if I am mixing incompatible metaphors ☺).

First of all, do you know your OEE by product type? It may be difficult to separate the OEE for different products. Secondly, you would need to do the calculation "*the other way around.*" Normally, I take the customer takt and calculate a target cycle time using the OEE. Then I group my tasks into suitable processes that are roughly as fast as the target. However, the task times are by themselves an average. Either I take the task times for the high runners and assume all others are the same, or I create weighted averages (see above).

But by then it is too late to distinguish by product type. Hence, if you really want product-specific OEEs, you would have to take the task times for the individual products and divide them by the appropriate OEE into the task takt time for the individual products. Only now you can combine the task takt times for either the high runner or the weighted average of all products, and then group them into processes where the process takt time matches the customer takt time. Hence, again, **unless you absolutely feel the need to treat products separately, don't!**

7.2 How Flexible Are You?

Figure 48: Illustration of Flexibility (Image Kennguru under the CC-BY 3.0 license)

An important factor is the flexibility you have in changing your system. By "flexibility," I mean mainly two things:

Sequence Flexibility: How much can you change the sequence of the processes? Some processes are a prerequisite for another process. Others, however, can be moved before or after another process. The more you can move the processes around, the easier it will be later to design a well-balanced system. There are probably software systems where you can enter the possible sequences; however, this is a lot of work. I would rather play around with the sequence later and see what works instead of spend lots of time adding dependencies into a software tool and then hope that the tool will give me a good result. Hence, as for data collection, you need to be aware of the possibilities of changing the sequence, but in my view it is too much work to actually define it beforehand.

Grouping Flexibility: If it consists mostly of manual work, you have lots of flexibility in grouping the work. If you buy new machines or have universal tooling machines, then you may also have flexibility in deciding which machine does which sub-processes. If you already own dedicated machines for the processes, then you probably have the least flexibility. Hence, some processes can be grouped together with other processes, whereas others have to be an individual cycle. Overall, manual processes are much easier to work with here. Similar to the sequence flexibility, I do not summarize my options beforehand, as this would be too much work. I'd rather play around with different sequences later and then check if they work.

7.3 Quick Summary so Far

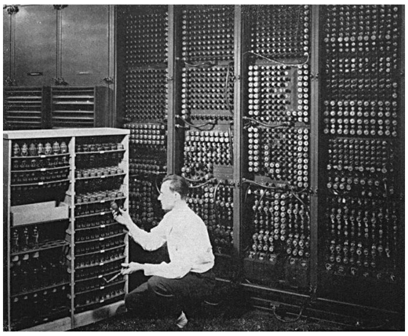


Figure 49: Changing a tube on ENIAC. (Image unknown author in public domain)

By now we should have a good overview of the system and all the data we need for the balancing of the line:

- List of tasks and the times needed for the tasks. May be based on high-runner example, weighted average, or multiple sets for multiple products. Usually, it is a task cycle time, but may also be a task takt time including the losses. Should include all tasks that are necessary to make any of the products that have to pass through the system.

- Target cycle time needed to achieve the customer takt with respect to losses (OEE), if your task times do not include losses. If your task times include losses, this should be simply the customer takt. Usually, it is the target cycle time or customer takt across all products, but in rare cases it may be distinguished by product type.
- Some understanding on flexibility in the sequence and the grouping, not necessarily in an exhaustive data set but rather in your head.

At this point you can also make a quick estimate on the number of stations or workers you probably need. You take the sum of all task cycle times and divide it by the target cycle time. For example, if you have work for 460 seconds, and have a target cycle time of 48 seconds, then you would need 460s/48s= 9.58 stations or workers. This means that after balancing you probably need around 10 stations or workers in your system.

Now we can actually start balancing the line ☺. In the next post I will explain how to do it on paper (my preferred method), before explaining how to do it on a computer and showing you some tricks in the post afterward. Until then, **stay tuned and organize your industry!**

8 Line Balancing Part 5 – Balancing Using Paper

Christoph Roser, February 23, 2016, Original at https://www.allaboutlean.com/line-balancing-5/

Figure 50: Hands raised (Image St22 used with permission)

The previous four posts in this series for line balancing all looked at how to prepare the data and do some initial calculations. You could balance the line using a computer or – much better – do it using paper. In this fifth post, we now actually start to balance the line though shifting around small pieces of paper. In the next post I will show you some important tricks, and also how to do it on a computer (bah!).

8.1 Balancing the Line on Paper

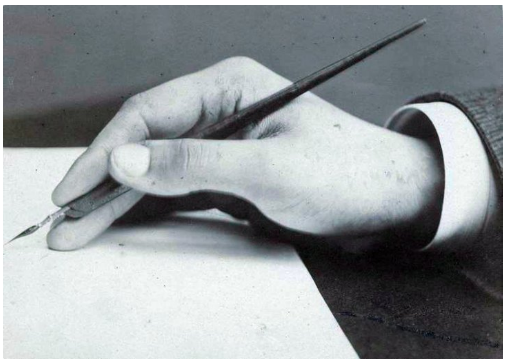


Figure 51: Hand with Pen (Image Josef Löwy in public domain)

Once you have the data, balancing the line is actually not that difficult. You simply rearrange the tasks in a sequence that comes close to the target cycle time (or customer takt). I highly recommend doing it on paper, but it is also possible to do it on a computer. Let's go through the paper version first:

8.2 Preparations – Group Selection

As with many lean improvements, line balancing will be better if done in a group. Hence, rather than doing it alone in your back office, I recommend involving multiple people through one or more workshops to get the maximum out of the group intelligence.

As with most workshops, a good group size is somewhere around three to five people. If you have more, some of them will mentally disengage. If you have less, you are back to one person. If you already have some people who make these products, include at least one of them in the balancing workshop. For example, get a foreman or a respected worker who knows the products well. This way your group has a much better understanding of the sequencing and grouping flexibility.

8.3 Preparations – Stacked Bar Chart

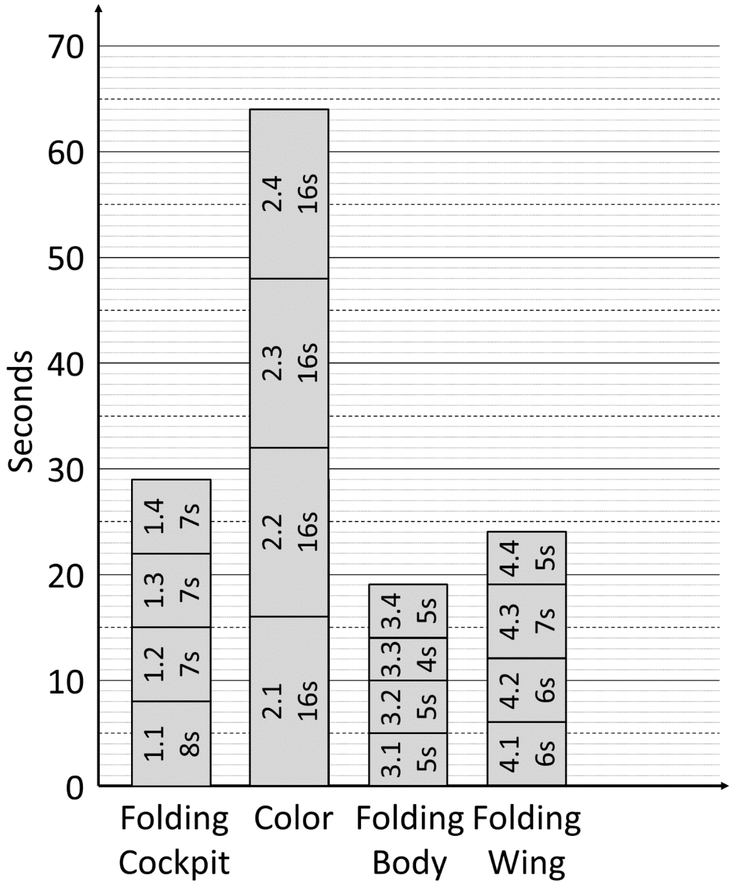


Figure 52: The Initial Data (for printing) (Image Roser)

You already have all the data you need from above. Now you need to get the data on paper. It is possible to draw it all by hand, but I usually find it difficult to get the scale right. Hence, I usually prepare a few printouts beforehand.

I usually create a bar chart that includes all the tasks that need to be distributed. Each stack should have the task (written out or numbered) and the time needed for this task. You can use Excel to make these stacked bar charts. If it is too tricky to add all the details in the actual bars, you can also write them on the paper by hand later.

The example shown is for my training simulation where I fold a paper plane.

You could also draw the entire bar chart by hand. This is useful if you are in the middle of a workshop and can't take a break to prepare the chart printout. Hence, drawing it by hand does not interrupt the flow of the workshop. It is tricky, however, to get the scale right. Hence, if I somehow can get the time, I prefer to quickly add the data in Excel and print it out. This way I can ensure that all tasks have the same time scale.

8.4 Preparations – Blank Bar Chart

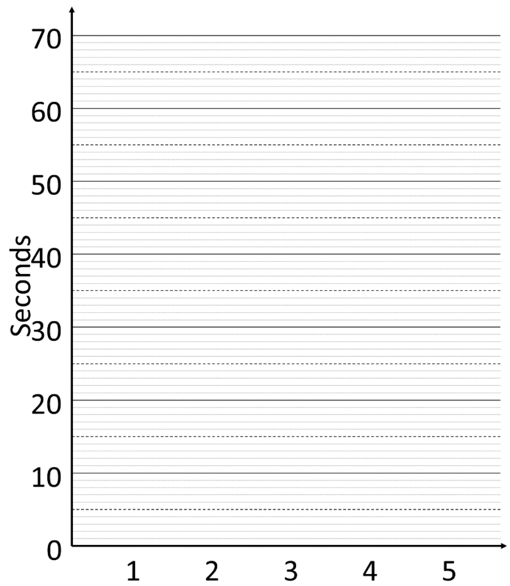


Figure 53: Line Balancing Blank Sheet (Image Roser)

It also helps to have a blank sheet to put the data on, although this is not absolutely necessary and can be drawn by hand too.

Regardless if it is drawn by hand or printed, it must have the same scale as the prepared bar chart. As for the paper size, usually I try to go for larger paper formats (e.g., A3 rather than A4 or tabloid rather than letter size). Otherwise it turns into quite a fiddling afterward.

Pro-Tip: Print out both sheets more than once, just in case you need to redo or create alternative versions.

8.5 Cutting the Tasks

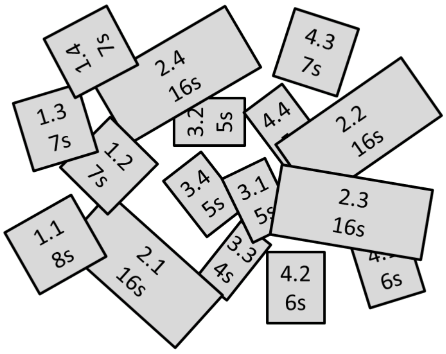


Figure 54: Tasks cut out (Image Roser)

You now cut the tasks out of the pre-printed bar chart with the list of tasks. This gives you a piece of paper for each task that you now can distribute for balancing.

It would be also possible to use, for example, Post-its and cut them to size. This has the advantage that you can stick them to a wall. The disadvantage is the difficulty in getting the scale right. I usually go for the printed version and arrange them on a flat table, but if you prefer Post-its, they are also usable and interactive. Either way works for me.

8.6 Adding the Target

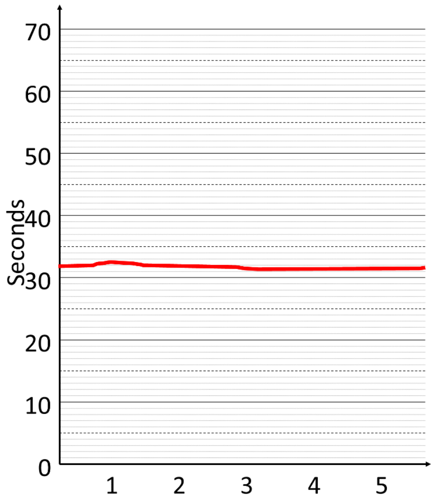


Figure 55: Adding the target (Image Roser)

Next, you add the target times to the blank chart. Usually this is the target cycle time, and usually it is the same for all processes. You could also print it out, although often I only have a black and white printer accessible but like to make the line in red. Additionally, if you do this in a workshop setting (recommended), it marks a mental milestone if you do it as part of the group activities.

If earlier you decided to go with different OEEs or to distinguish by product type, it gets a bit messier here. Hence, I again try to keep it simple.

8.7 Balancing the Line

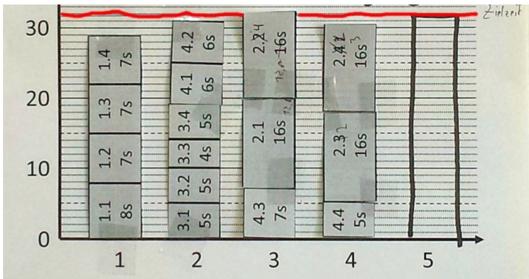


Figure 56: Line balancing results (Image Roser)

Now comes the actual balancing of the line. You arrange the tasks in a way that they stack up to approximately your target. Always keep an eye out to see if the sequence and grouping is actually possible.

This balancing probably includes quite a few iterations. You balance the line, check if it is a doable sequence, and then adjust as needed.

By the way, if you have heard of a Yamazumi chart for line balancing, this is it! Yamazumi (山積み) literally means "to pile or heap upon."

Once you are done, use glue or adhesive tape to attach the tasks to the paper in a more permanent way.

8.8 Summary

The above is a quick walk-through with the most important points for balancing a line by hand. However, there are still some tricks and tips that can help you. I describe these in the next post, along with the balancing of the line by computer (bah!). In the meantime, stay tuned and **organize your industry!**

9 Line Balancing Part 6 – Tips and Tricks for Balancing

Christoph Roser, March 01, 2016, Original at https://www.allaboutlean.com/line-balancing-6/

Figure 57: Hands thumbs up (Image Robert Kneschke with permission)

In the last post I described how to balance a line using pen and paper. This description was a basic, straightforward approach. In this post, I will enhance it with a few tips and tricks for balancing a line. Also, I will briefly describe how to balance a line using computers and then tell you why I much prefer the paper version. If you have not yet done so, please check out my earlier posts on line balancing.

9.1 A Few Pro-Tips on Line Balancing

9.1.1 The Target Cycle Time Is Not a Hard Target

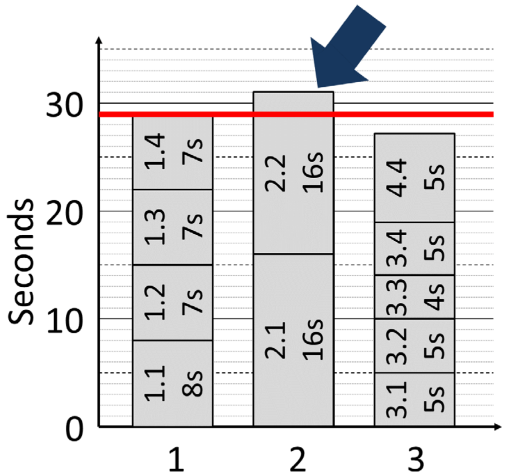


Figure 58: Cycle time exceeds target—probably OK! (Image Roser)

In the last post, we added a target line on the chart for the line balancing. This is usually the target cycle time. Please be aware that **this target line is not a hard limit!**

We calculated the line by combining the customer demand with the OEE, and then stacked the duration of the tasks underneath. These numbers are probably not precise. The OEE, especially, often has lots of ambiguity, and the customer demand is also somewhat uncertain. The duration of the tasks is usually most precise – if you have a system that you can already measure. In any case, the numbers involved in fitting the task durations to the target are usually rather imprecise.

That means you have wiggle room. If you stack the task durations up, **you may have a situation where you only slightly exceed the target. That is probably OK.** Based on your uncertainties, a small excess duration may turn out to be no excess at all.

If it turns out to be a problem, you still have options. You could put in some more effort and **reduce the duration of one or more of the tasks** that exceed your target. In fact, adding a tiny bit of pressure for improvement often helps with the improvement.

Finally, in the unlikely event that it is indeed a problem, and you cannot fix it by improving, you may have to **go into overtime** to meet the customer demand.

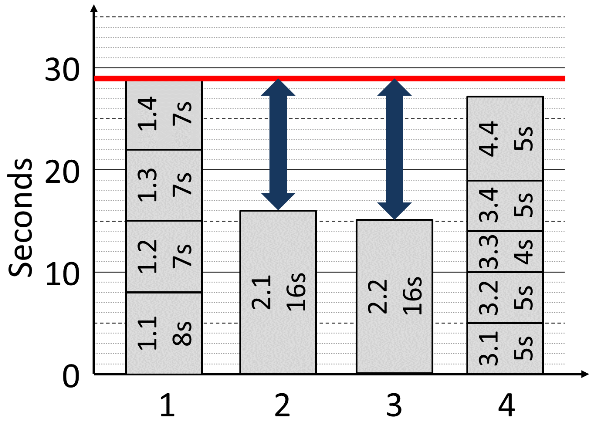


Figure 59: What a waste – I'd rather take my chances… (Image Roser)

While there is a bit of risk involved, it may be much easier to take the risk than to rearrange the tasks differently and end up with a very wasteful structure where there are lots of gaps and idle waiting time for workers and machines.

Overall, if you exceed the target, there may not be a problem in the first place, or you can optimize the durations, or you can do some overtime. All of these may be easier than an alternative rearrangement, so you have to decide which path is the easiest for your situation.

9.1.2 Parallel Processes if Task Time Exceeds Target Time

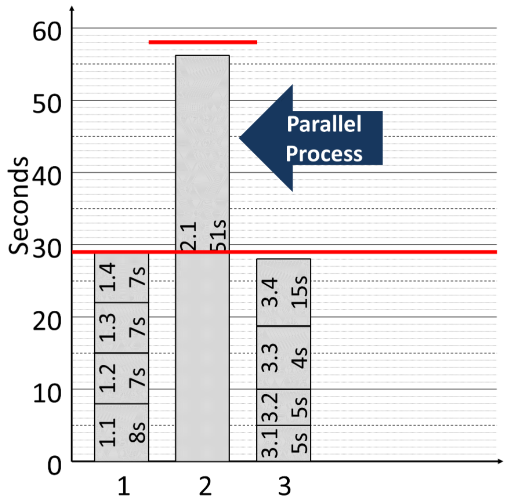


Figure 60: Use parallel processes if they are too slow (Image Roser)

Please keep in mind that while a small excess may be acceptable, a larger excess may be more problematic. When your cycle time exceeds your takt time, you do have a problem. It may be necessary for you to duplicate an especially slow process so that the combined speed of the two processes meets the target.

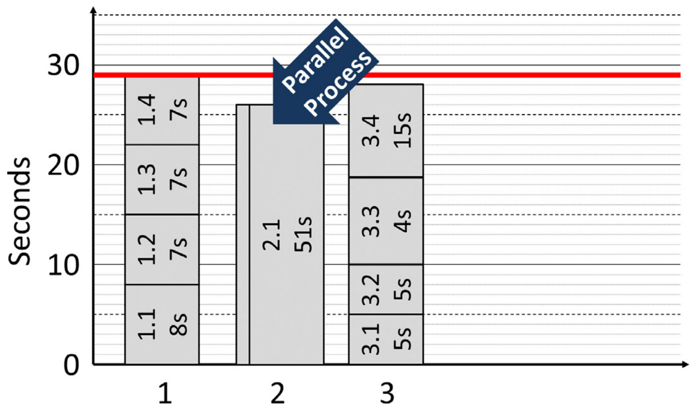


Figure 61: Alternative for parallel processes (Image Roser)

Please do so. If you duplicate the process in parallel, your target line for an individual process doubles – or your combined cycle time divides by two. Similarly, if you triple or quadruple the processes, so does the target, or alternatively the cycle time reduces to a third or a fourth. Either way works. In general, **if you have n parallel processes with identical speeds, the target line multiplies by n, or alternatively the joint cycle time divides by n.** It does become more tricky if the processes are not identical (i.e., a fast one and a slow one). (See Pitfalls of Takt Times.)

9.1.3 Pool Leftover Time at the End

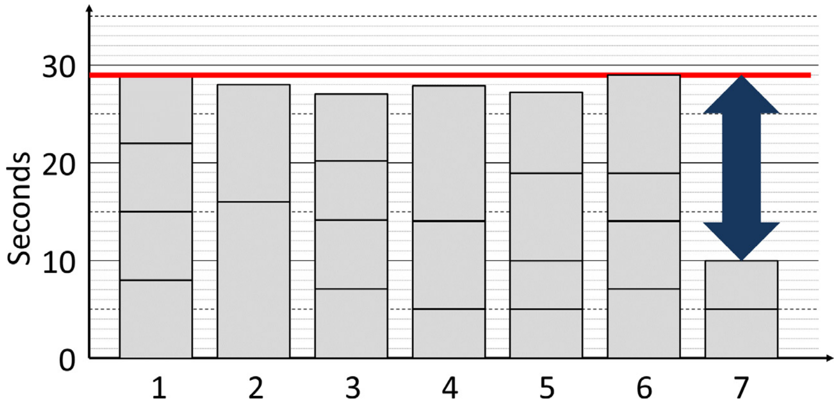


Figure 62: Put the remaining tasks at the end (Image Roser)

In all likelihood, you will have a few tasks left at the end that are not enough for a full cycle. For machines, that is not a problem. For operators, however, it is an issue. In lean manufacturing, it is considered impolite to let people wait. That is true. Since the last process has lots of waiting time, some shop floor managers distribute the tasks evenly so that everybody has a similar waiting time.

Don't do it!

While the goal of having nobody wait is valid, in this case it may be the smaller problem. If everybody has additional time, either you produce more than needed (bad), have a group that needs less work hours (acceptable depending on your situation), or have a group that can slack off and work slower (really bad). Working slower than a regular speed may be boring, increase quality problems, and damage worker morale.

Overall, the wisdom at Toyota is to (usually) have one process or worker with less tasks than the others. Preferably, this is also the last process of the line. This has a few advantages.

- The worker has a longer waiting time. Depending on the situation, **there may be additional tasks** that can be done during this time (e.g., restock line inventory, remove boxes, etc.).
- The waiting time is more obvious, and hence **there is more mental pressure to optimize the tasks** and reduce their durations so that eventually the line can work with one station less. Hence, it helps with optimizing the processes.
- While we wish that all our workers are young, fit, and able, we do have workers that are older, less able, or temporarily or permanently impaired. This could be anything from back pain and pregnancy. We do have the duty to also provide these people with work, and such a **slower task may just be the right thing for temporarily or permanently impaired workers**.

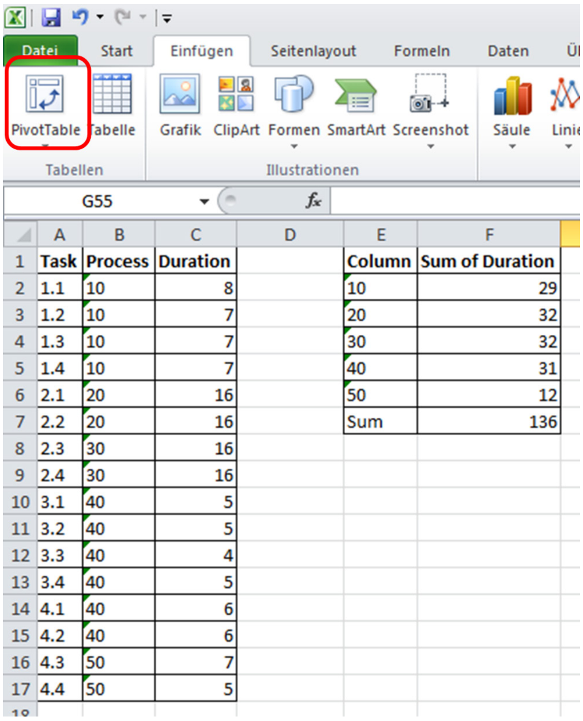
9.2 Balancing the Line Using a Computer

In my last post, Line Balancing Part 5 – Balancing Using Paper, I explained how to do balancing with paper. Of course, this can also be done using computers. Some programs let you play with the sequence and do the calculation of the total duration for you. Others even do the optimization for you. I would avoid having a computer do the optimization of the tasks. For one, it is probably quite an effort to add all the necessary sequence conditions in the system. Additionally, I think humans are still better at understanding the complexity of the line balancing, and where you may have wiggle room and where you may not. **Hence, let people make the decision on the sequence, and have computer only help.**

I much prefer line balancing in a group and on paper. However, sometimes when I do line balancing on my own, I use Excel simply because I know Excel very well. For the amount of line balancing I do, it is for me not worth the effort to learn a new software. In Excel, it is just quick and dirty, nothing fancy.

I make a simple table with a column for the processes, their sequence, and their duration. I then add a pivot table (see red circle in the image below), where I automatically calculate the total duration for each process. In the image below I have the pivot on the same Excel sheet for visualization, although usually I do my pivots on a separate sheet.

I then change the sequence by changing the numbers in column B below. In my example I numbered the processes 10, 20, 30, and so on. If I need a new process between two processes, I can just number it 25 and keep the sequence. I could also use decimal points and number them 1, 2, 3, 3.5, 4, and so on. Either way works. Don't forget to update the pivot after you have changed the numbers. I keep on playing with the sequence until I am happy with the result.



Task	Process	Duration
1.1	10	8
1.2	10	7
1.3	10	7
1.4	10	7
2.1	20	16
2.2	20	16
2.3	30	16
2.4	30	16
3.1	40	5
3.2	40	5
3.3	40	4
3.4	40	5
4.1	40	6
4.2	40	6
4.3	50	7
4.4	50	5

Column	Sum of Duration
10	29
20	32
30	32
40	31
50	12
Sum	136

Figure 63: Line balancing in Excel (Image Roser)

However, if possible, I try to do it on paper as a group, because the group usually knows much more about the processes and their sequence limitations than I do. Besides, involving the group in decisions regarding their workplace is a sign of respect and will result in better morale.

I hope the tips and tricks on line balancing above have helped you. If you have any more, I am always eager to hear new tricks. This concludes my rather lengthy series of six posts on line balancing, even though I haven't even touched on the topics of job shops, multi-machine handling, the pearl chain (sequence your products so that a high workload product is followed by a low workload product at the same station – i.e., a car with a sun roof followed by one without, so that the "sun roof station" can catch up), etc. Maybe some other time. In the meantime, **go out and organize your industry!**

10 Visit the Shop Floor or Your People Will Fool You! – Genchi Genbutsu

Christoph Roser, March 08, 2016, Original at https://www.allaboutlean.com/genchi-genbutsu/

Figure 64: Only the fool trusts the presentation… (Image Bill Nye in public domain)

To manage your shop floor (or any other part of your enterprise), you need to have reliable data about the situation on the shop floor. Even with reliable data, the remaining uncertainty makes good management a challenge. Many managers, to save precious time, rely on data and information provided to them by their people. **This is a grave mistake! Always verify at least part of the data with you own eyes!** You would be surprised how different – and usually worse – it is in reality.

10.1 A Few Anecdotes…

Throughout my career I have seen lots of examples of managers being ignorant of the real situation on the shop floor. The following conversation is a real example with a manufacturing plant manager, albeit without source to protect the (not so) innocent.

Me: How much time do you spend on the shop floor?
Plant Manager: Oh, about one hour or so.
Me: Per day?
Plant manager: No, per week!

Another plant manager visited the shop floor only if there was a bigwig to show around. The plant manager was scared of his employees asking him questions that he could not answer.

Overall, managers usually spend way too little time on the shop floor, and way too much time in meetings and at the computer. As a result, they are usually blissfully unaware of what is really going on on the shop floor.

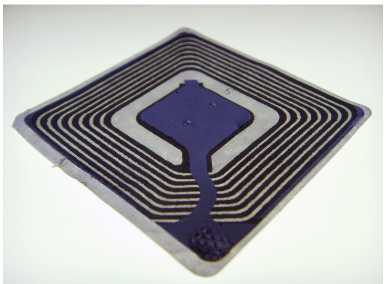


Figure 65: RFID Chip (Image Maschinenjunge under the CC-BY-SA 3.0 license)

There are tons of anecdotes for this too. For example, in another plant, RFID was implemented to improve the material control (RFID: Radio Frequency Identification tags, small chips that respond to a wireless inquiry). After completion of the project, a successful presentation was given to management and everybody was happy. None of them knew that the ERP suite behind it was so slow that the workers just ignored the RFID completely and entered the data by hand like they always did.

As a result, an expensive RFID system was set up but not used. Surely somebody knew. But nobody told management. Instead, they provided a whitewashed version of the truth (i.e., they lied about the real situation). For more examples, check my post Lies, Damned Lies, and KPI – Part 1: Examples of Fudging and Lies, Damned Lies, and KPI – Part 2: Effects of Fudging.

10.2 Everybody Lies

There are many different studies on how often people lie, usually with quite drastic results. Depending on which study you believe, most people can't go for ten minutes without telling a lie (Robert Feldman: The Liar in Your Life: The Way to Truthful Relationships). At the same time, very few people in the study realized that they were telling lies.

And, to a certain degree, this is necessary. If you would be brutally honest all the time, you probably would have very few friends. This also extends to industry, where too much honesty can be bad for the career. Surely you have had experience with a manager who habitually shoots the messenger. Other managers seem to believe that good people make no mistakes. With most managers, it is often better to tread carefully.

Even an open-minded manager (like you [hopefully] are) tends to look more favorably on people who (appear to) return the positive views. This is just in our human nature. We like people who like us back. In sum, everybody lies – some more, some less.

10.3 No Matter What, You Will Get Fooled. The Question Is: How Much?

Figure 66: Is this you? (Image bilderstoeckchen with permission)

Since everybody lies at least a little bit, you will definitely be lied to regarding the situation on the shop floor. Or, to phrase it more kindly, you will get a selective version of the truth (*lie* is such a harsh word). Some may be white lies, some may be more serious. But there is no way around the fact that some of the information you are getting is less than truthful, while other information is not mentioned at all. Due to the aforementioned reasons, you will usually get an overly optimistic view of the positive side, and little or no information on the negative side. This is, of course, unless the person wants to block or stop the project, in which case the negative side is emphasized.

You will be fooled at least some times! The question is: How much? Your goal should be to reduce the misinformation and to increase the accuracy of the data. Yet, you have to accept that you will not be able to eliminate it completely.

10.4 Real Place, Real Situation, Real Parts!

Figure 67: The situation looks great! (Image Gino Santa Maria with permission)

And that's where the reality comes in. The closer you get to reality, the more reliable the data will be. You must check at least some of the information you receive at the source.

Japanese lean experts often refers to this as the *three reals*. They all start with the same kanji 現, which stands for *reality, existing, actual, current,* or *present*. These three reals conventionally stand for these three terms (although there are many more Japanese words that start with 現):

> *Gemba (現場, sometimes also written Genba): actual spot; scene; scene of the crime; site; location; sometimes also shop floor*
>
> *Genbutsu (現物, sometimes also written Gembutsu): actual articles; actual goods; the real thing*
>
> *Genjitsu (現実): reality; actuality; hard fact*

In English, *Gemba* usually refers to the shop floor, although depending on your value stream, it may be anywhere where it is really happening. As for *Genbutsu* (現地現物), you may also have heard of Genchi Genbutsu. This would be yet another "Gen-" word:

> *Genchi (現地): actual place, actual location, local, on-site*

So, *Genchi Genbutsu* (現地現物) means nothing more than to look at the real products in their actual location (i.e., *in situ* (just in case you prefer Latin ☺).

10.5 How to Check…

10.5.1 Verify Some of the Information

Ideally, a manager should check everything on the shop floor. Practically, he/she doesn't have the time for it. Ohno's chalk circle is good but too time consuming as a regular exercise for managers. Hence, there is no way but to make sample checks. As for that, more is better. Most managers seriously underestimate the time they should spend on the shop floor.

10.5.2 Have a Plan or a Routine

When visiting the shop floor, it is easy to be physically present but mentally absent. Personally, I have two strategies to address this problem. **Strategy 1: Have a routine**. Walk the same path every time, and try to see if it looks different from before. In fact, do not only rely on looking, but also see if it smells different, sounds different, or generally feels different. Some people can feel if a stamping press is working correctly based on the vibration they have.

Figure 68: Focus! (Image Mentalitanissarda under the CC-BY-SA 3.0 license)

Strategy 2: Focus on a narrow problem. Do not try to look at everything, because you will only see nothing. Focus on a particular aspect that is of interest to you to verify some information you received from your people. For some more tips, see also Make Your Plant Tour a Success!, or for a sarcastic view on how to be fooled, check How to Misguide Your Visitor – or What Not to Pay Attention to During a Plant Visit!.

10.5.3 Foster a Culture of Openness

If your people are getting shot for reporting bad news, it is only natural that they will stop reporting on the negative side and emphasize the positive side. You have to accept that even with the best intentions, sometimes things go bad. Focus on a solution, not on a scapegoat. If you shoot the messenger, messengers will be much more hesitant to come.

10.5.4 React If You Are Fooled

Figure 69: Do you want to eliminate the liars or the honest ones? (Image peshkova with permission)

If you find out that someone misleads you, you must act! Tolerating being fooled is probably the worst thing you can do. If the *fooling* works, it is a success for the employee; if it doesn't, there are no negative consequences. It is your job to introduce negative consequences if you are misled, in order to improve the quality of the information you receive.

Your actions determine if you reduce the number of liars in the company, or if you reduce the number of honest ones. In any case, always keep in mind that some of the information you receive will be misleading, no matter what. Now, go out, look at your shop floor, and **organize your industry!**

11 On the Benefits of a Pencil in Lean

Christoph Roser, March 15, 2016, Original at https://www.allaboutlean.com/pen-vs-pencil/

Figure 70: Pen or pencil? (Image Clker-Free-Vector-Images in public domain and Lothar Spurzem under the CC-BY-SA 2.0 Germany license)

In many lean books and other writing, it is often recommended to use a pencil for certain tasks as, for example, the A3 report. Yet, I have seen very few uses of pencil in lean manufacturing in the Western world. Most of the documents are computer printouts based on Excel, PowerPoint, or Word. The few handwritten documents are usually done in pen (see also my post on [The Advantage of Handwritten Data on the Shop Floor](#)).

In this post I will look into why almost nobody uses pencils and why it would be good to use more pencils. I myself am also guilty of that, but I plan indeed to use more pencil in the future.

11.1 The Mighty Fountain Pen

Figure 71: Make your mark for eternity… (Image BillionPhotos.com with permission)

In public perception, the ultimate writing instrument is the fountain pen. It is the weapon wielded by the mighty. It is designed to leave a mark for eternity. Many people prize their high-quality fountain pen. There is even a Fountain Pen Day on the first Friday of November.

The most expensive pen on Amazon.com at the time of writing is a (in my view, rather ugly) [Montegrappa Chaos Limited Edition 18K Gold Fountain Pen Fine Point](#) for an eye-popping $65,700.00 – but it comes with free shipping 🙂. As usual with such high-priced products, the reviews are quite entertaining. Still, not a pen for me. With that money, I'd rather buy a car.

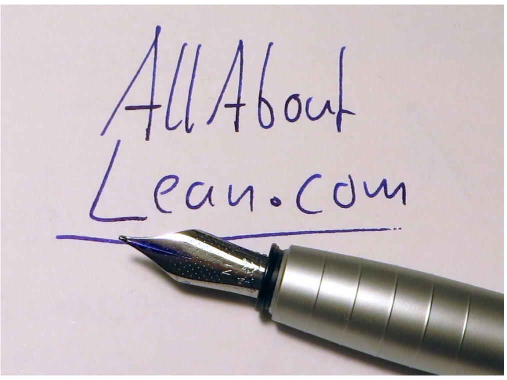


Figure 72: A mark for eternity? (Image Roser)

Even I use a (red) fountain pen for grading exams, to show respect for the significance of the document I am checking. My blue fountain pen, however, I use very rarely, simply because I usually have a normal pen closer nearby. Last time I used it was for an image for this blog post. Before that I used it to sign my real estate purchase contract.

Most of you are probably writing with less fancy pens. Most common are ballpoint pens, felt tip pens, or rollerball pens. Quick and easy. **In any case, all of them are permanent!**

11.2 Why a Pencil is Better in Lean

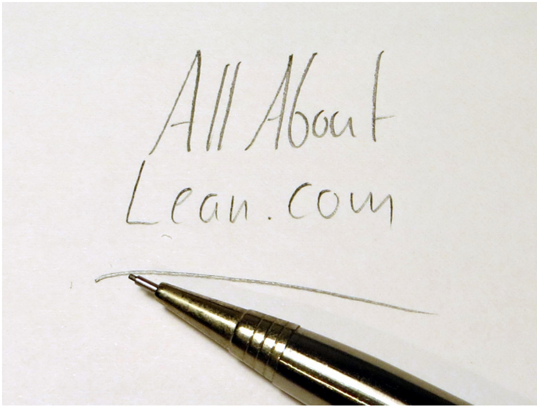


Figure 73: Here today … (Image Roser)

While it is often useful to write with a permanent pen (e.g., in many exams it is even a requirement), it is difficult to change afterward.

Yet, **lean is all about change!** Continuous improvement means continuous change. Very little is permanent. What may be a good way today may be old hat tomorrow. This applies to both improvements and setbacks.

For example, I recently did three days' worth of workshops (plus preparation and wrap-ups). When it came to the implementation, we received news that upper management decided to do a fundamental change in the organization. As a result, the entire project was no longer needed 😕. What a bummer … but that's life.

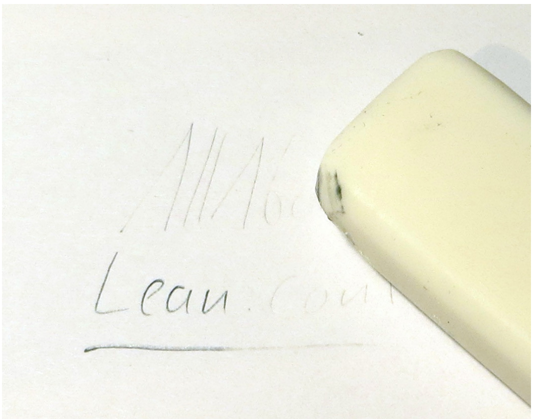


Figure 74: ...gone tomorrow? (Image Roser)

Also, as per my previous post [The Advantage of Handwritten Data on the Shop Floor,] you could do this on a computer. However, it goes much faster and easier with pen(cil) and paper. It sounds cliche, but using a computer requires a lot of your brain power, leaving less for your creativity. For example, a processor gave students the task of designing a barbecue grill. Some teams had to do it on computer, some in pencil. Overall, the pencil designs were much better and more creative than the computer ones.

11.3 Where to Use a Pencil

In lean, many documents are continuously updated. A prime candidate is the **A3 report** for problem solving. It is highly recommended to do this in pencil. It is highly unlikely that someone can do an A3 correctly from scratch, as it usually goes through multiple rounds of revisions. Therefore, data is continuously added and erased.

Another good candidate is a value stream map. Every time you walk through the shop floor, you will find additional data that goes in and other data that has to be erased. If you want to use a value stream map for improvement, use pencil – although most value stream maps I have seen in the West were unfortunately done only to impress management, in which case you should just make it shiny.

Yet another candidate is **work standards**. This may be surprising. In the West, a standard is given from above and then rarely changed. In Japan, however, workers have much more freedom to influence, and especially improve, the standard. This is often done by adding additional points by pencil until the standard can be updated. Of course, you still have to make sure that the workers follow the new standard (which is often the part skipped in the Western world).

Finally, **reports and documentation on the shop floor** can also be done in pencil. This writing and erasing can be very useful for the regular status updates in the team corner, for problem solving, and for many other frequently changing documents.

11.4 Why Westerners Use Pens and Japanese use Pencil

Figure 75: Some U.S. and most German school emphasize fountain pens. (Image hayo with permission)

In the Western world, I have the feeling that a pencil is often looked down upon. However, in Japan, people write quite frequently with a (mechanical) pencil. I think this is due to the difference in school education.

In Germany, where I received my education, we started writing with a fountain pen. In the United States some schools also require a fountain pen, although others also use pencil. Some schools even have a pen license where children with proper pencil handwriting are allowed to graduate to a fountain pen. Other schools simply forbid ballpoint pens and other pens. With these rules, you grow from being a kid with crayons to being an adult with a fountain pen. Overall, **much of the writing in Western schools emphasizes fountain pens.**

Figure 76: In Japan, schoolchildren use pencils. (Image BRAD with permission)

In Japan, however, much of the writing in school is done with a pencil. A saying in Japan is that your writing reflects what your heart looks like. Using a pencil makes it easier to erase mistakes – and to provide a flawless handwriting, even if it is not on the first try.

As a result, Japanese have much less bias against pencil, and feel much more comfortable using it. Hence, they have no problem with creating documents in pencil. In the Western world, pencil seems to have a dirty and uneducated feel, and people are much more hesitant to use pencil for documents someone else can see.

This can even be extended to a wider view of the difference between lean in Japan and lean in the Western world. In Japan, it is absolutely okay to fix, improve, and change until the result is flawless. In the Western world, the goal has to be achieved on the first try, even if there are a few smudges and spots left at the end.

Amazing! The whole difference between Japanese and Western lean boiled down to what we wrote with at school!

Hence, merely using a pencil will magically transform you into a lean expert … or maybe not. Actually, probably not. At best, it is a tiny nudge in the right direction. In any case, I am just happy that (with the help of my wife) I stumbled on this beautiful nugget of a cultural difference between Japan and the West 🙂.

11.5 My Pencil Resolution!

I have to admit that up to now I have rarely used pencils. Having a proper German education, I was conditioned to fountain pens, which my laziness downgraded to ballpoint pens. But I made myself a resolution: From now on I will write more often in pencil.

After a bit of research, I found out that the best mechanical pencils are (unsurprisingly) from Japan. I liked in particular the Uni-ball KuruToga Mechanical Pencil. This pencil rotates the mine while writing, and hence avoids any loop-sided-ness. I went for the 0.5 mm HB medium hardness. I also went for Japanese Pencil Leads, which supposedly break much less than Western mines. Now I just have to find out how not to make a mess in my shirt pocket …

Of course, you can find even better stuff in Japan, where, for example, mechanical pencils with an extremely thin 0.2 mm lead mine are popular. But these are difficult to find outside of Japan, and I am not going to fly to Japan just for a pencil. But next time I am there …

In any case, I hope the above musings on pens and pencils were interesting to you. Maybe you too can grab a pencil instead of a pen next time, before you **go out and organize your industry!**

12 The A3 Report – Part 1: Basics

Christoph Roser, March 22, 2016, Original at https://www.allaboutlean.com/a3-report-part-1/

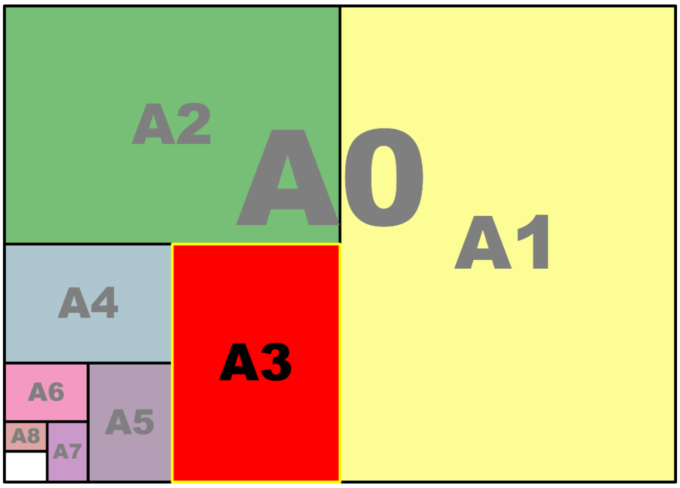


Figure 77: DIN A Paper Sizes (Image Roser)

If you know your way around lean, you surely have hear about the A3 report, famously named after the DIN-A3 paper size. It is also known as the A3 problem-solving sheet. The goal is to get all the necessary data on **one sheet** of **A3 paper** using **pencil** while you are on the **shop floor**. The A3 report is commonly used for problem solving, but also for project management or status reports.

12.1 Why the Shop Floor?

Figure 78: The presentation looks great! (Image Gino Santa Maria with permission)

Obviously, that is where the real situation takes place. Only on the shop floor can you observe the real situation. If you use primarily reports and presentations, you will get a filtered opinion on the situation – usually in a way that makes the presenter look good. See also my post Visit the Shop Floor or Your People Will Fool You! – Genchi Genbutsu!

Of course, you could observe the shop floor (or wherever your action happens) and then go back to the computer to add the data. However, while walking back and forth, you are likely to forget details of what you have seen on the way. You may also get distracted. It is also a waste of time walking back and forth repeatedly. Finally, due to the walking distance, you may be inclined to make the document in one go. However, I am a strong believer of iterations and changes to work my way toward an improved (not perfect!) situation. This brings me to my next point:

12.2 Why Pencil?

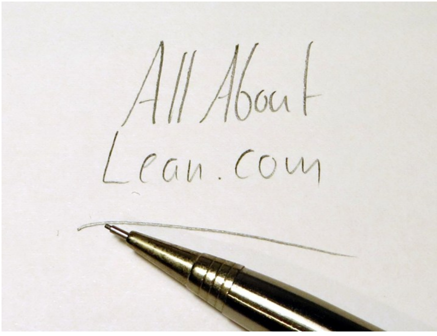


Figure 79: Use pencil! (Image Roser)

Using pencil has lots of advantages. Most importantly, it makes it easy to change the content by using an eraser. Therefore, there is much less of a mental barrier to change the document. With a pen, you will have the subtle pressure to make it correct in the very first try – which usually does not happen.

Another advantage of the pencil is that it is easy to do. While you can change computer documents, it actually uses a lot of your mental capacity merely to operate the software. Doing a sketch by hand is much easier and faster – and can also easily be done on the shop floor. Yet, if you do an image search for A3 report on Google, almost all are clearly done on a computer ☹. For more on the advantages of a pencil, see my last week's blog post On the Benefits of a Pencil in Lean.

12.3 Why One Sheet of Paper?

Figure 80: Which page was it again … (Image aldegonde le compte with permission)

You are all familiar with stacks of paper. To add more information to a document, you merely add more pages to the stack. This works fine with printouts. However, going through that stack is more cumbersome than having one sheet of paper.

Especially if you are on the shop floor, working with multiple sheets of paper is a pain. Believe me, I have tried. Additionally, if you are working as a small team of two or more people, you can look only at the page that is at the moment on top. If you have only one page, then others can see all the data right away, without asking you to flip to another page.

The idea to fit all information related to one project/problem on one sheet of paper dates back to quality guru Joseph Juran (1904–2008). He was very influential in Japan, possibly even more so than the better known William Edwards Deming (1900–1993). Juran guided Toyota toward using one sheet of paper for problem solving, which then was improved at Toyota to the A3 report.

12.4 Why A3?

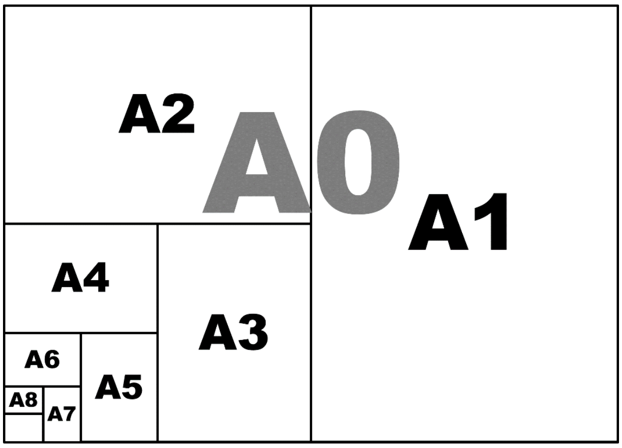


Figure 81: Standard ISO paper sizes (Image Roser)

A0, A1, A2, A3, A4, and so on are part of the ISO 216 standard for paper sizes. All of these paper sizes have the same aspect ratio of , which means that simply by cutting the page in half you arrive at the next paper size. They were originally developed during the French Revolution, and are now used worldwide – with the exception of the United States, Canada, and Mexico.

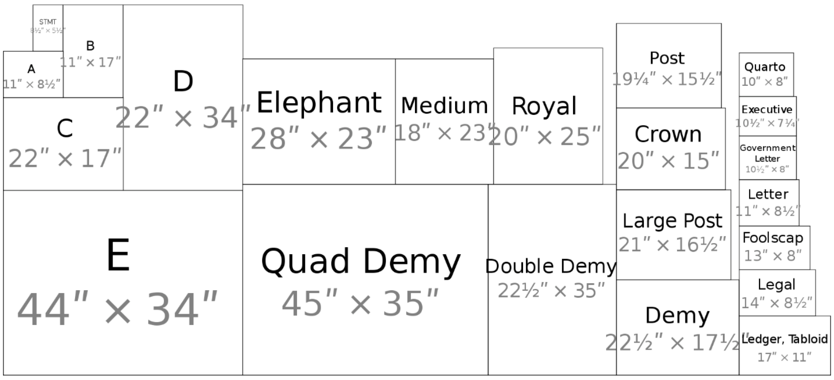


Figure 82: U.S. paper sizes (Image Mikla in public domain)

In the United States, Canada, the Philippines, and in Chile, the U.S. paper sizes are common. Mexico seems to use both standards. The U.S. system is somewhat less structured compared to the *rest-of-world* ISO standard. For someone traveling between both worlds, the difference in standards always turns out to be a hassle.

Figure 83: A bit too small for all your information. (Image zea_lenanet with permission)

In any case, the most commonly used size in (non-U.S.) offices is the A4 paper size (210 × 297 mm or 8.27 × 11.7 inch), which is similar to the U.S. letter size. Probably over 90% of the paper used in a typical (non-U.S.) office is A4 size.

However, Japanese engineers trying to get an overview of a problem on the shop floor quickly found out that an A4 sheet of paper is simply too small to fit all the information. While it is very practical to use, it just was not big enough to give an overview of the entire problem.

Figure 84: Practical size with plenty of space. (Image vitalliy with permission)

Hence, they doubled the size and used A3 sheets of paper (297 × 420mm or 11.7 × 16.5 inch), which is also still commonly found in most offices. The A3 size is somewhat similar to the U.S. ledger or tabloid size.

Please note that some sources say that A3 was the largest size that fit in a fax machine, although most faxes can do only the smaller A4, and special faxes can do even larger than A3 format. Additionally, the A3 report was developed after World War II, but the first fax was developed only in 1974. In any case, now the page was large enough to fit all the information related to the problem at hand.

Figure 85: A bit too big and cumbersome. (Image vitalliy with permission)

The next even larger A2 size (420 × 594 mm or 16.5 × 23.4 inch) could fit even more data. The A2 could easily be used in the office where you placed it on a a table. However, the idea is to bring the sheet along with you on the shop floor. And remember, the shop floor is the only place where you get an unfiltered version of the real situation. See my post Visit the Shop Floor or Your People Will Fool You! – Genchi Genbutsu. While an A3-sized clipboard is manageable, an A2-sized clipboard is just too much to carry around.

12.5 Summary

Overall, the A3 report is **one sheet of A3 paper, written in pencil, that is created on the shop floor!** This makes it more likely (but, of course, by no means certain) that you will get a representation of the actual situation and a workable solution to your problem through multiple iterations.

You may have noted that the above does not (yet) talk about what actually goes in the report. Well, for me, the conditions above are quite important. Hence, I focused my first post on A3 reports on these four factors. But fear not, in my next post I will go into more detail on what an A3 report actually contains. In the meantime, **go out (preferably on the shop floor with a pencil and a single sheet of A3 paper) and organize your industry!**

12.6 See also

Roser, Christoph. "Der A3-Report: Mehr Als Nur Eine Problemlösungsmethode." Yokoten 5, no. 3 (2016).

13 The A3 Report – Part 2: Content

Christoph Roser, March 29, 2016, Original at *https://www.allaboutlean.com/a3-report-part-2/*

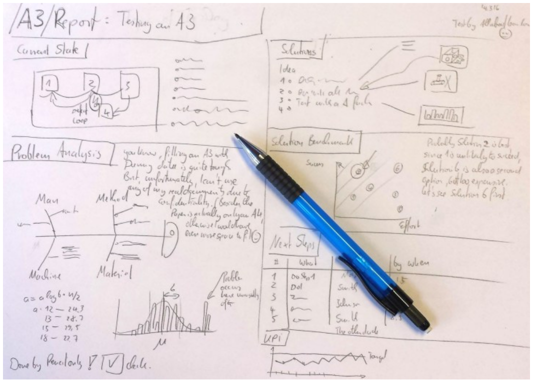


Figure 86: An A3 visualization in pencil (Image Roser)

In my last post I wrote about four basic factors for an A3 report (**one sheet / A3 size / with pencil / on the shop floor**). This week I would like to show you what goes in an A3 report. The important framework here is **PDCA** (Plan, Do, Check, Act). However, in my view there is no single perfect A3 template that will fit all of your problems. Rather, an A3 is created on the go. **Make the tool fit the problem, not the other way round!**

13.1 What Is the A3 Report Good For?

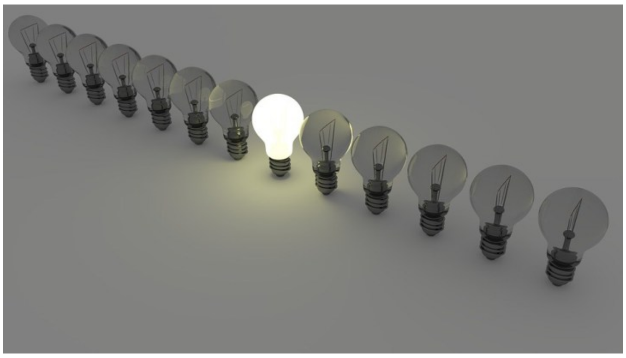


Figure 87: Solve your problems! (Image ColiN00B in public domain)

A3 is often used for slightly different tasks. **The core use of an A3 report is for structured problem solving**. It can also be used for project management. It is also used for status reports on problem solving and project management, although especially with handwritten A3's, they make sense mostly to the people who wrote them. Some sources also consider the A3 report for planning, although I am not quite convinced. A3-sized sheets of paper are also used to display work standards or other information, although in this case I would no longer call it an A3 *report*. I associate an A3 report mostly with some type of problem solving.

Generally, the A3 report can help in the transformation from a current state to a (hopefully better) future state.

13.2 The PDCA Framework

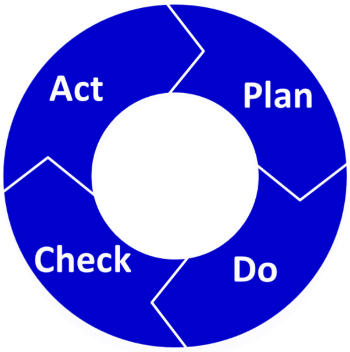


Figure 88: PDCA Circle (Image Roser)

There is one underlying tool that should be present in all A3 reports: the PDCA. PDCA stands for Plan-Do-Check-Act. For me, the PDCA is fundamental for any kind of problem solving or project management. The **Plan** is to determine the nature of the problem and how to solve it. The **Do** is the actual implementation. *Plan* and *Do* are the two steps that are common in the Western industry. Unfortunately, the next two are often skipped over. With **Check**, you should check if your *Do* actually fixed the problem! **Act** is the step where you try to figure out why your solution from *Plan* and *Do* did not work, and how to make it better the next time. Act can also include the sharing of the gained knowledge with others.

As such, it is a continuous circle. Hence, you could also see it as a series of loops, as shown below, that have to been repeated until the problem is solved. The PDCA is for me one of the essential approaches in lean manufacturing. As such, it has a whole fruit stand full of variants and flavors, including PDSA, DMAIC, LAMDA, SDCA, maybe even KATA, and many more that I don't know yet (see my glossary for more details).

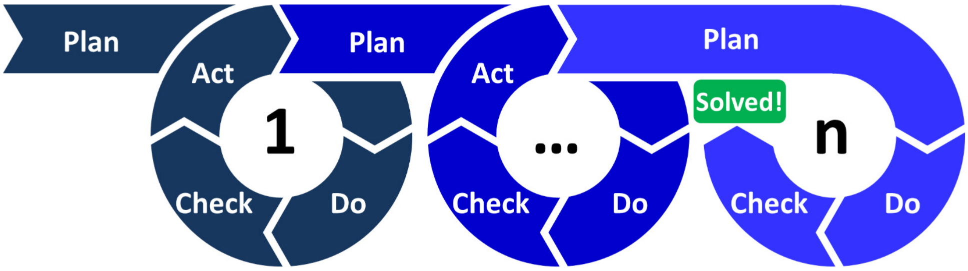


Figure 89: PDCA Circle Sequence (Image Roser)

13.3 Typical Content of the A3

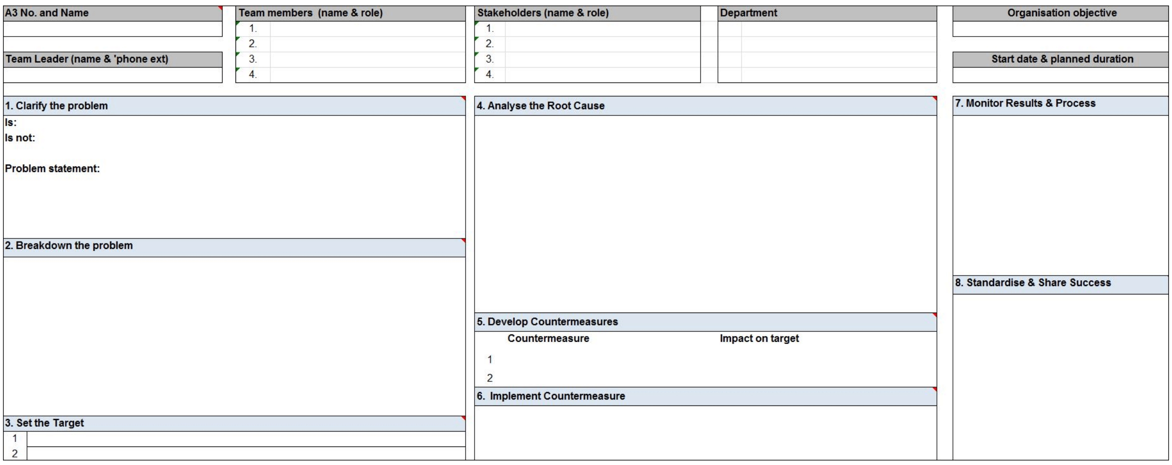


Figure 90: A3 report from Wikipedia (Image Zsever in public domain)

Often in literature you find a sample A3 sheet with the explicit mentioning or implicit indication that this is the "*right*" way to do an A3. However, since there are many different ways to use the A3, I strongly believe there is not a single standard sheet that will fit all problems. I am a strong believer in **making the tool fit the problem, not the other way round!** Unfortunately, in many lean implementations, I just see exactly this use of a tool regardless if it fits the problem.

In any case, every useful A3 report should be centered somewhat around the PDCA. Which headers and blocks you include depends on the problem you are trying to solve. Do not use one A3 template for everything, but mix and adapt – as long as there is a PDCA. It is okay to use a template, but I recommend keeping it flexible. If, for example, you add a fishbone diagram to your template, you push the user toward a fishbone diagram in lieu of other options. If there are a number of similar-parallel problem-solving activities reporting to the same management, a standardization may have benefits for the management. However, a company wide *one-size-fits-all* A3 report in all likelihood will fit all tasks equally bad.

Having said that, here is a list of possible headers or parts to include in your A3 report. You will also find more if you look around different sources. But again, do not use them all but only the ones that help you with the problem at hand. All of the below can include graphics, diagrams, layouts, sketches, etc. if needed. And again, **one sheet, A3 size, with pencil, on the shop floor!**

13.3.1 Plan

Figure 91: How do we solve the issue? (Image michaeljung with permission)

- **Background**: What are we looking at, which part of the plant/product is under investigation, what is the business case?
- **Current State** or **Initial Condition**: What is the current situation?
- **Problem Statement**: What problem do we actually try to solve?
- **Target Condition** or **Targets**: What do we want to achieve? What are our (numeric) targets?
- **Problem Analysis** or **Root Cause Analysis**: What is the cause of our problems? You could use a *fishbone diagram*, a *5 why* approach, or any other problem solving method useful to you.
- **Solution Comparison**: Which of the possible solutions has the best chance of being successful for a reasonable effort? Which solution idea should be implemented?
- **Proposed Solution**: What is our approach to fix the problem?

13.3.2 Do

Figure 92: Let's do it! (Image Photographee.eu with permission)

- **Next Steps**, **Corrective Actions**, or **Implementation Plan**: List of actions that need to be done to implement the proposed solution.

- **Schedule of Implementation**: Deadlines, planned and/or actual start and completion dates, status (open/in progress/done). Is often combined with the next steps in one table.
- **Responsibilities**: Who is in charge of which step? Can also include other functions as, for example, Accountable, Consulted, Informed, Support, etc. Can also be included in the Next Steps, but be wary of overdoing it.

13.3.3 Check

Figure 93: Did it work? (Image philipimage with permission)

- **Indicators** or **Targets**: Comparison of the target conditions to the current conditions. This is especially interesting after implementation. It is often shown as a timeline or a graph. It is also often combined with the Targets from the Plan above. Please note that one swallow does not make a summer, and hence achieving the targets once doesn't mean you have achieved it. The situation has a tendency to revert to its old state as soon as management's attention has passed on to the next topic.
- **Monitor Results** or **Process**: Keeps track of the effect of the implementation and changes fro the Do step.

13.3.4 Act

Figure 94: Where did I go wrong? (Image Кирилл Рыжов with permission)

Hopefully you may not need this if the problem is solved on the first try. Actually, most A3 reports do not include the Act part. It is somewhat negative and depressing to include a "*Why it did not work!*" section after all that "*What we did to make it work!*" before. I myself often do not include it from the start. However, if the problem is not yet solved despite some changes (improvements?), you would need to add this. You do not need to have it from the start, but you need to be mentally prepared to go through the Act if you need to. Nevertheless, there are some possibilities for a general and more positive Act on the A3 sheet:

- **Follow-up Actions**: What are the next steps?
- **Share the Successful Ideas with Others**: Sort of a fig leaf Act on A3 reports. The idea is to share the good results with others. Since it automatically implies that there are good results after the first try, I feel that it pushes you away from analyzing "W*hy it did not work?"* if it did not work.
- **Update Standard Work Sheets**: Naturally, a successful change in a standard would need to be added into an updated work standard sheet.

13.3.5 Miscellaneous

Figure 95: Check the checks and sign the signs… (Image Clker-Free-Vector-Images in public domain)

On top of all that, an A3 can include a lot of additional general project-related data:

- Title
- Reference numbers
- Date of report
- Project team members, project owners
- Stakeholders
- Contact information
- Part numbers
- Section manager or patron (which gives an upper manager the possibility to add his name without being responsible if it does not work)
- Signature fields, possibly even for different steps to get approval from others and management, or just at the end confirming that the section manager has accepted the successful project
- Budget/expenses

13.4 Summary

As mentioned above, you need to make the tool match the problem, not the other way round. In any case, there are still many things that can be done wrong when doing an A3 report. I will write more about the mistakes and limits of the A3 report at a later time. Until then, however, I hope the above summary was useful for you. Now **go out and organize your industry!**

13.5 See also

Roser, Christoph. "Der A3-Report: Mehr Als Nur Eine Problemlösungsmethode." Yokoten 5, no. 3 (2016).

14 The A3 Report – Part 3: Limitations and Common Mistakes

Christoph Roser, April 05, 2016, Original at https://www.allaboutlean.com/a3-report-part-3/

Figure 96: A3 Report on Clipboard (Image OpenClipart in public domain)

In the last two posts I showed you the basics of the A3 report and the (possible) content of the A3 report. In this last post of this series, I would like to talk about common mistakes and the limitations of the A3 report. Overall, for me the A3 report is a minor tool to help organize the real work of problem solving, despite all the fuzz some make about the A3 report.

14.1 Common Mistakes

I mentioned many requirements and useful suggestions for an A3 report already in my previous posts. You should do as much of the A3 on the shop floor as possible, ideally using an pencil and an A3 (or ledger or tabloid) paper size. But here are a few more things that can be done better or worse:

14.1.1 Computer vs. by Hand

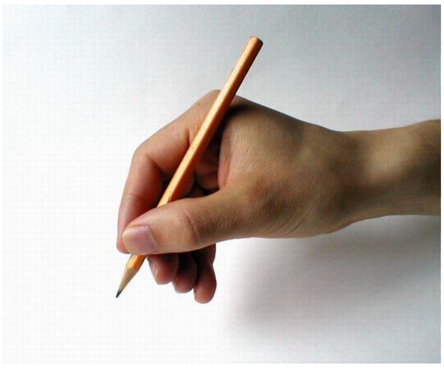


Figure 97: Hand holding pencil (Image Johnny Magnusson in public domain)

Frequent readers of my blog know that I am a big fan of writing by hand rather than using a computer. (See my previous post The Advantage of Handwritten Data on the Shop Floor.) Same is true here too.

As mentioned above, it is probably best to use a pencil. Worst is probably a permanent pen, since it would require you to get the A3 report perfect on the first go. The computer indeed does make it easier to modify the report. However, a computer is a brain drain. Even if you do not notice it, creating and formatting the report takes a lot of effort, which all distracts from the actual problem solving. And, do not forget, solving the problem at hand is the real issue here.

However, I have to admit that there are instances when a computer-generated A3 report may be useful. It is much easier to share, present, and – depending on the handwriting – even read a computer-generated document than a handwritten one. Hence, again, make the tool fit the problem, not the other way round. If your task is primarily to solve a problem, use pencil.

However, if it is (also) important to present a nice fancy spreadsheet to management, use a computer. After all, your job as an employee is to make your bosses happy, and if they want fancy graphics, give ’em fancy graphics.

14.1.2 Getting Stuck in the Details

Figure 98: Don’t lose your focus! (Image BirgitKorber with permission)

Another problem I often see is that people do get stuck in the details, and start to neglect the bigger goal of solving the problem. There are no strict requirements on the A3 report. If it is something simple, you could use a smaller A4. While technically speaking, it is no longer an A3 paper size, people all over the world frequently use A4 paper but call it an A3 report. While A3 is probably better in most cases, A2 is also possible.

I already mentioned that you can use a computer, and that you can adjust the content to fit your needs. Probably the only thing I would insist on is using only a single sheet of paper – and this is only because multiple sheets would have a different name and no longer be called an A3 report.

14.1.3 Emphasizing Form over Content

The A3 is a tool, and like every tool it has to fit your problem. Like you have different screwdrivers for different screws to tackle, so does the design of your A3 report adapt to the problem you have to solve. Do not let yourself be constrained by any template you find in literature. (However, if your boss insists on using a certain template, you better do it.)

14.1.4 Trying to Squeeze in Too Much Information

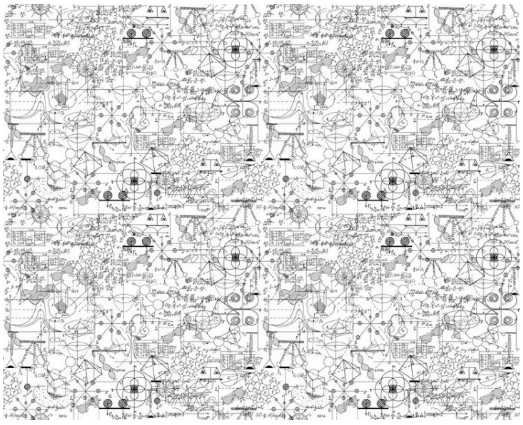


Figure 99: Math Formula Background (Image belkaelf25 with permission)

One of the benefits of the A3 is to boil down the content to the core. Remove everything that is not essential, until it fits on an A3 sheet of paper. No cheating with magnifying glasses though! Less is more!

Whenever possible, use pictures, diagrams, sketches, and graphs in lieu of words and text. A picture is often much easier to understand than text, especially on a handwritten report.

14.1.5 Doing It Alone

Figure 100: The power of many… (Image shock with permission)

Working on paper using pencil is also great in smaller groups. Try not to do an A3 alone. Rather, involve others and get their input and ideas on the paper too. Generally, I like to work with teams of two to five people to have different opinions but still a team where all have to participate and cannot hide in the second row.

14.2 Limitations of the A3 report

Figure 101: Watch out, here comes the A3 report! (Image Fennec in public domain)

It sometimes feels like the A3 report is one of the magic tools in lean, and simply using the tool makes your shop floor miraculously good. Hint: It doesn't. And neither do any of the other *magic tools* like 5S or value stream maps.

Even if the A3 report is sometimes paraded around like a sacred relic, it is in my view only a minor tool. The main work is still identifying and solving the problem. If I have the choice between a sloppy root cause analysis on an A3 report and a good one on the back of an used envelope, I would go with the envelope any time. **Using an A3 report will offer no advantage at all if the content is garbage!**

Hence, put the effort of the A3 report into the content, not the format!

- Make a thorough analysis of the current state.
- Go deep when trying to understand the root cause of the problem.
- Ideally, get ideas for multiple solution approaches to your problem, and
- Then pick the most promising solution idea.
- Ensure a good implementation, and
- Verify with some delay if the implementation really solved the problem.

Fail any of the above and your risk of not solving the problem increases significantly. Again, it is not the format but the content that will make or break your project!

By the way, I did it again. I was planning to write a short 1,000-word article on the A3 report, and now I have 4,000 words over three posts. Whenever I touch a seemingly simple topic, I find lots of details and suggestions. In any case, this is my last post of this three-post series on the A3 report (for now). I probably could not fit all that text on an A3 sheet of paper ☹. But I do have lots of pictures 🙂.Thanks for staying with me through this lengthy analysis. Now **go out with a pencil and a single sheet of A3 paper and organize your industry!**

PS: Also see the comment by Michel Baudin on my post:

14.3 See also

Roser, Christoph. "Der A3-Report: Mehr Als Nur Eine Problemlösungsmethode." Yokoten 5, no. 3 (2016).

15 Supermarket vs. FiFo – What Requires Less Inventory?

Christoph Roser, April 12, 2016, Original at
https://www.allaboutlean.com/supermarket-vs-fifo-wip/

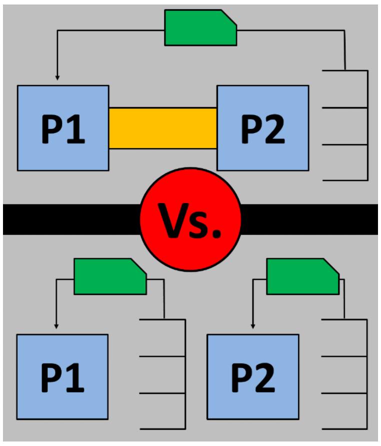


Figure 102: Supermarket vs FIFO (Image Roser)

To create pull production between two processes, you can add either a FiFo lane or a supermarket. In one case you will have the FiFo as part of a bigger kanban or CONWIP loop, and in the other case you split the value stream into two different kanban or CONWIP loops.

Some questions that I have been pondering are: Which one has less inventory for the same delivery performance? Is it better to use a big loop or two smaller loops for the WIP and delivery performance trade off?

15.1 Introduction

Figure 103: Pull is great! (Image Luis Louro with permission)

In almost all cases, pull systems are superior to push systems (read, for example, my posts on The (True) Difference Between Push and Pull and Why Pull Is So Great!). Good flow shop pull systems are implemented using either kanban or CONWIP loops. And here you have multiple options. You can make one big loop with FiFo lanes between the processes, or you can split it into multiple smaller loops by adding supermarkets between selected processes. I have already looked at the question on when to use supermarkets and FiFo based on ease of use. More details are available in my posts Ten Rules When to Use a FiFo, When a Supermarket – Introduction and The Rules, as well as Top Five Cases When NOT to Use a FiFo.

However, so far I have not yet looked into the aspects of inventory or work in progress (WIP) and the influence on the delivery performance. As you surely know, reducing inventory is a constant drive in industry in order to reduce the associated costs. Similarly, delivery performance is also high on the agenda of most managers. Unfortunately, they are usually somewhat inverse related. More inventory often gives you a better delivery performance, and vice versa. Hence, I gave a master's student the task to look into it, and this student did an excellent job of looking into these details (source below).

15.2 Analysis

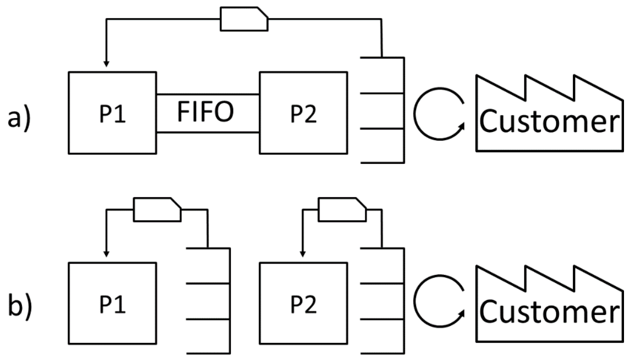


Figure 104: Our two analyzed system set-ups (Image Roser)

To keep things simple, we analyzed a small system having only two processes and only one part type. We always compared the performance of a single loop with the performance of a double loop.

We did vary the cycle times quite a bit for both processes as well as the customer. Naturally, the customer always had to be a bit slower than the processes, or otherwise the delivery performance would go toward zero. We varied this speed difference between the customer and the processes. We also varied the speed difference between the processes. We experimented with different types of random distributions and different standard deviations for the processes and the customer. In short, we tried to replicate as many different situations as possible that can be expected in industry.

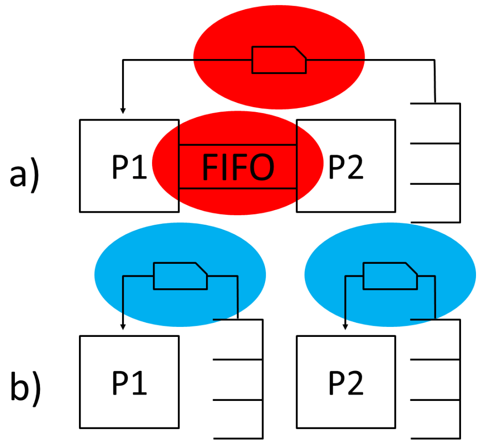


Figure 105: Analyzed variables (Image Roser)

For each system, there were two variables we could play with. For the first system we could set the number of kanban cards and the maximum capacity of the FiFo lane. For the second system we could set the number of kanban cards for either loop.

With these variables we did an exhaustive search. We analyzed pretty much any combination of number of kanban and FiFo size for the first system as well as any combination of number of kanban for the second system. In short, we pretty much tested every combination, also repeating it multiple times for accuracy. The image below shows, for example, the WIP surface plots for all combinations of kanban and FiFo size for the first system as well as any combination of number of kanban for the second system.

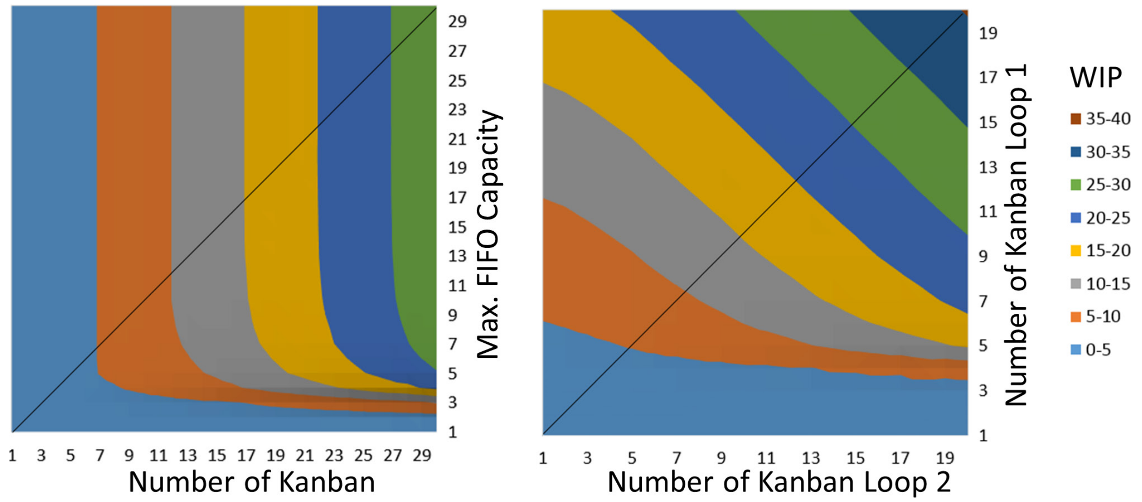


Figure 106: Example WIP surface plots for both systems (Image Denis Wiesse under the CC-BY-SA 4.0 license)

Similar surface plots were also done for the delivery performance. All of them were also done for many different set-ups with respect to cycle time and customer demand.

15.3 Results

The question we wanted to answer was: **Where do you need less WIP – one loop with FiFo or two loops?** Out of the mass of data, we always looked for the best combination of inventory and delivery performance. In other words, if I set up my system perfectly (more on that later), what is the lowest WIP I can get away with for a certain delivery performance, or, similarly, what is the best delivery performance I can get for a given WIP?

The graph below shows you the best trade off between WIP and delivery performance you can get for both a single loop and FIFO system and a double loop system where the two processes had equal cycle time and the customer was 10% slower. However, no matter which system we simulated, the results were all very similar. In all cases the single-loop system was better than the double-loop system.

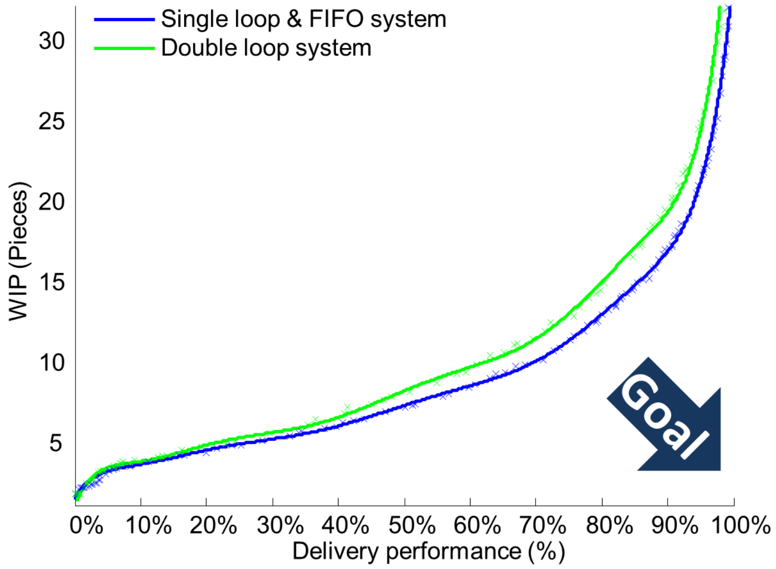


Figure 107: WIP vs Delivery Performance (Image Denis Wiesse under the CC-BY-SA 4.0 license)

These two lines are close together. We also went through the difficult math using confidence intervals and statistical hypothesis testing to verify that this difference is not just a random fluke.

The difference is statistically significant for delivery performances above 50% – which is where most factories are. More similar results can be found in the sources given below.

15.4 Interpretation

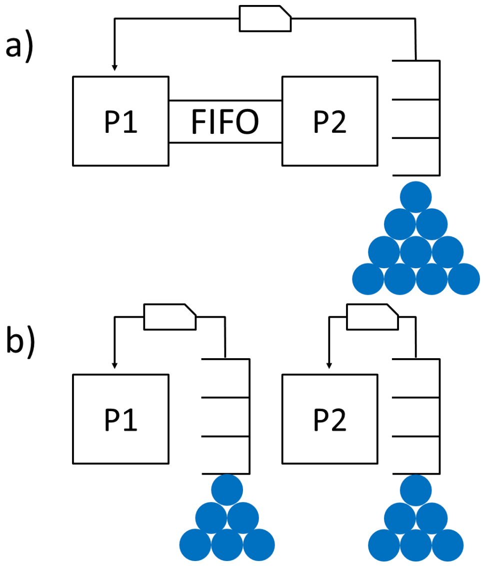


Figure 108: Inventory during low demand (Image Roser)

Thinking about it, these results make sense. In cases of low demand, inventory will pile up at the end of the loop. For a single-loop system, you will get a big pile at the end, whereas for the double-loop system, you will get two smaller piles as shown in the picture.

If this period of low demand is followed by a period of high demand, the single-loop system can deliver all parts immediately if necessary. The two-loop system, however, can deliver only the second pile, whereas the first pile still has to go through the second process. Hence, it is more likely that the two-loop system may miss a delivery.

15.5 Relevance

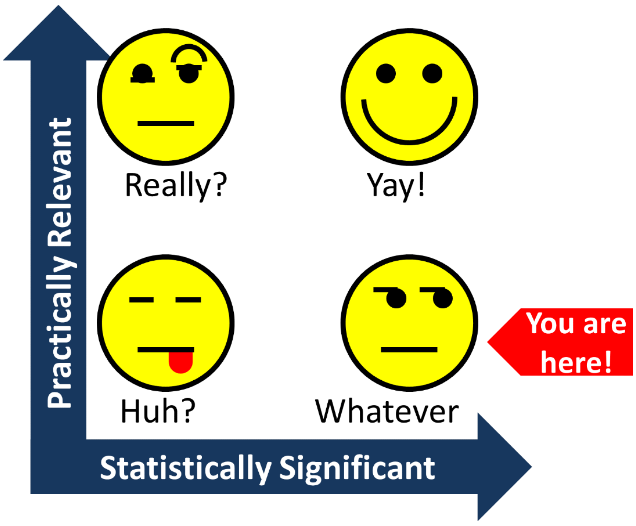


Figure 109: Practically Relevant vs. Statistically Significant (Image Roser)

Hence, using a single larger loop requires statistically significant less inventory for the same delivery performance than two smaller loops. However, statistically significant does not necessarily mean practically relevant! In fact, I do recommend you to take other factors into consideration before making a single large loop across your entire factory to optimize your WIP!

First of all, the benefit is not that big. For example, to achieve a 95% delivery performance (a common number in industry), you would need about 20% more WIP with a two-loop system compared to a single loop with a FiFo in between. There are much better ways to reduce inventory (e.g., by reducing the lot size).

Second, the above graph represents the perfect set-up of number of kanban and FiFo capacity. However, unless you test all combinations of number of kanban, you are unlikely to get to this perfect setting. In fact, most ways to determine the number of kanban are extremely crude. The kanban formula is an extremely rough estimate, and with equally valid but different assumptions you quickly get a difference of 30% or more (see also my series How Many Kanbans? – The Kanban Formula). The other alternative to the kanban formula is an expert estimate, which is nothing but a rough guess by someone who knows the system (see How Many Kanbans? – Estimation Approach and Maintenance). Overall, your chances of actually hitting that sweet spot are rather slim.

Third, if you know lean, then you know the idea of reducing unevenness (Mura). The single-loop system, however, may end up with a big pile of material at the end, and little in between, a very uneven result. This is usually not desirable in lean. There is even an A–B Control method in lean that stops other machines to prevent exactly this unevenness.

Finally, due to the small improvement in WIP, I think other considerations are much more important than merely a slight WIP reduction. In one of my previous posts I listed ten reasons when to use a supermarket instead of a FiFo lane (Ten Rules When to Use a FiFo, When a Supermarket – Introduction and The Rules). The default fallback is always a FiFo lane anyway, not because of less WIP but rather because it is usually so much easier to manage than a supermarket.

I hope this article on the detailed relation between inventory and delivery performance with respect to the manufacturing system design was interesting to you. Granted, it is not a great revelation about a new lever to play around with. However, I do find it necessary to also know which levers are NOT important. Now **go out, play with the levers that work, and organize your industry!**

15.6 Sources

Wiesse, Denis. "Analyse des Umlaufbestandes von Verbrauchssteuerungen in Abhängigkeit von der Nutzung von Supermärkten und FiFo-Strecken." Masters Thesis, Karlsruhe University of Applied Sciences, 2015.

Wiesse, Denis., Roser, Christoph. Supermarkets vs. FIFO Lanes – A Comparison of Work-in-Process Inventories and Delivery Performance, in: Proceedings of the International Conference on the Advances in Production Management System. Presented at the International Conference on the Advances in Production Management System, Iguassu Falls, Brazil, 2016.

16 The Key to Lean – Plan, Do, Check, Act!

Christoph Roser, April 19, 2016, Original at https://www.allaboutlean.com/pdca/

Figure 110: PDCA Circle (Image Roser)

Plan-Do-Check-Act (or PDCA) is one of the key elements in lean manufacturing, or for that matter in any kind of improvement process. In my view, it is the most basic framework for any kind of change. All other lean tools are only *on top* of the PDCA.

In my experience, most lean projects in the Western world fail not because they do not have some detailed tool, but because the PDCA is neglected. Of course, (almost) everybody knows what the PDCA is, but there is a huge difference between knowing the theory and doing it correctly. In this post I will explain in more detail how PDCA should work. In my next posts I will show you the common pitfalls of PDCA, its history, and the many, many different variants of the PDCA that are out there.

16.1 What is the PDCA?

16.1.1 Plan

Figure 111: Develop your plan! (Image Schmiljun under the CC-BY-SA 3.0 Germany license)

The first step in the PDCA is the *Plan*. As the name says, you *plan* what you are going to do. Depending on the project, this may be the largest part of the effort of the PDCA. In fact, you can see it as a number of sub-steps or points that you have to address in the *Plan*. Depending on your progress, you may even have to do some of them iteratively until you get a suitable solution.

- Define the scope: What problem are you looking at?
- Define the target: What do you want to achieve? What are your goals?
- Analyze the situation: Try to understand what the current situation is. Talk to people. Visit the shop floor and observe (Genchi Genbutsu). Collect data.
- Develop solutions: What approaches could help you to fix the problem?
- Select the best solution: Out of the different solution ideas, select which one you think is most promising with the biggest bang for your buck.

The *Plan* covers a lot of ground. Personally, if I would have to re-invent the PDCA, I would give it a few more letters beyond just *plan*. Oh, wait, people already did re-invent the PDCA, although I am not always convinced of the results (post with more details on PDCA variants coming up soon).

16.1.2 Do

Figure 112: Make your changes (Image Alfred T. Palmer in public domain)

This is the actual implementation. Change the shop floor, create the product, actually make it happen. In all likelihood you will encounter additional problems during the *Do* that you did not think of before. That is normal. Just solve them as they come along.

In any case, **try to make the Do stick**. For example, if you change the way workers work, it is easy to have workers do it in a new way once. It is much more difficult to have them do it in the new way from now on. Depending on the problem you are trying to solve, **standardization** can really help here. Create a standard, train the workers, and confirm that they are following the standard even a few days later.

16.1.3 Check

Figure 113: Check carefully if it really works! (Image unknown author in public domain)

This is probably the most frequently overlooked part of the PDCA. **Did your implemented solution actually work?** Did you achieve your goals? This is a very serious question. Judging from my experience, in most cases it does not, or at least not well enough.

Far too often, management is satisfied with a spiffy-looking presentation, and is ignorant of the reality on the shop floor. Additionally, they are also ignorant of the Hawthorne effect. This effect was first observed at the Hawthorne Works of Western Electric in 1930 and was named in 1950. In many cases, changing something on the shop floor will improve the system, regardless of what you change – but only for a short time! In other words, the management attention during a change process on the shop floor will lead to higher productivity and better quality, regardless of what is actually implemented. However, as soon as the management attention has moved on, everything reverts back to the old state.

This is a very common trap. You do a project, the KPIs improve, you move on, and the KPI then reverts to what it was. For an improvement project to work, the improvement not only has to actually work, but also has to continue working. That is the whole idea of the *Check* part in the PDCA.

16.1.4 Act

Figure 114: Give me the next problem! (or the same one again …) (Image NACA in public domain)

The *Act* is to decide what to do next. This depends on the outcome of the *Check*. If your implementation failed to achieve the targets, you have to find out the reason. Why did your solution fail to perform as you expected? This will lead to a repetition of the PDCA with another *Plan* to figure out a new or better solution to achieve your goals.

Figure 115: A victory parade (Image Roser)

If you managed to achieve the goals (without falling back after two weeks, mind you!), you should **congratulate your team and show your appreciation!** With shop floor teams, I always had great success with a three-pound bucket of gummy bears or similar.

However, work never stops. Now you have to think about which problem to solve next. Prioritize your problems, pick the most relevant one (usually the one with the best expected benefit for the effort), and start a new PDCA.

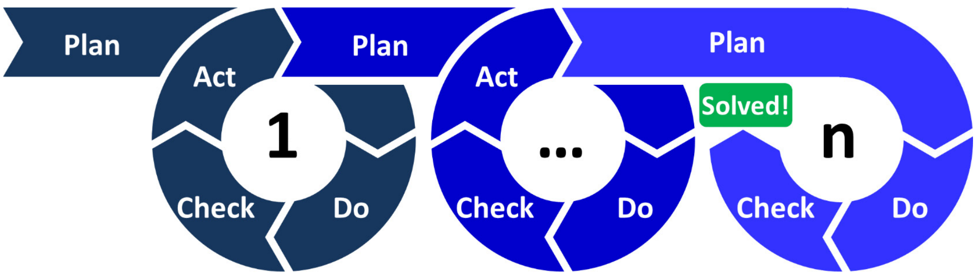


Figure 116: The PDCA repeats until the problem is solved. (Image Roser)

16.2 Summary

Overall, the PDCA is for me the basic fundamental framework underneath all improvement activities. And I know it is not easy. I often find myself skipping steps or doing the PDCA sloppily if I do not pay attention. It takes a lot of focus and concentration to do it well. While the first two steps, *Plan* and *Do*, come naturally to most project managers, actually *checking* if it works and *acting* upon it is much rarer. I sometimes even have the feeling that the *Check* and *Act* are not really wanted in industry. Pointing out that the newly installed immensely expensive equipment does not work is something not everybody wants to hear. I will talk more about the possible mistakes in a PDCA and the history of the PDCA in my next post.

I hope your boss has an open ear for such things, and you can go out and not only *Plan* and *Do* but also *Check* and *Act* in order to **organize your industry!**

17 Common Mistakes with the PDCA (and Some History)

Christoph Roser, April 26, 2016, Original at https://www.allaboutlean.com/pdca-history/

Figure 117: The mysteriously vanishing Check and Act (Image Ali in public domain)

In my previous post I explained how the PDCA (Plan, Do, Check, Act) should work. However, while most people know the PDCA in theory, I find that the practical implementation is often lacking. And, quite frankly, I am also sometimes sloppy with the PDCA way more often than I would like to admit. Time for some reflection and observation on what works, and why so often it does not.

Hence, in this post I will show common pitfalls and problems when doing a PDCA. Also, simply because it is one of my pet interests, I will also show a bit of the history of the PDCA and its origins in quality control.

17.1 Common PDCA Failures

17.1.1 Skipping Check and Act

Probably the biggest cause of failure in PDCA (and all its variants) is to skip the *Check* and *Act* steps. Way too often in industry, people are not really interested if it actually works. Of course, they say that they want it to work, but all their actions show that they do not really care. A spiffy presentation is all that is needed to satisfy them, and they can move on to the next problem.

In fact, I sometimes get the feeling that pointing out that an expensive installation does not work is not very popular in industry. Hence, it is unsurprising that few career-oriented people bring up such an unpopular issue. Soon people will learn that a spiffy presentation is as good for the career as solving the actual problem. Maybe even better. In any case, a presentation is usually easier than solving the issue at hand.

If there is no checking to see if the implementation actually works, there will be a high percentage of projects that won't work. The problem is not solved, but everybody moves on to the next project. Everybody is running but nothing is moving forward. What a waste! I know it is difficult and I have to force myself every time too, but please do not skip the Check and Act! This is probably the biggest cause of most failures in lean projects!

17.1.2 Developing Only One Solution

Figure 118: Children with a spaghetti tower (Image Oregon Department of Transportation under the CC-BY 2.0 license)

There is a nice lean exercise called the Marshmallow Game. You have to build a tower from (dry) spaghetti that has to support a single marshmallow on top. The highest tower wins. This game has been done with many different people. The best results are not with consultants, or engineers, or academics, but with kindergarten children. The adults discuss a lot and eventually build one tower – which often fails. The kids simply try out different things and learn from their mistakes.

This type of problem solving is also good for industry. Of course, you cannot always try out many different solutions. However, you should not only develop one solution and then start implementing. In Japan, there are commonly many different solutions considered, and in the end the most promising one is implemented. See also my post Japanese Multidimensional Problem Solving.

17.1.3 Doing It Alone

Figure 119: The power of many (Image shock with permission)

A group is usually smarter than an individual. Try to get a few people together when solving a problem. Ideally, it should include at least one person actually working at the site, but additionally a technician for the implementation and a supervisor to authorize things. For me, the perfect group size is between three and five people. This way, it may take a bit longer to agree on a solution, but the solution is almost always better than what a single person could have figured out.

17.2 Origin of the PDCA

After a selection of what could go wrong, here now, as promised, is a bit of history on the PDCA:

17.2.1 Scientific Method

Figure 120: That is how it is done! (Image Paul van Somer I in public domain)

Many writers base the PDCA on the scientific approach of conducting experiments and checking the outcome. In this scientific approach, a method is tested with experiments (think Francis Bacon, Galileo Galilei, etc.). I think this is maybe a bit far fetched, but it is a nice bit of history.

17.2.2 Shewhart Cycle

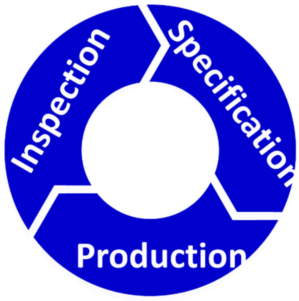


Figure 121: The original Shewhart cycle (Image Roser)

Probably the first to show it as a circle was Walter Shewhart, also known as the father of statistical quality control. However, he originally had only three steps, first in a line and later in a circle: **Specification, Production, Inspection. Hence it is also known as Shewhart cycle.**

17.2.3 Deming Cycle

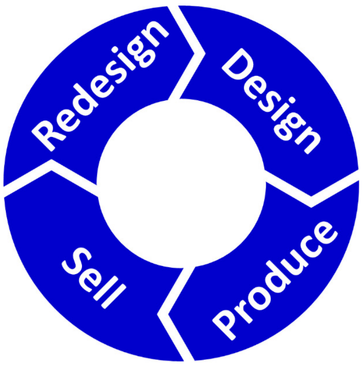


Figure 122: The original Deming cycle (Image Roser)

A young quality engineer edited Shewhart's book in 1930. This engineer was Edwards Deming, who later became famous in Japan for teaching the Japanese quality control. Later in 1950, he renamed the steps slightly and added a fourth step: **Design, Produce, Sell, Redesign,** and taught it in Japan. Hence it is also known as **Deming circle/wheel/cycle**. In any case, you can clearly see that the origin of PDCA is rooted in product development and product quality, with the idea to constantly improve a product through redesign so that the new product sells even better. In comparison with the modern PDCA, however, I think the *Check* section of analyzing flaws and improvements is a bit short.

17.2.4 The Japanese PDCA

Figure 123: The Japanese version from 1951 (Image Roser)

Deming's teachings in Japan fell on fertile ground and probably helped Japan significantly improve product quality. He also taught his Deming cycle to the Japanese. Japanese engineers picked up the idea and in 1951 evolved it into the Japanese version of the modern PDCA, consisting of:

- 計画 (Keikaku) for plan; project; schedule; scheme; program
- 実施 (Jisshi) for enforcement; implementation; putting into practice; carrying out; operation; working
- チェック, which is the English word "check" written in Japanese letters
- アクション, which is the English word "action" written in Japanese letters

17.2.5 The Western PDCA

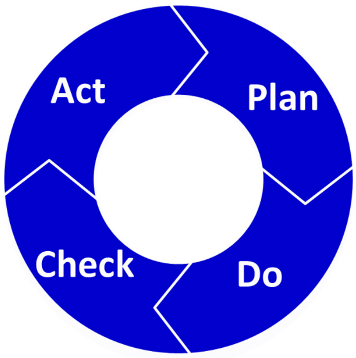


Figure 124: The modern PDCA as developed in Japan (Image Roser)

Translating the Japanese version into English (with a tiny bit of liberty) gives the modern **Plan, Do, Check, Act**. This is also the cycle used by Deming later on, and modified into a **Plan, Do, Study, Act**.

Figure 125: Deming teaching in Japan 1950 (Image unknown author in public domain)

The original two cycles by Shewhart and Deming are all but forgotten. Most references nowadays give the Shewhart cycle and the Deming cycle as alternative names to the PDCA, although to be frank I have never heard anybody call it by these names. In any case, these references usually mean the PDCA and not any of the earlier versions.

17.3 Summary

I hope this overview of causes of PDCA failure and also the history of the PDCA was of interest to you. In the next post I will show you a selection of the different variants and similar methods out there, including PDSA, SDCA, OODA, ODCA, DMAIC, LAMDA, Kata, and 8D. In the meantime, **go out and organize your industry!**

17.4 Sources for the History Part:

Moen, Ronald. "Foundation and History of the PDSA Cycle." Associates in Process Improvement–Detroit, 2009.

Moen, Ronald, and Clifford Norman. "Evolution of the PDCA Cycle." Associates in Process Improvement–Detroit, n.d.

18 The Many Flavors of the PDCA

Christoph Roser, May 03, 2016, Original at https://www.allaboutlean.com/pdca-variants/

Figure 126: PDCA Variants (Image Roser)

In my last posts I explained the PDCA (Plan, Do, Check, Act), common mistakes, and its history. However, there is a whole fruit stand of additional versions with some modifications that have popped up: PDSA, SDCA, OODA, ODCA, DMAIC, LAMDA, FACTUAL, Kata, and 8D – and probably more that I do not know of. Let me explain a bit on the different offshoots and alternatives of the PDCA.

18.1 PDSA: Plan, Do, Study, Act

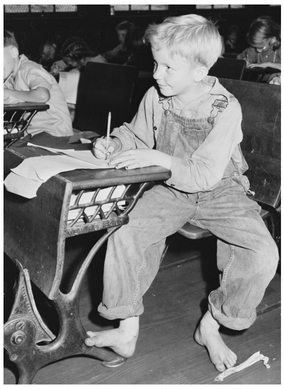


Figure 127: Study some more… (Image Russell Lee in public domain)

The PDSA was developed by Deming. The main difference is that the *Check* was replaced by *Study*. Deming said that the original *Check* would mean in English to "*hold back,*" and hence he called the original PDCA a *corruption*. Maybe my English is not good enough, but "*hold back*" would not have been on my mind when I heard "check."

In any case, the implied meaning is nearly the same. The *Study* part analyzes if it actually worked and improved the situation, and also tries to learn from the *Plan* and *Do* parts.

18.2 OPDCA: Observe, Plan, Do, Check, Act

Figure 128: Prow lookout aboard USS NASSAU (Image Lt. Wayne Miller in public domain)

Yet another PDCA variant, this time with *Observe* added at the beginning. For me, this is part of the *Plan* in the original PDCA, but I am also fine with giving it a separate letter. The *Plan* in PDCA would benefit from more letters anyway.

18.3 SDCA: Standardize, Do, Check, Act

And yet another PDCA variant, where the *Plan* is replaced by *Standardize*. You may wonder why there is a *Standardize* at the beginning, while in the PDCA it is part of the *Do*. The idea is to observe the current standards and see where the workers deviate from the standard. You can continue with *Do, Check, Act* if they deviate to find out why, and to change the system that either the standard is updated or the worker follows the standard.

However, in my view, I think this limits the list of problems you can solve. If all your cycles require you to have a standard first, then you can only improve things that have a standard. This would exclude non-standardized steps (infrequent or simply just not yet standardized), and limit many other approaches like machine problems or product quality. Hence, I do not like it too much.

18.4 DMAIC: Define, Measure, Analyze, Improve, Control

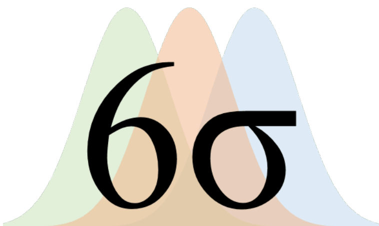


Figure 129: Six Sigma (Image Roser)

This DMAIC (*Define, Measure, Analyze, Improve Control*) is a PDCA offshoot in the Six Sigma offshoot of lean manufacturing. While it has more words, the meaning is somewhat similar. However, I do think DMAIC has some shortcomings compared to the PDCA.

The original *Plan* from PDCA is split into *Define*, *Measure*, and *Analyze*. First, the positive side: I like that the project is clearly defined in the *Define* step. However, I think that *Measure* and *Analyze* are not always sequential, but rather iterative. Usually you measure, you analyze, and then you go back to measure some more. The goal at the end of the *Analyze* step is to understand the root cause.

The development of the solution, which at PDCA is still part of the *Plan*, is now mashed together with the implementation as the *Improve* step. What really irks me here is that **DMAIC**

has the entire PDCA included as part of the Improve step merely to test solutions. I think that is just wrong. But then, Six Sigma in general has an irksome tendency to claim that it is on top of the world, and even "lean" is just a tool in their toolbox.

The last step, *Control*, aims to ensure the results are sustainable, usually through standards. What I completely miss in the DMAIC is the *Check* part of the PDCA. It seems **at no part does DMAIC actually check if the implementation worked!** For me, this is a crucial flaw if someone follows the DMAIC by the books! Overall, DMAIC goes in the right direction, but it falls short in a few key areas.

18.5 LAMDA: Look, Ask, Model, Discuss, Act

LAMDA is actually specialized on product development (i.e., a similar task as the original Shewhart cycle). It also aims to be a PDCA replacement in this field, but for me it has some shortcomings too. Additionally, different sources define it differently. Luckily, it is rarely used.

The *Look* represents observations on site (i.e., the shop floor). *Ask* stands for asking questions. So far so good, similar to Genchi Genbutsu. The *Model* part creates engineering models, simulations, or prototypes. *Discuss* is more talking about the models and the product. With *Act*, you would think it is the same as in PDCA, but unfortunately, no. It means to test the experiment or to implement. Hence, it is closer to the *Do* part of the PDCA. Another definition of LAMDA I have found copies the *Act* from the PDCA, meaning you try to learn from the previous process.

Did you notice that LAMDA never defined the problem? LAMDA never considers what you want to achieve, or which problem you want to solve. Due to the inconsistency of the *Act* part, it either never asks if it actually worked, or it never actually generates a finished product. Either way, too many holes in the method for my taste.

18.6 8D: Eight Disciplines Problem Solving

Figure 130: Ford Motor Company Logo (Image Ford Motor Company for editorial use)

This one comes from Ford. Since it was created, a ninth "D" was added at the beginning. Hence, the 8+1D are:

- D0: Plan
- D1: Use a team
- D2: Describe the problem
- D3: Develop an interim containment plan
- D4: Determine and verify root causes and escape points
- D5: Verify that permanent corrections for problem will resolve problem
- D6: Define and implement corrective actions
- D7: Prevent system problems
- D8: Congratulate your team

Overall, not too bad, although I still miss the *Check* from PDCA, where you check if it actually worked.

18.7 Kata

Maybe you are surprised to see Kata here. Currently quite the hype in the lean community, Kata, I think, has a goal similar to PDCA, although it is more oriented toward the big picture. First, Kata is not an abbreviation but a Japanese word for repetitive exercises in martial arts (among other meanings). The four steps of Kata are:

- Determine a vision or direction
- Grasp the current condition
- Define the next target condition
- Move toward the target using PDCA

Of course, there is quite a bit more detail – for example, the exact definition of target condition (it is not a target, but more of a longer term vision). The PDCA is actually part of the KATA step 4. Overall, I think KATA is useful, but also way too over-hyped in the lean community. After all, the underlying ideas are not really that new, and already existed, for example, during the World War II TWI (Training within Industry) program.

18.8 OODA: Observe, Orient, Decide, Act

Figure 131: United States Department of Defense Seal (Image United States Department of Defense for editorial use)

This one actually comes from the U.S. military. In industry, it is sometimes used for higher level strategic decisions rather than practical problem solving of the PDCA. As such, it is also a possibility if you have higher level strategic issues to solve.

18.9 FACTUAL: Focus, Approach, Converge, Test, Understand, Apply, Leverage

After I completed this post, Nicolas below suggested yet another PDCA variant: FACTUAL. This is part of the Shainin toolbox developed by Dorian Shainin (1914-2000). The Shainin approach is using quite a bit of statistics to determine the relation between cause and effect, and to determine the most relevant cause, also known as the Red X. Hence, it is no surprise that FACTUAL is structured around this statistic. *Focus* defines the problem. *Approach* investigates the desired effects. *Converge* identifies the possible causes, including the Red X main cause. *Test* verifies the Red X. *Understand* establishes the statistical relation between cause and effect, including the tolerance limits. *Apply* implements the corrective actions. Finally, *Leverage* determines the lessons learned.

In my view, you don't always have the luxury of a deep statistical understanding of the problem, which means you cannot always use FACTUAL. Even so, the focus is on the statistics of understanding the problem, and very little on developing a solution, let alone checking if it worked.

18.10 Which One Should I Use?

Figure 132: Question Mark (Image Horia Varlan under the CC-BY 2.0 license)

Okay, so now we have eight variants or other methods that move akin to the PDCA. Which one should you use? Good question. I personally tend to use PDCA, simply because I am used to it, although I think the *Plan* could have benefited from one or two additional letters to make it clearer. PDSA and OPDCA are also fine. I am not too fond of SDCA, DMAIC, LAMDA, and 8D. Kata and OODA are good for more strategic thinking. To answer the question: Use whichever suits your problem best. If in the past you had good results with DMAIC, continue to use it. If you are a fan of SDCA, go ahead. If you are new and are just starting this type of thinking, probably stick to the traditional PDCA, since it has the most information and support online, and avoids some of the flaws of DMAIC, LAMDA, and SDCA.

In any case, whichever method floats your boat, use it to **go out and organize your industry!**

19 How Operators Hide the True Workload

Christoph Roser, May 10, 2016, Original at https://www.allaboutlean.com/trickery-employees/

Figure 133: Poker cards and chips (Image Marco Verch under the CC-BY 2.0 license)

Employment is an exchange of work for money. As with most negotiations, both sides would like to keep their cards hidden, so employers and employees use different tricks in an attempt to hide the true facts from the other.

This post looks at the tricks of employees, whereas the next post will look at those of employers. As employees have more control over the work than they do over the salary, this post shows how to keep management in the dark about the true workload.

19.1 The Daily Quota

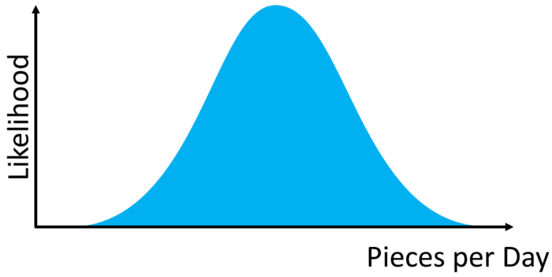


Figure 134: A normal distribution of the daily production quantity (Image Roser)

In most workshops, there are targets for the daily production quota – in other words, how many goods should come off a line every day. Normally, this is expected to fluctuate around a mean value. The image here shows a normal distribution, although it can be argued that the tail on the left should be bigger than on the right. In any case, there should be some fluctuations on the left and on the right.

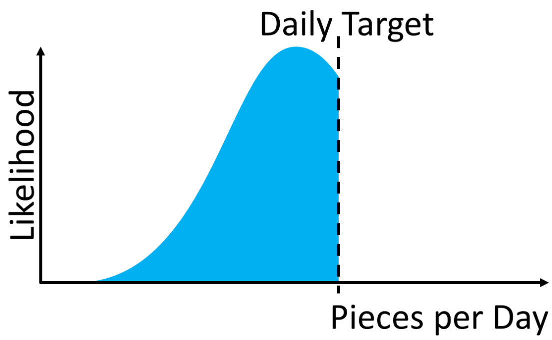


Figure 135: A cut off normal distribution (Image Roser)

However, in reality the distribution often looks very different. Often, the distribution is cut off sharply on the right side whenever the daily quota is reached. In many factories, it is extremely rare to exceed the daily production quota, even though the actual quota is reached quite frequently.

If you ask the workers, they will tell you that they can reach the daily quota with maximum effort and skill, but it is impossible to produce more (i.e., this is the maximum limit they can produce). You could believe that. Or you could not. While the daily quota is sometimes truly a demanding limit, usually it is not.

19.2 The Curious Case of the Overachieving Student Temps (on Their First Day)

Figure 136: And not one piece more than the quota. I dare you! (Image auremar with permission)

The effort needed to achieve the daily quota can often be seen when observing student temps doing a holiday job or similar. Quite commonly, a student worker on his or her first day will easily exceed the daily quota limit. Mind you, that student is still at the beginning of the learning curve, and could be even faster with a bit more experience.

However, in most cases the student will fall back after the first day. Normally, this would be puzzling. People should become better with experience, yet often these temps become worse. The explanation is simple: the other operators had a stern talk with the temp, and warned him or her to never ever exceed the daily quota again.

19.3 Intentional Slow Downs

Figure 137: Which one is it? (Image cynoclub with permission)

The example above details workers trying not to exceed the daily quota. However, workers are also very skilled when influencing the daily quota.

There are two basic ways to determine target speeds of manual tasks: you measure, or you use a system of predetermined motions (with Methods-Time Measurement [MTM] being the most popular one). MTM is more difficult to manipulate, and is mostly influenced through the regulations.

Measuring times, on the other hand, are easier to manipulate. First of all, in many plants you cannot take a stopwatch to the shop floor without the permission of the employee representatives. Even with permission, it is difficult to measure accurate times, because the operators often … start … to slow … down … while appearing … to work … at full … speed.

Since nobody knows the workplace as good as the operator, he or she can easily look tremendously busy while adding lots of unnecessary little tasks or slowing down the process.

Trained time takers are aware of this behavior, and often adjust their measurements using an efficiency or performance level. Nevertheless, I would still say the advantage lies with the operator when it comes to manually measured times.

19.4 Another Example: Machines

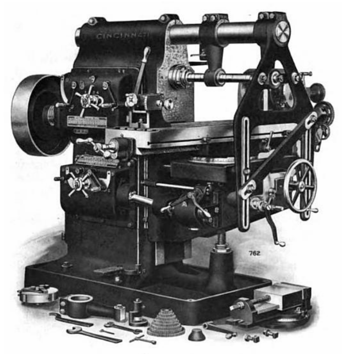


Figure 138: Horizontal milling machine (Image Cincinnati Milling Machine Company in public domain)

Yet another example I've heard of is not a manual process but a CNC machine. The foreman set up the machine, which was then able to produce one part every ten minutes. Yet, according to an external expert on cutting tools, all cutting speeds were only half of what they could have been with the given material and tools.

Now, to be frank, I do not know the exact details on this. It could have been an error, or it could have been that there was another technical reason that was not obvious to the external expert. Or, the foreman wanted to intentionally slow down the machine. Again, I am not saying that it was intentional manipulation, but I would not rule it out either.

19.5 Why Do They Do That?

This behavior of operators is as old as the process of hiring operators. It was one of the main problems Frederick Taylor had to fight. Back then it was known as soldering.

Figure 139: Work for money (Image Prazis with permission)

Employment at its core is an exchange of work for money. The amount of work and the amount of money are hence two major issues to negotiate. **Employers want to get the work for as little money as possible. Employees want to get the money for as little work as possible.** In this negotiation, both sides would like to keep some true facts hidden. The workers are better at hiding the work speeds, whereas the managers are better at hiding the true value of the work.

Now **I don't want to accuse operators of dishonesty!** Please don't get me wrong. While the process is not pretty, it is part of a normal healthy negotiation: keep your cards hidden! And again, the employers do the same with their data. While it would be nice to have a world (or at least a company) where everybody trusts everybody else, this is usually not the case. There are a few companies where it works, but this is the exception rather than the rule. **Anyway, it is more important to work together and to have a good, respectful relationship**, even though neither side is putting all the information on the table.

This post looked more at employees, but employers also play this game. My next post will look more at how employers way to keep their data hidden. In the meantime, **go out and organize your industry!**

20 The Curious Case of 100% Work Performance

Christoph Roser, May 17, 2016, Original at
https://www.allaboutlean.com/trickery-employers/

Figure 140: Poker of aces (Image Kiko Jimene with permission)

Employment is an exchange of work for money. In my last post I showed a few tricks on how operators keep management in the dark about the true workload. However, management is also not giving out all the details on their side either. Naturally, the true value of the work is difficult to asses. Even if companies could know exactly how much each employee contributes to the success, they probably would keep this information top secret.

More interesting, however, is the value of the target workload, where operators are able to work continuously at 130% capacity without problem. The following are my own thoughts, as I have never seen these conclusions anywhere else before.

20.1 The 100% Workload

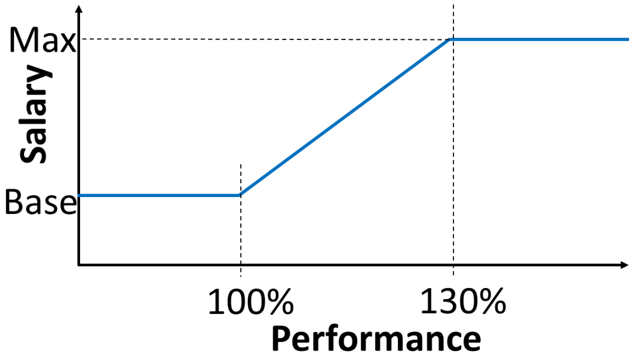


Figure 141: More money for more work … (Image Roser)

On many shop floors, workers receive performance-based pay. There are different ways to determine the target speed, often through predetermined motion time systems.

Usually, there is a base salary if the worker performs at 100% of the target speed or less. If the worker is faster than the target speed, he or she will get more money. In most cases, this is also capped at an upper end, often around 130%. While there are also systems without a cap, they are rare because they all too often generate large quantities of bad quality.

20.2 Predetermined Motion Time Systems

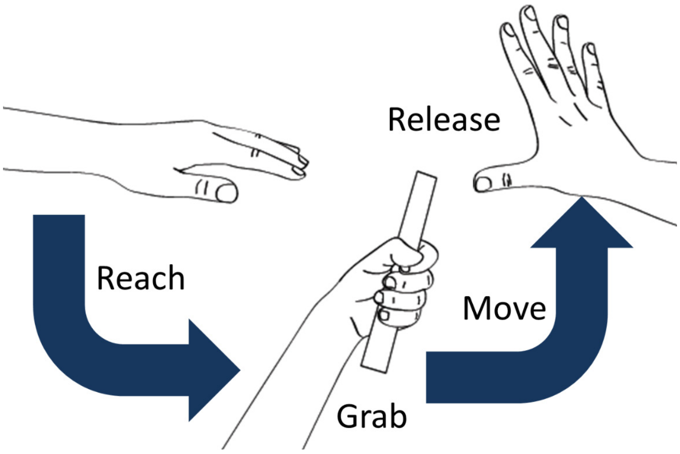


Figure 142: MTM Example (Image Roser)

Predetermined motion time systems date back to Frank Gilbreth and his 18 Therblings around 1910, although they are forgotten nowadays, and Methods-Time Measurement is probably the most common approach.

Those systems are based on thousands upon thousands of measurements of small movements. If you pick up a screw, you look up in tables how long it takes to reach a certain distance, how long to grab an item similar to the screw, and how long to move the item over a distance somewhere else. Overall you break down the movement into individual steps, look up the time for each step, and calculate the total time. While these calculations take quite some time for more complex tasks, at the end you have a time that corresponds to a 100% workload.

20.3 What You Would Expect

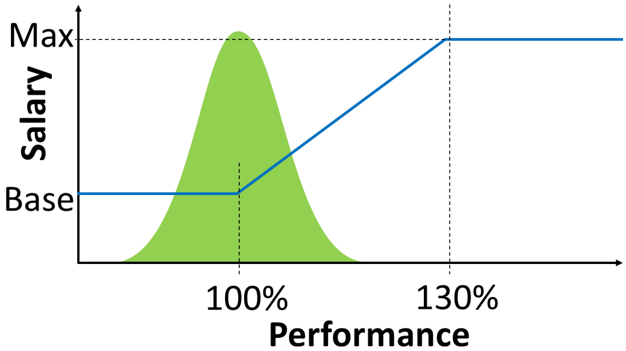


Figure 143: What you would expect (Image Roser)

Hence, you would expect that the true performance of the workers is distributed somewhere around the 100% workload. Sometimes people are faster, sometimes slower, but overall they should be somewhere in the vicinity of the 100% workload.

20.4 What You Actually Get

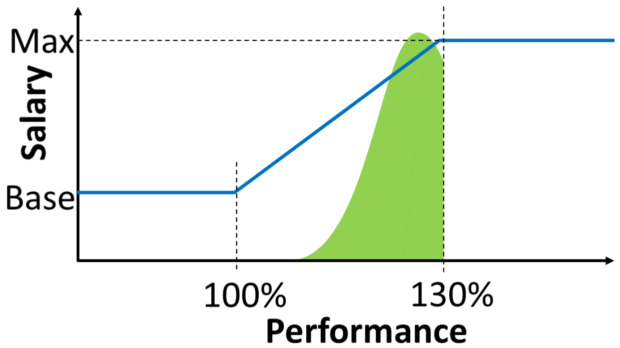


Figure 144: What you get (Image Roser)

In reality, however, the workers are able to perform consistently near or at the salary cap (i.e., they constantly work at 130% of what would have been expected from them).

This has been my observation in many, many plants. I also think that many of the more experienced shop floor managers know this too. The operators probably could work much faster, but for reasons described in my [last post](#) they will not exceed this upper limit. The few times when the operators fail to reach this 130% is usually due to circumstances out of their control (e.g., breakdowns or missing material).

20.5 Is 130% the New 100%?

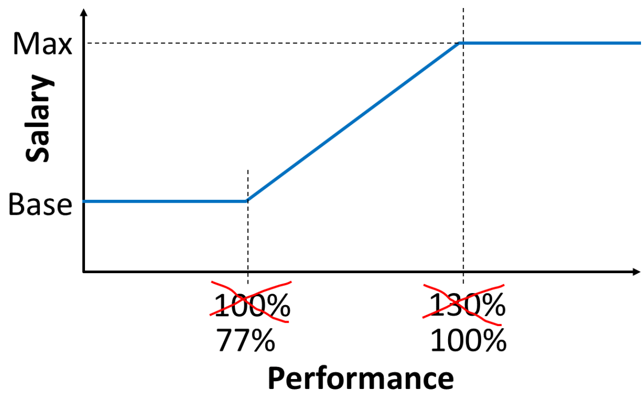


Figure 145: Performance Based Salary New 100 (Image Roser)

Okay. If workers are consistently able to achieve 130%, wouldn't it make sense to update the tables and times so that what was formerly 130% is now 100%?

We could even keep the salary at the same levels by not changing the graph. The worker would still get the same salary for the same work, as before, except the old 130% is now 100% and the old 100% is now 77%. Hence, there should be no difference in salary.

20.6 Reward vs. Punishment

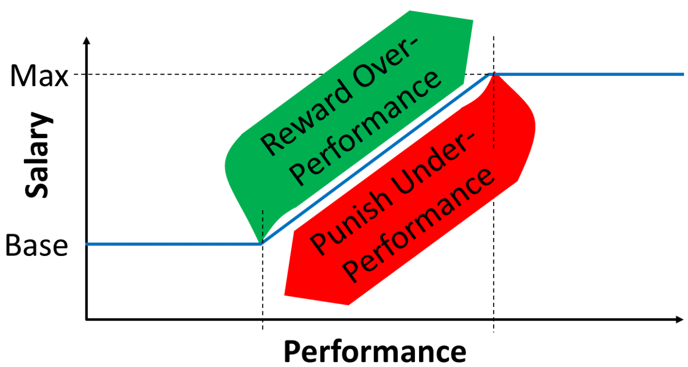


Figure 146: Performance Based Salary Reward Punish (Image Roser)

While there is no difference in salary regardless of which level you call 100%, there is a big difference in the view of the operators.

According to Herzberg's two-factor theory, there are some things that motivate (motivators), whereas other things don't motivate but have to be there to avoid demotivation (hygiene factors). In this view, money clearly is a hygiene factor. Giving more money will motivate only for a short time (around 3 months) before the effect vanishes. However, reducing the salary will undermine morale and demotivate an employee for a long time.

Hence, if you start with the old 100% and increase salary for performance up to 130%, you don't really get much motivation, but you don't demotivate either. However, if you start at the "*new*" 100%, and reduce salary if it is not reached, operators will be pissed. No matter that they get the same money as before. In one system it is seen as an increase, in the other it is seen as someone taking away their money.

20.7 For the Sake of Peace …

Figure 147: Peace dove (Image Elembis in public domain)

I am not sure how many managers are aware of the difference between the official 100% and the true 100%. Yet, even if you know, you would be well advised not to touch it. Readjusting the 100% will bring no benefit, but it will result in lots of demoralized employees. Hence, for the sake of peace, everybody pretends that 77% is actually 100%. You should keep in mind that it is most likely not, but you should not touch it if you can avoid it.

This post may have been a bit philosophical, but for me the main lesson is about **the effort and the pretense that goes into the workload targets from the employers' side**. The goal is that everybody can walk away from the work and money negotiation feeling good. It makes no difference money wise, but it makes a lot of difference for morale. So, **go out, motivate your people, and organize your industry!**

21 Using Lots of Effort and Money to Demotivate Your People

Christoph Roser, May 24, 2016, Original at https://www.allaboutlean.com/demotivate-case-studies/

Figure 148: Unhappy office People (Image mast3r with permission)

Motivation is a key aspect to success. This applies not only to individuals, but also to corporations. Since this is not really any new revelation, many companies put in quite a bit of effort into raising corporate morale. One popular morale booster is corporate events. It is difficult to make such events truly exceptional, but most companies manage to do at least a decent job. Others, however, produce just cringe-worthy results. Or, you could say they create a *night to remember*. Luckily for us, these are there for all to see on YouTube. Let's have a look!

21.1 Plante Moran 100 Dollar Gift Card

Figure 149: Plante Moran Logo (Image Plante Moran for editorial use)

Plante Moran is an accounting firm with over 2,000 employees. Some time ago they invited their employees to their annual conference to raise morale. The highlight of the event was a … drum-roll … **$100 gift card**.

Seriously?! I know that $100 is $100, but to make an entire event around it is overkill. But wait, it gets worse. Watch the video below. It is truly cringe-worthy. After the usual "*we could not have done it without you* " pep talk, they emphasize that the gift "*represents how big of a deal this really is […], something that shows how much all of your contributions are truly appreciated."* And, apparently their contribution is valued at $100.

Balloons fall from the ceiling, music plays, and selected people on stage cheer and hold up signs with "$100" and bags of money. And "*you get one, and you get one, and you get one, and and you get one, and we all get one.*" It is really hard to describe the condescending cringe, but if you watch the video, you know what I mean.

The Video by Stefan Hans is available on YouTube as "The Healthineers Song" at https://youtu.be/K5LiUrezV6k

21.2 Siemens Healthineers

Figure 150: Siemens Healthineers Logo (Image Siemens for editorial use)

The industrial giant Siemens is well known in the world. Up until recently, its healthcare division with 50,000 people was known simply as Siemens Healthcare. No more. Someone in marketing/management/elsewhere came up with a new name. It combines Healthcare, Engineer, and Pioneer into … drum-roll … **Healthineers**!

Now, Siemens is a German company. The people making the decision hence were probably not native English speakers. For them, words in a foreign language sound probably quite exciting, but for native speakers it just sounds weird. Yet, even in Germany many employees think "Healthineers" sounds more like a preschool than a technical enterprise. By the way, using foreign language also works the other way round. For example, the ice cream brand *Häagen-Dazs* was created in the Bronx, trying to make a Danish sounding name, even though Danish has no umlaut "ä". The difference is that *Häagen-Dazs* works, at least for me 🙂.

But, back to our Healthineers. Siemens decided to promote the new name through a company event. The highlight (and shown in the video below): A *Karaoke*-style song for everybody to sing along, together with dancers, in what the *Financial Times* called a "Spandex-clad horror." Except, the thousands of employees were not singing along. The reaction was more a shock. While a few employees liked it, the vast majority was flabbergasted. It did help with team-building – as everybody mocked the new name. Overall, it looked like straight out of a Dilbert strip.

The original video was taken down after a lot of negative press, but another video popped up soon thereafter. Below is also a short excerpt of the text for you to enjoy.

> …
>
> *We are innovators, a family of friends,*
>
> *We are Healthcare Pioneers*
>
> *We are We are We are Healthineers*
>
> *We are We are We are Healthineers*
>
> *One Mission, One Vision, One Focus, One Name*
>
> *We are we are we are Healthineers*
>
> *Oho Oho Oho Oho Oho Oho Oho Oho*
>
> …

21.3 General Singing, Dancing, and Silly Games

There are more examples out there. For example, two executives of the Bank of America sing a song by U2 but change the lyrics to "**credit cards**."

The Video by thelookmachine is available on YouTube as "Bank of America sings U2's One" at https://youtu.be/0qAuqq1LFnU

Ernst & Young abused the gospel song "*Oh Happy Day*" from Edwin Hawkins with changed lyrics about – you guessed it – Ernst & Young! ("*Oh happy day … when Ernst & Young … showed me a better way*").

The Video by Denise Fezza Beall is available on YouTube as "Ernst & Young 'Oh Happy Day!'" at https://youtu.be/MaIq9o1H1yo

Semiconductor Company Qualcomm did a keynote presentation at the CES 2013 (Consumer Electronics Show). They tried to come across as hip, young, and modern, but the three actors looked more like a parody ("*Dude,*" "*Chill,*" "*Can you dig it?*" etc.). The video is quite long, but the interesting bits are in the first five minutes, until the CEO appears.

Now, don't get me wrong, I have no problem if people like to sing and dance. On (very rare) occasions I have done it too. But being forced to do so at work just leaves a bad aftertaste. It is also my impression that only a minority of employees enjoy this kind of activity at company events. Yet, I have also personally witnessed this *mandatory fun* myself.

In a normal company, only a small fraction of the employees are highly enthusiastic about their job. A larger part like their work, but don't love it. And a third group do it only for the money, and may even hate the company. Hence, such kind of *mandatory fun* is likely to reach only a few people while having the opposite effect on most others. Furthermore, in my experience, top executives usually vastly overestimate the enthusiasm of the employees for the company. Yet, a few phrases on "*being a team*" or "*valuing the employee*" do not raise morale. Most employees have lots of experience in seeing through this bullshit bingo.

Hence, if you work with people, stay sincere, give true respect, and put your money where your mouth is. Your people will be much happier than with any expensive Spandex karaoke song. So **go out, motivate your people, and organize your industry!**

P.S.: This post was inspired by a discussion on Reddit on how Siemens embarrasses 44,000 employees with new "Healthineer" mandatory dance concert.

22 The Relation between Inventory, Customer Takt, and Replenishment Time

Christoph Roser, May 31, 2016, Original at https://www.allaboutlean.com/inventory-customer-takt-replenishment-time/

Figure 151: Kid with Glasses (Image Robert Kneschke with permission)

Inventory is helpful for a fast delivery of goods. If you have it in stock, you can deliver to the customer right away. In that respect, more inventory is better. Yet, at the same time, inventory creates cost, some visible, some more hidden. Hence, one of the goals of lean is to reduce inventory and therefore reduce cost. During my research I stumbled on a very interesting relationship between inventory, customer takt, and replenishment time. Let me elaborate …

22.1 The Variables

Before I go into detail, I first want to clarify what I am talking about.

22.1.1 Inventory

Figure 152: Inventory (Image Axisadman under the CC-BY-SA 3.0 license)

Inventory should be pretty clear. It is all the goods you have, both finished and unfinished. When looking at the relation between inventory, replenishment time, and customer takt, I focus on the work in progress and the finished goods inventory for a certain product.

22.1.2 Replenishment Time

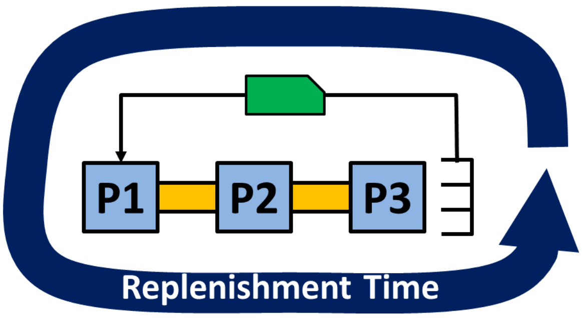


Figure 153: Replenishment Time (Image Roser)

Replenishment time is the time needed to replenish a part. This does not mean when the next part comes down the line, but instead how long it takes for a work order to come back with a part.

22.1.3 Customer Takt

Figure 154: Metronome (Image Vladimir Voronin with permission)

The customer takt (or takt time) is one of the fundamentals for determining the speed of a production system. It represents the average demand of the customer during a time period. You simply take the working hours for a process or line over a given time period, and divide it by the number of parts ordered by the customer during this period. The result is the customer takt measured as a time per part.

22.2 Theoretical Approach

To get a better understanding, let's start with a theoretical approach. Assume you have one product that sells very, very infrequently (i.e., you have a very large customer takt). Yet, if you want to be able to deliver to the (rare) customer without delay, you need to have at least one of these products in stock. If the customer wants a product, you give him the one in stock, and then reproduce to increase your stock again to one piece. Hence, your inventory over time may look something like the image below.

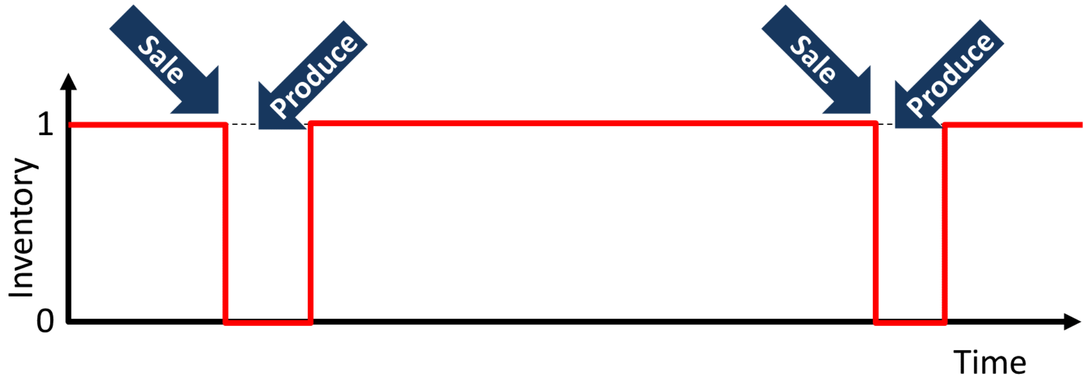


Figure 155: Sale and reproduction at low Demand (Image Roser)

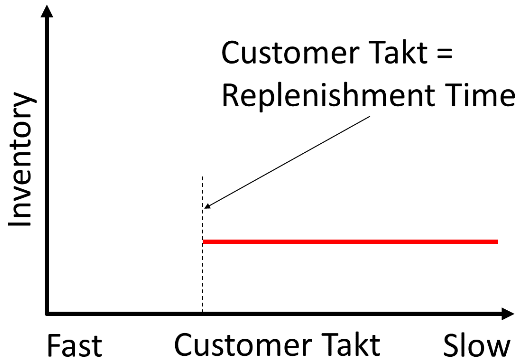


Figure 156: Customer Takt Inventory (Image Roser)

It makes no difference in inventory if your customer takt increases or decreases. As long as you can reproduce faster than the customer takt, you (theoretically) need only one unit in inventory for a near 100% delivery performance.

However, it starts to make a difference if your customer takt becomes faster. At one point the customer wants parts faster than you can replenish within the replenishment time. Hence, even though your system can produce enough parts per minute (i.e., the cycle time or, similarly, the line takt), a new work order takes too long before the customer is back asking for more (the replenishment time is larger than the customer takt).

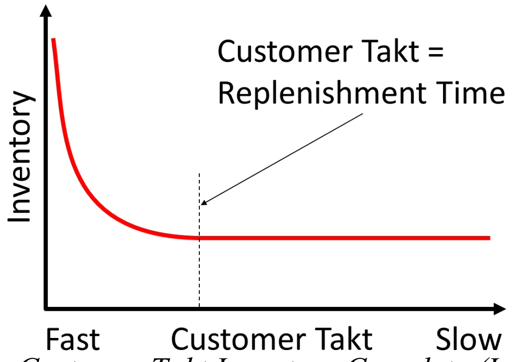


Figure 157: Customer Takt Inventory Complete (Image Roser)

The solution is simple: you increase your inventory. You put multiple units in inventory so the customer can receive a part right away, and multiple work orders are in the queue to replenish. Theoretically, your required WIP would be the ratio of the replenishment time to the customer takt (ignoring variation and fluctuations for now). This relation can also be found in the kanban formula.

$$Inventory = Roundup\left(\frac{Replenishment\ Time}{Customer\ Takt}\right)$$

22.3 Simulation Verification

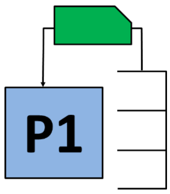


Figure 158: One Process Kanban Loop (Image Roser)

To test the relation, we used a simple simulation. We had a single process in a pull production system that was able to produce a part every 9 time units (Pearson-Type-V distributed with α = 4.7778 and β = 34.000). A part was sold to a customer on average every 10 time units (exponential distributed), and the simulation ran for a total of 100,000 parts.

To verify the customer takt without changing the system performance, we produced two part types, with 100,000 in total for each run. We changed the ratio of the part types. For example, we had a simulation with 10 parts A and 99,990 parts B, a simulation with 10,000 A and 90,000 B, and so on. We experimented with different inventories (or number of kanban), and compared only systems of similar delivery performance.

The results are shown in the graph below for different delivery performances of 99.99%, 98.6%, and 97.2% delivery performance. It is stunning how well they fit the theoretical line (shown in black). Please note that the difference in appearance to the diagram above is that here both axes have a logarithmic scale, since otherwise everything would be squeezed too much into a corner. In any case, the simulations have a constant average inventory of around 1 if the customer takt is larger than the replenishment time, and an inventory that increases indirect proportionally with the customer takt if the customer takt is smaller than the replenishment time.

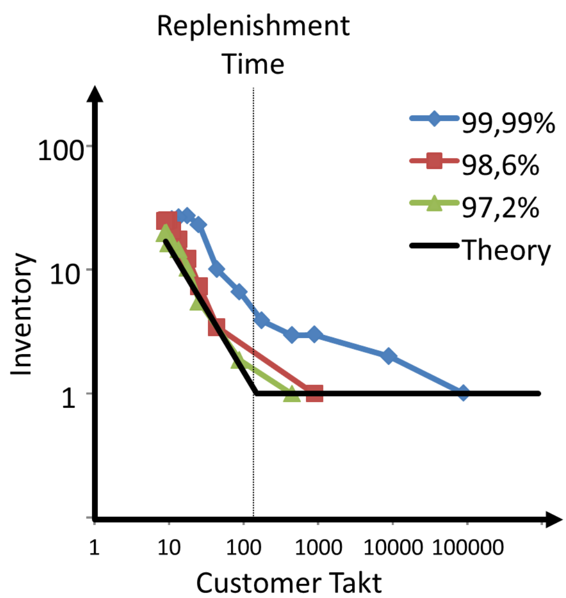


Figure 159: Customer Takt Inventory Data (Image Roser)

You can also see it the other way round. The graph below shows the relation between the number of units sold and the inventory needed for each unit sold. Again, you see the same relationship, with the bend where the customer takt matches the replenishment time.

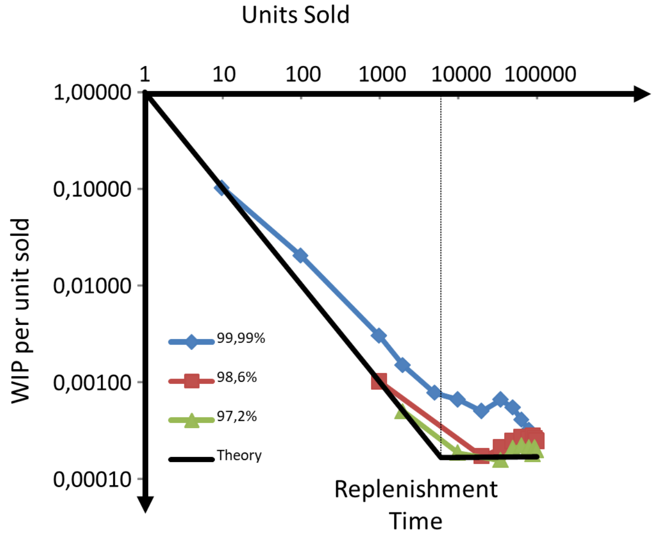


Figure 160: WIP per part over quantity Inventory Data (Image Roser)

22.4 What Does This Mean?

Overall, the deciding factor is the ratio of the replenishment time and the customer takt.

- If the customer takt is faster than the replenishment time, inventory goes up proportionally to the units sold, but the inventory per unit sold stays constant.
- If the customer takt is slower than the replenishment time, inventory stays constant, but the inventory per unit sold goes up linearly.

Hence, this relation can help you to estimate the inventory needed.

$$Inventory = Roundup\left(\frac{Replenishment\ Time}{Customer\ Takt}\right)$$

- If the customer takt is faster than the replenishment time, your recommended inventory is the replenishment time divided by the customer takt (plus a safety margin).
- If the customer takt is slower than the replenishment time, your recommended inventory is 1 (plus a safety margin).

Now, you could think that you can reduce your inventory by reducing the replenishment time. Theoretically correct, but practically a bit more difficult.

You could reduce your replenishment time by creating multiple kanban loops. However, the inventory in question applies to a single kanban loop. Hence, your inventory would not change much; it would merely be distributed across two kanban loops. See also my post Supermarket vs. FiFo – What Requires Less Inventory?

You could reduce replenishment time by reducing inventory in the kanban loop. This, of course, would reduce replenishment time. But overall, you would reduce your inventory by … reducing your inventory. It is still worthwhile, though!

I found this relation between customer takt, replenishment time, and inventory quite interesting. I hope it was interesting for you too. In my next post I will discuss how this influences the relationship between the number of variants and the inventory. In the meantime, **go out and organize your industry!**

22.5 Data Source

Meier, Hauke. "Analyse des Zusammenhangs zwischen Variantenvielfalt, Lagerbeständen und Lieferbereitschaft." Master Thesis, Karlsruhe University of Applied Sciences, 2016.

23 How Product Variants Influence Your Inventory

Christoph Roser, June 07, 2016, Original at https://www.allaboutlean.com/product-variants/

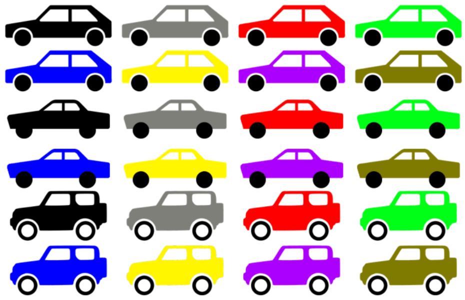


Figure 161: Array of cars (Image Roser)

The sales & marketing department often aims to create more and more product variants to target even the smallest niche in the market. Yet, it is common wisdom that more variants also mean more inventory.

However, the relation is not quite as clear cut. In my last post I wrote about the Relation between Inventory, Customer Takt, and Replenishment Time. The relation is similar for variants, and it all depends on the ratio of the customer takt to the replenishment time.

23.1 The Conflict of Interest between Sales and Manufacturing

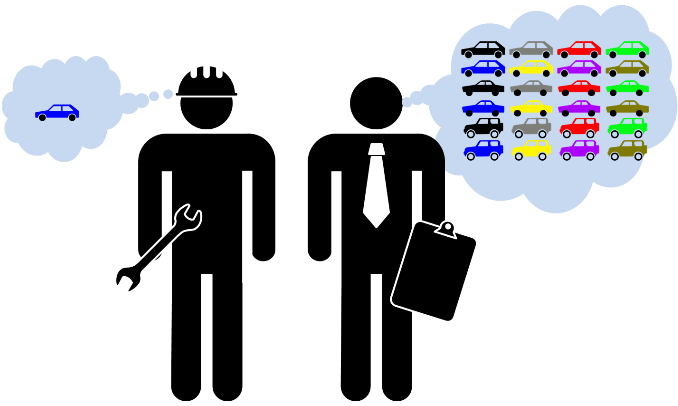


Figure 162: Sales and Manufacturing Dream (Image Roser)

There is often a conflict of interest between sales and manufacturing. Sales would like to sell as many products as possible, and ideally would like to have a product for every market niche so no potential customer will be missed.

Manufacturing, on the other hand, wants to produce as quickly, easily, and efficiently as possible. Ideally, manufacturing would like to have one and only one product, since that can be made most efficiently.

Obviously, a successful company is interested not only in quantity of sales or cheap manufacturing, but also (and most of all) in profit. Hence, aiming at every market niche but losing money with every sale is not good. Similarly, producing very efficiently but having no market share worth mentioning is not good either. A trade-off is needed.

In this post I will look in more detail at one aspect of this trade-off. How does your inventory change if you change the number of variants produced? Common wisdom is that more variants usually means more inventory for the same quantity sold. That wisdom is true, but let's back it up with data.

23.2 Theoretical Approach

I explained the theory in detail in my [last post](). The inventory is directly related to the replenishment time over the customer takt, rounded up (and, in reality, you should also have a bit more to consider variation and a safety margin).

$$Inventory = Roundup\left(\frac{Replenishment\ Time}{Customer\ Takt}\right)$$

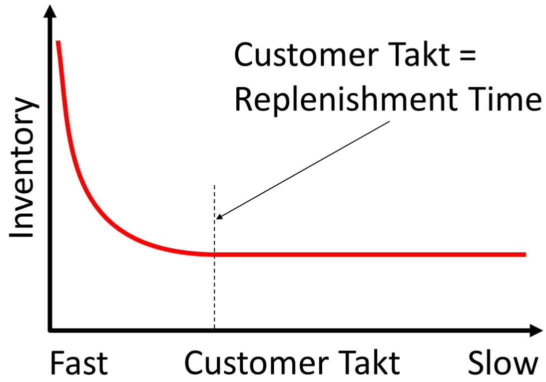


Figure 163: Customer Takt Inventory Complete (Image Roser)

Overall, this will give you a relation for one product as shown in the graph. The inventory is constant if the customer takt is larger than the replenishment time, and increases if the customer takt is faster than the replenishment time.

23.3 Simulation System

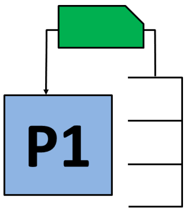


Figure 164: One Process Kanban Loop (Image Roser)

The theory has been tested using the same simulation data as in my [last post](), using a simple system with one process.

Assume we sell a total of 100,000 items in a year. Now, we could sell all 100,000 items of only a single variant. For example, we produce 100,000 of one variant, or 50,000 of two variants, or 10,000 each of 10 variants, and so on down to 10 items each of 10,000 different variants. We always look at the total inventory necessary for systems with similar delivery performance (99.99%, 98.6%, and 97.2%).

23.4 Simulation Results

As mentioned above, the defining element is the ratio between the replenishment time and the takt time. The graph below shows the simulation data and also the theoretical expected value, comparing the total inventory with the total number of variants. Please note that both axes use a logarithmic scale.

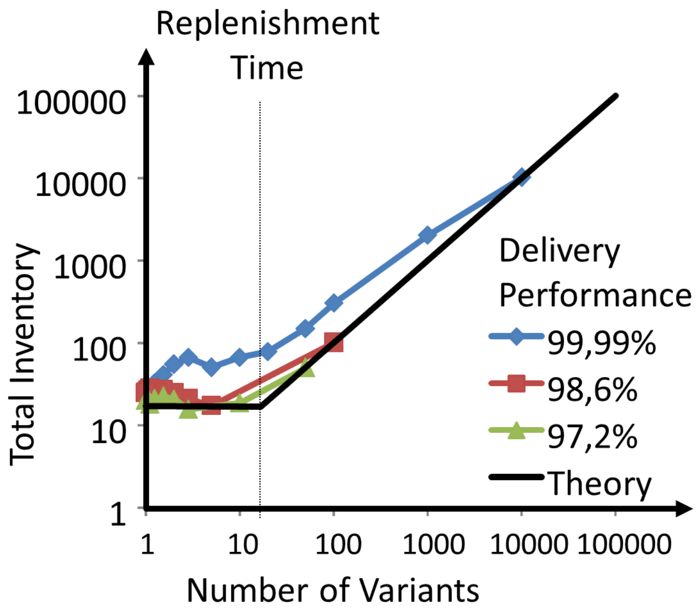


Figure 165: WIP over Variants Data (Image Roser)

The vertical dashed line shows where the customer takt equals the replenishment time. To the left of this line, **the inventory stays the same regardless of the number of variants.** To the right of this vertical dashed line, however, **the inventory increases with the number of variants.** Naturally, for a higher delivery performance, you need a higher inventory to account for random fluctuations.

23.5 How Do Variants Influence the WIP?

As above, the behavior of the WIP based on the number of variants differs depending on the customer takt and the replenishment time.

- If the replenishment time is faster than the customer takt for an additional variant, then this additional variant WILL increase the inventory.
- If the replenishment time is slower than the customer takt for all additional variants, then these additional variants WILL NOT increase the inventory.

I think this is quite an insight that I have not seen anywhere before. Especially, the distinction of the customer takt being larger or smaller than the replenishment time is new and original research.

This means that you can increase the number of variants with little WIP penalty, as long as the customer takt is faster than the replenishment time. However, if your customer takt is slower than the replenishment time, then additional variants will punish you with larger inventories, whereas reducing variants will also reduce your inventory. In sum, **you should eliminate variants if the customer takt is slower than the replenishment time!** At the same time, **you can introduce additional variants without inventory penalty as long as the variant sells often enough that the customer takt is faster than the replenishment time.**

Of course, this looks only at inventory. There are more costs for additional variants. For example, the cost of complexity goes up. You have to stock more and different materials, which increases the work associated with maintaining the material. At the least, you may have to issue two purchase orders when one was enough before. You also have to train your employees in producing these additional variants, and you have to introduce new part numbers. Don't forget development cost for the new product either!

Also, as for the part numbers, it is estimated that in the automotive industry, an additional single part number will cost around $50,000 over lifetime. For less "rigorous" products like a fridge or washing machine, a new number will still cost around $8,000 over lifetime. So, even if there is no additional inventory, there is still cost associated with every new variant.

Hence, go out, reduce the number of variants, and organize your industry!

23.6 Data Source

Meier, Hauke. “Analyse des Zusammenhangs zwischen Variantenvielfalt, Lagerbeständen und Lieferbereitschaft.” Master Thesis, Karlsruhe University of Applied Sciences, 2016.

24 Tales from Japan – Lean in the Japanese Public Toilet

Christoph Roser, June 14, 2016, Original at https://www.allaboutlean.com/japanese-public-toilet/

Figure 166: Japanese Toilet Sign (Image Roser)

Whenever I am in Japan, I look for examples of lean behavior visible to the public (see, for example, Japanese Standard Pointing and Calling). This time I would like to talk about **Japanese public toilets** and all the nifty features to make their use a pleasant experience. You will be surprised how much thought goes into public toilets in Japan. The same level of attention to detail is also something necessary for good lean implementations. Japanese public toilets in particular do a great job servicing the not-average user!

24.1 Introduction

Figure 167: Multi Gender Toilet Symbol (Image Roser)

There is currently much discussion about public toilets in America. As far as I understand it, women who look too manly or have short hair … now have to use the men's bathroom … or something … I guess …

I think I don't really understand the problem. It seems to be a solution in desperate search of a problem. Personally, I think public toilets are, more than anywhere else, a place to mind our own business. In any case, let's look at the Japanese toilet.

24.2 The Entrance

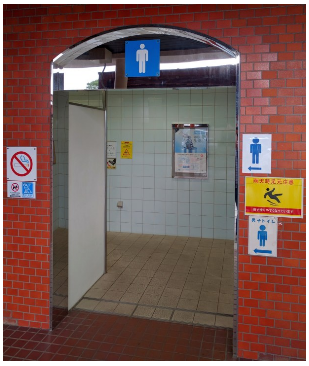


Figure 168: Kyushu Public Toilet Entrance (Image Roser)

The first thing is the entrance area. The picture here is from a rest stop in Kyushu, but its features are common for many public toilets in Japan. (Click on any image for a larger version.)

Of course, there are the different labels. No smoking, no (uncaged) animals except service animals. Beware of the slippery floor. I find it neat that they did not forget to admit service animals like guide dogs. While only a small part of the population have a service animal, it is important for them.

The most important feature, however, you probably may have missed. In fact, the feature is the absence of something. There is no door! **You can walk in and out without touching a door handle!** Consider that in the USA, only 66% of people wash their hands after the toilet – and even fewer are using soap – and you will be glad to avoid this door handle. The percentages in Japan are even lower. There is of course still a door handle for the toilet stall, but this is behind the sink area and you can wash your hands on the way out (please do!).

24.3 The Toilet Map

Figure 169: Kyushu Public Toilet Map (Image Roser)

Another neat feature is the toilet map. It gives you a detailed overview of the features of the restroom, and where to go for what. It starts with your present location, and tells you where to find the urinals and the washbasin. It also shows where you can find Japanese squat toilets and Western toilets (more below). Of course, for an average person it may not be necessary, as few people get lost in public toilets.

However, not everybody has "*average*" toilet needs. For example, if you are blind, it may be much more difficult to find your way around a restroom. Did you notice the braille on the map? Also, the map locates the baby changing areas, baby seating areas, and the handicapped stall. It also tells you where you can find the ostomy toilet (more below). All of this is very helpful if you are actually in need of any of these special features.

Figure 170: Haneda Public Toilet Map (Image Roser)

Here's another example of a toilet map from Haneda airport. Naturally, here you can find the ostomy toilet. Children's urinals are also indicated. A neat feature – especially for an airport – is the changing board. It is a small board that can be flipped down for you to stand on when you change in fresh clothes. After all, you don't really want to stand on the floor of a public toilet in your socks! Finally, a multi-purpose bed is also provided for disabled persons with a helper.

This map is missing the braille, but did you notice the little speaker below the sign? There is, in fact, **audio guidance for the toilet!** The blind are not forgotten here either. (Update: I took a video of the voice guidance and added subtitles, just in case you want to feel your way around the toilet in Haneda airport blind …)

The Video by AllAboutLean.com is available on YouTube as "Voice Guidance for Public Toilet in Japan (with subtitles)" at [*https://youtu.be/SRm0MC-eG8U*](https://youtu.be/SRm0MC-eG8U)

24.4 Waiting in Line

Figure 171: Kyushu Public Toilet Wait Here (Image Roser)

On this one, I am uncertain if it is over the top or not, but they have a floor indicator for where to wait if all stalls or urinals are occupied!

This is again very much aligned with the lean principles of getting your "*material*" flow organized. However, in this case I am not sure how much this floor indicator is actually used.

In any case, did you notice that the indicator is part of the tiles, and not merely a sticker? This means that this indicator was planned beforehand and installed when they built the toilet.

24.5 Toilet Stall Equipment

Figure 172: Kyushu Public Toilet Western (Image Roser)

Here you see the equipment in the toilet stall. You find a fancy toilet with backrest, handicapped railings, a children's toilet seat (with terrycloth cover), a sink, soap, toilet paper on either side, toilet brush, wastebasket, and controls for the space-age features of the toilet (see below). Again, this exceeds by miles what I have experienced in toilets in the rest of the world.

24.6 Ostomy Toilet

Figure 173: Kyushu Public Toilet Ostoma (Image Roser)

Most public toilets in Japan are also prepared for people with colostomy. A colostomy is a medical procedure where a doctor diverts the intestines to the midsection (e.g., in the case of colon cancer). The waste goes into a plastic bag that needs to be changed.

Similar procedures are also done for the bladder, and both are known as ostomy. The ostomy toilet shown includes a special flushable sink, hot and cold water, soap, a mirror, and toilet paper.

Figure 174: Haneda Public Toilet Ostoma (Image Roser)

Hence, ostomy toilet procedures differ markedly. Having only a normal toilet can be quite a pain in the … midsection. While only a small part of the population have an ostomy, for them it is quite important.

Here's another ostomy toilet, this time from Haneda, with similar features except for a shower head instead of a faucet.

24.7 Traditional Japanese, Western, and Space Age Toilets

Figure 175: Japanese Squat Toilet (Image 浪速丹治 under the CC-BY-SA 4.0 license)

Japanese distinguish typically between two types of toilets, but in fact there are three. First, there is the traditional squat toilet. They are still popular, and supposedly have medical benefits from squatting. (There is a great related video of an [unicorn pooping rainbow ice cream] explaining the concept, if you're curious. Please note that this is not an endorsement by me, as this is waaay outside of my expertise.)

Figure 176: Japanese Toilet Bidet (Image Chris 73 under the CC-BY-SA 3.0 license)

The other official type of toilets are Western toilets. Yet, while there are typical Western toilets in Japan, most Japanese "*Western*" toilets are rather space age. These washlets include a cleaning system that washes your behind, or your front (females only) with a nice stream of warm water. Temperature, pressure, vibration, and oscillation can often be adjusted. An integrated blow drier makes this truly a paperless toilet. And don't forget the integrated seat heating!

While this sounds odd if you have never used it, it is in my view a great feature (read the excellent Wikipedia article Toilets in Japan if you want to know more). In Japan, almost all newly installed toilets nowadays are these space-age washlets, even for public toilets. I even found them on Japanese aircraft.

24.8 Nice Touches

Figure 177: Kyushu Public Toilet Sink Area (Image Roser)

There are also some additional nice touches. The sinks in the highway restroom, for example, included flowers – real ones, not plastic!

Figure 178: Haneda Public Toilet Janitor (Image Roser)

The janitor schedule is usually shown, sometimes even with name and number to call in case of problems.

The Haneda Airport Toilets shown in some of the images above even have their own website, detailing the available services: Haneda Airport Facilities Listing.

Overall, Japanese toilets are very well prepared to serve the needs of all of their customers, not just the average John (or Jane) Doe. This deep level of planning, preparing, and organizing is also something I see in good lean implementations.

And, mind you, these are average public toilets in Japan. While of course there are still some (literal) shit holes, most public toilets have a lot of features that exceed what I am used to in other countries. Hence, the photos above are not really hand-picked toilets, but just facilities that I came across and took pictures of (trying very hard not to look like a pervert with a camera in the bathroom).

Hence, for your shop floor, try to think about what people need, not only normally, but also in special situations. The smoother and faster your team can resolve problems, the better your productivity will be. Hence, I hope this post gave you some inspiration (which often comes on the toilet anyway). **Now go out, use that inspiration, and organize your industry!**

PS: After writing this post Katie Anderson pointed out a similar post of hers on the same topic, where the occupation of the stalls was visible by green and red lights at the toilet map.

25 What Is "Just in Time"?

Christoph Roser, June 21, 2016, Original at *https://www.allaboutlean.com/what-is-just-in-time/*

Figure 179: Just in time … (Image tableatny under the CC-BY 2.0 license)

Just in Time (or JIT) is a powerful method to reduce costs and increase efficiency. However, it is also very difficult to achieve. Most times when a Western company tells me it does JIT, it turns out that this is merely wishful thinking. Let me tell you what JIT really is. I will also talk a bit about the history of JIT. Finally, I will show you a few negative examples of wishful thinking common in modern industry. In my next posts I will go into more details on how to make it work.

25.1 Historical Background

Figure 180: Kiichiro Toyoda (Image unknown author in public domain)

The idea of Just in Time originated with Kiichiro Toyoda (1894–1952), founder of the Toyota Motor Company. During a trip to England, Toyoda missed a train. The train was on time, but Toyoda was slightly late. This had him thinking about analogies for material. Material arriving too late is obviously bad, as it causes stops and delays. However, material arriving too early is also bad, as it increases material. Hence, the material had to arrive *just on time*. Combined with a grammatical error, this is now the famous **Just in Time (JIT)**, first mentioned at Toyota around 1936.

However, having the idea is one thing; creating a successful implementation is another. This can be credited to the Toyota employee and mastermind behind the Toyota Production System, Taiichi Ohno.

Figure 181: Taiichi Ohno (Image unknown author in public domain)

The experience of Ohno and Toyota during World War II probably helped too. The company was constantly plagued by material shortages, and having unused material sitting around while they lacked other materials was especially painful. In combination with pull, kanban, and many other things, Ohno successfully managed to reduce inventories. This also included the use of Just in Time.

The Western world became curious about the success of Toyota only after the 1973 oil crisis, which hurt many Western car makers but not Toyota. A large study and the resulting bestseller The Machine That Changed the World showed that Japanese car makers were indeed far superior in cost and quality. This started the whole *Lean Production* wave.

The topic of JIT in particular started to take off around 1980 but reached its peak in 1990. Since then it has been still present but is less frequently mentioned in publications. The Google Ngram graph below shows the occurrence of JIT in English Literature over time, and the 1990 peak is clearly visible.

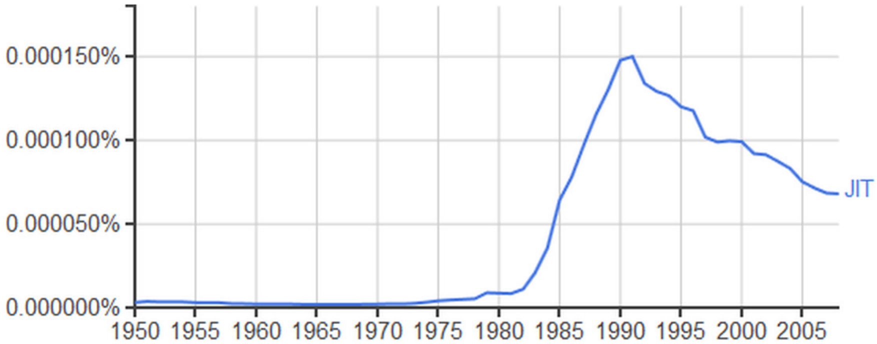


Figure 182: JIT Ngram (Image Roser)

25.2 What Is Just in Time?

In its pure theory, **Just in Time is a method where material arrives just on (in) time when it is needed.** This is valid both for purchased or delivered material and material processed on site. Ideally, the moment a worker needs a part, it should arrive right where he needs it.

This is of particular interest for value-adding process in the material flow. Of course, non-value-adding processes also benefit from JIT, although the benefit for the actual manufacturing processes are a bit bigger. In any case, you should work on reducing and eliminating non-value adding processes (a.k.a. waste).

However, the material arriving Just in Time is only half of the story. The other half is often missed. The material also has to depart on time. Hence, in a perfect JIT world, all material would be either in transport or currently worked on. There would be no idle inventory anywhere.

Figure 183: Uh-oh… (Image tableatny under the CC-BY 2.0 license)

But, back to reality. We do not have a perfect world. Even for good companies, there are small inventories needed to buffer fluctuations. Working without any buffer inventories will cause delays in the machines, even for good companies. The important part is that inventories between processes should be reduced, and JIT does not only require an arrival on time but also little waiting times for material between processes.

25.3 How Little Material Do I Need for Just in Time?

JIT is reduction of material in the supply chain, with particular focus of the material arriving just when it is needed. Yet, it is almost impossible to truly hand over the material just at the moment when the worker needs it. Even good companies have small inventories at the manufacturing location, and other small inventory buffers at different points along the supply chain. So, **how little do you need to call your process JIT?**

Unfortunately, there is no clear answer. Nobody has defined when you are JIT. **In my view, if you have more than a day's worth of material at the plant, then you are probably not JIT.** But, if another company wants to call its month's worth of inventory "Just in Time," there is nobody who can stop them from doing so (although I would strongly disagree!).

25.4 Why Just in Time Is Useful

Just in Time primarily reduces inventory. This reduction in inventory then reduces cost. Factors relevant here are, for example, less tied-up capital, less handling, less storage cost, less administrative overhead for inventory, and less scrapping or obsolescence (see The Hidden and Not-So-Hidden Costs of Inventory). However, there are two derived benefits from reduced inventory trough JIT that I would like to especially point out.

25.4.1 Faster Reaction

Figure 184: Tortoise and Hare (Image cynoclub with permission)

In my view, one of the two big benefits of JIT and the resulting reduction of inventory is the reduced lead time and hence the reduced response time. With less inventory, your ability to react to changes will improve drastically. The direct linear relation between inventory and lead time is defined by Little's law. If you reduce your inventory by half, your lead time goes down by half too.

Product design changes will progress through the system faster, defects will be detected earlier downstream, production plan adjustments can be reacted on faster, and so on. Overall, this is one of the big benefits of JIT. Yet, this is the more difficult part where your material has to both depart and arrive on time.

25.4.2 More Space in Manufacturing

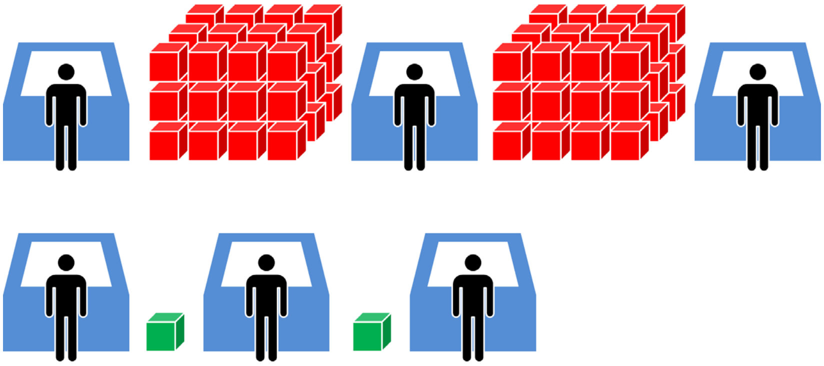


Figure 185: Inventory between Processes (Image Roser)

The other big benefit of reduced inventory is the reduced storage space. While this sounds obvious, there is an interesting twist to it for JIT. Let's assume you have a large pile of material. You could store it in a dedicated storage area, or you could store it right next to your manufacturing processes. While it would be convenient for logistics to have the material right where it is needed, it would be better to store your material elsewhere.

The combined cost of storing material is not equal everywhere. The closer you get to the manufacturing processes, the more precious your floor space becomes. The less material you have at manufacturing, the closer together you can place your processes. This is good for efficiency. If you have large piles of material around your processes, then the processes have to be farther apart. Workers have to walk more, material has to be transported farther, information flow is slowed down, and so on.

With JIT, you can reduce the inventory, especially around the processes where space is most valuable. Best of all, for this it is enough when the part arrives just on (in) time. It does not matter when the part departed. You do not need to reduce inventory along the entire supply chain, but only at the last stop where the material is consumed. The benefit of reducing inventory around your machines and processes can also be achieved simply by storing the material elsewhere, without an overall reduction in material. Of course, reducing inventory still has lots of other benefits and is usually worthwhile.

25.5 How Not to Do It

Figure 186: Business fraud (Image Brian Jackson with permission)

Just in Time is popular (although slightly declining since 1990). Hence, lots of companies want to do it. Unfortunately, implementing JIT is quite difficult, as explained in my next post. It is much easier to do some pretending.

Some companies outright call their inventory JIT and are done with it. At a public tour of a large automotive manufacturer, we went through large halls stuffed to the roof with materials, while the guide casually remarked, "*This is our JIT inventory.*"

Another company used a third-party warehouse across the street. Most of the material was stored in this warehouse. Since, officially, it was not yet their material, it wasn't even counted as inventory, even though the whole expense was forwarded to the company through the purchasing price. Their ability to get material from across the street was then called JIT, even though this usually required a *three-day* notice beforehand.

Overall, JIT is quite powerful, bringing all the benefits of reduced inventory, especially at the critical manufacturing processes where space is at a premium. Unfortunately, while it is easy to claim to be JIT, it is much more difficult to actually get it working. In my next posts I will go into more detail on the different ways to move toward JIT. In the meantime, **go out and organize your industry!**

26 How to Make "Just in Time" Work – Part 1

Christoph Roser, June 28, 2016, Original at
https://www.allaboutlean.com/how-to-just-in-time-1/

Figure 187: Just in time (Image Sunday Truth in public domain)

Just in Time (JIT) is the delivery of parts just when you need them. In my last post I explained what JIT is all about. In this post (and the next one) I will go into much more detail on different measures you can take toward JIT. But be warned, most of them are not easy, either in implementing or in convincing cost accounting about it beforehand.

26.1 What Do I Need for Just in Time?

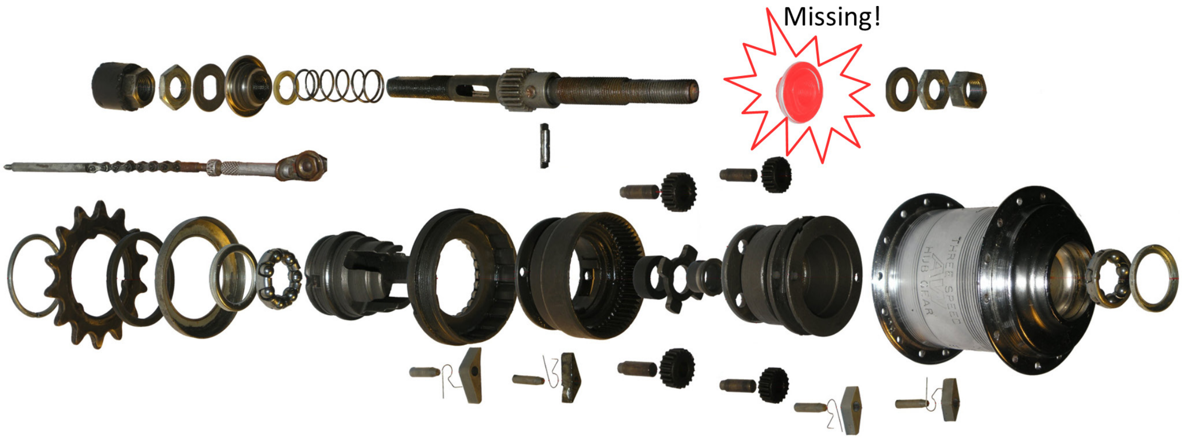


Figure 188: One piece is missing… (Image Keithonearth under the CC-BY-SA 3.0 license)

How do you get JIT? The English Wikipedia has (at the time of writing) a JIT list that looks like just about anything related to lean. While all benefit somehow, I would like to go into more detail.

Unfortunately, achieving JIT is the difficult part. You see, inventory serves a purpose. One of the main reasons we have inventory is to decouple fluctuations. If you just reduce inventory without reducing the fluctuations, you will actually increase inventory, since more material is waiting for a few missing parts.

Hence, for JIT you have to reduce fluctuations. For JIT in particular, there are a couple of measures that you can take (although all of them are quite a bit of work).

26.2 Smaller But More Frequent Deliveries

Figure 189: Big and Small Truck (Image Roser)

One of the easier ways to approach JIT is to make smaller but more frequent deliveries. Instead of one truck per week, can you do one truck per day (or less).

You can probably already hear the outcry from cost accounting about the additional expenses. Yes, more deliveries may cost a bit more. However, the benefit of reduced inventory is usually worth it. The problem with cost accounting is that you can calculate the expenses very easily, but it is hard to put a number on the benefits.

Figure 190: Maybe a too-small lot size for your supply chain? (Image Uwe Aranas under the CC-BY-SA 4.0 license)

Hence, you could use smaller trucks and have them arrive more often instead. Of course, this cannot be sized down indefinitely. If you deliver every part separately with a scooter, then it probably will no longer be worth the benefit. In fact, even at Toyota I see most parts arriving in a mid-sized truck.

Please note that there is no point to have deliveries smaller than your lot size in production. Hence, JIT benefits also from small lot sizes and one piece flow in production.

26.3 Supply Milk Runs

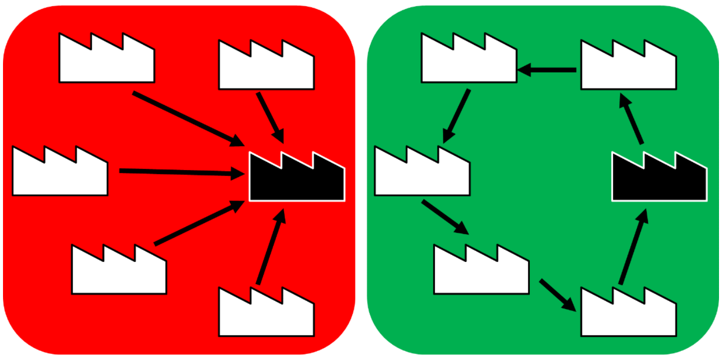


Figure 191: Hub and Spoke vs Milk Run (Image Roser)

The next option to reduce your delivery size and increase you frequency (besides Pizza scooters ☺) is a change in the delivery structure. Instead of a hub and spoke system where a truck originates at every supplier, you could have a milk run (i.e., a truck that visits multiple suppliers in sequence and picks up their parts).

Of course, this works only if the suppliers are close to each other. After all, the travel time increases. If you increase the travel time too much, then the quantity of material on the road due to the long trip will be more than what you saved through smaller deliveries.

Here again, Little's law is true. If you double the trip duration, you automatically double the material on the road. In this case you would need to at least half the delivery quantity for each part in order not to make it worse. However, if you can half your delivery quantity with only a slightly longer tip duration, then it will be worth it. All of this depends on how close the suppliers are to each other.

26.4 Use Clusters of Suppliers

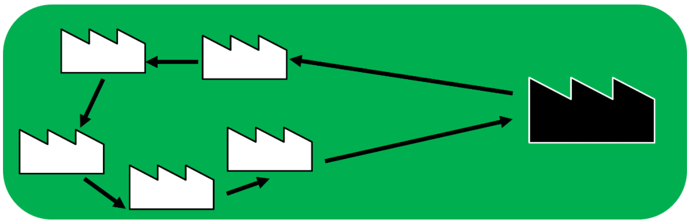


Figure 192: Supplier Route Cluster (Image Roser)

The additional time needed for a supply milk run depends not so much on how far away the suppliers are from you (although this is relevant for another aspect as detailed in the next section). The additional time depends more on how close a group of your suppliers are together, or at least if there are some suppliers along the route to other suppliers.

Hence, try to find groups of suppliers so you can visit multiple suppliers on a single route without incurring too much additional trip duration.

26.5 Use Local Suppliers for Fast Reactions

Figure 193: Short Long Distance Delivery (Image Roser)

While it is good to have clusters of suppliers, it is even better when you are at the center of this cluster. The closer you are to your suppliers, the less material you need. Here again, Little's law is valid. If you get your goods shipped from China, then they are en route for two to three months (including customs and all). Hence, you need two to three months of additional material that is making a tour of the world.

Being closer to your suppliers requires much less material for your supply chain. Even better, this gives you a faster reaction to changes. For example, most Japanese suppliers of Toyota are within a 100-km radius around Toyota city. For foreign plants too, Toyota tries to convince suppliers to establish a subsidiary nearby. In the case of seats, they even want to have the supplier on site, so the seats arrive just in time and just in sequence.

Another company, Inditex, better known for the clothes brand Zara, produces for the European market mostly in Europe. Despite the higher labor cost, they are successful. They have new items in stores while the competition is still loading in Shanghai. They need only one week from design to sale, whereas the competition needs around six months.

The main benefit of being close is not so much the inventory reduction, but the reaction to changes in the demand. And, while we all wish to have a constant demand, changes in the demand and subsequently in the production program and supplier orders are just a fact of life. Hence, **a shorter supply chain allows a much faster reaction to the unenviable changes in production**. But, the material flow is only one part of this reaction.

26.6 Work Together with Your Suppliers

Equally important is the time it takes for the information about the inevitable production changes to reach the supplier. To deliver Just in Time, the supplier has to know what you need and when. The longer the delay for the information to reach the supplier, the more difficult it will be for the supplier to deliver just in time. This, of course, means more inventory to react to unpredictable changes in what you order from the supplier. The alternative would be missing material and stopped production.

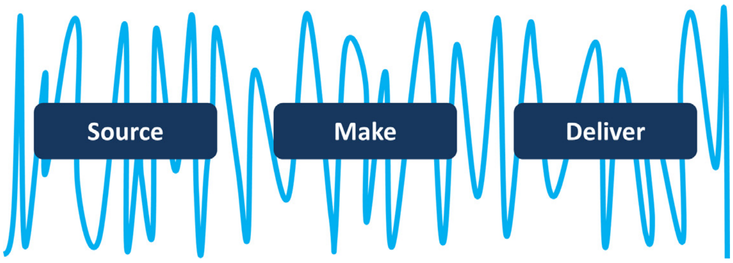


Figure 194: Source, Make, and Deliver Fluctuations (Image Roser)

Overall, you should stay close to your supplier not only in a physical sense, but also with sharing information. Unfortunately, many companies (especially in the automotive industry) see this relation very one-sidedly. If the customer says jump, the supplier has to jump. However, when reducing fluctuations (and that's still the big picture here), fluctuations on the supplier side are only one part of it.

26.7 Stabilize Your Production

Your supplier has to deliver the products just when you need them. For this, the supplier needs reliable information about your demand. If you decide at the last minute to change your production, then your supplier will be unable to deliver in time. Your supplier needs information about your orders some time before you need the part.

If you change your production plan when the parts are already under way, then it is too late. In fact, even when the parts are just about to be loaded may also be too late, as the supplier also needs some time to organize and structure the shipments. Hence, do not change orders on short notice, as you likely won't get the parts in time anyway. To achieve this, you need to have a stable production with few changes. Again, this is much easier said than done.

There are many more methods to help with Just in Time. This rather lengthy list is continued in my next post. In the meantime, **go out, reduce fluctuations, and organize your industry!**

27 How to Make “Just in Time” Work – Part 2

Christoph Roser, July 05, 2016, Original at https://www.allaboutlean.com/how-to-just-in-time-2/

Figure 195: Just in time… (Image 22nd Asian Athletics Chapionships under the CC-BY-SA 4.0 license)

In my previous posts I explained what “Just in Time” is, and started with different actions on how to make “Just in Time” work. As it turns out, there are a lot of things you can do, and one blog post was not enough. So here’s part two on how to make “Just in Time” work! As before, be warned that most of these methods or actions are not easy!

27.1 Level Your Production

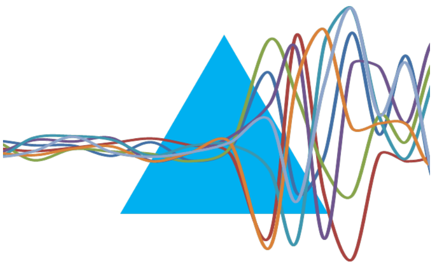


Figure 196: Leveling (Image Roser)

In addition to a reliable signal, it is also important to give the supplier a steady and stable demand. This means leveling your production (which is again easier said than done). I wrote a whole series of posts on the different ways to do leveling (heijunka). The more stable your orders are for the customer, the easier it is for your suppliers to deliver the products just on time. Lean tools like small lot sizes, SMED, and a good product mix help.

Hence, avoid changes in your product mix if you can. The less you change your mix, the better. If you frequently increase or decrease quantities – even if you tell the supplier a day before shipping – the supplier will need additional inventory again to cover these fluctuations.

27.2 Internal Milk Run

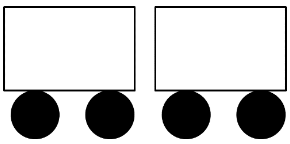


Figure 197: vsm Milk Run (Image Roser)

Previously I talked about the benefit of an external milk run, or delivery routes with multiple stops at multiple suppliers. The same can be done within the plant. A milk run that delivers parts at a higher frequency than a conventional delivery will require less material at the production processes. And remember, the space there is the most valuable in your plant! Hence, if you have not done it already, consider implementing a milk run to achieve a Just in Time delivery at least between your warehouse and your manufacturing location (although, traditionally, this may not be considered Just in Time, as JIT usually involves the supplier. But the effect is the same).

27.3 Pull Production and Pull Deliveries

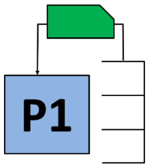


Figure 198: Simple Kanban Loop (Image Roser)

One major source of fluctuations is humans, especially when planning delivery or production quantities. They may over- or underestimate demand, pool orders, or have other quirks that makes their plan less stable than it could be. If I were in their shoes, I would probably do the same, since I am merely human too ☺.

However, if I could, I would implement a pull production, both for my own production system and for the deliveries of goods to me. I have written a lot about pull before (e.g., [Why Pull Is So Great!](#) and [The (True) Difference Between Push and Pull](#)). So, without going into too much detail, pull production will help you a lot when you try to do JIT.

27.4 Ship to Line

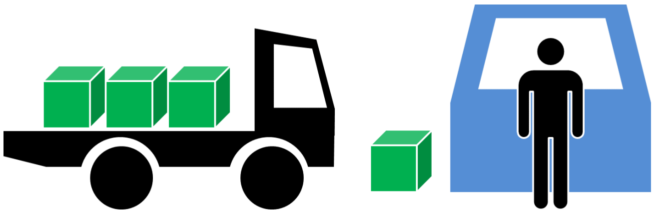


Figure 199: Ship to Line (Image Roser)

A related approach is Ship to Line. The idea is to deliver arriving shipments not into the warehouse, but directly to the line (or, in general, the processes) where they are needed. This, of course, works only with small shipments, as otherwise the space around your processes would be overloaded.

27.5 Just in Sequence

Figure 200: Different Screws (Image Ssawka under the CC-BY-SA 3.0 license)

Yet another related approach is Just in Sequence. The idea is to deliver the parts not only in time, but also in the sequence they are needed. This way there is less effort in sorting out the sequence after unloading, which reduces another source of fluctuation.

This is commonly done in the automotive industry with seats. Due to the many different seat variants, it is usually not possible to keep them in stock. Instead, the supplier is very close to the plant, has a direct line to the production plan, and delivers the seats for the car just in the right sequence (and naturally also just on time) as they are needed.

27.6 Focus on Your High Runners

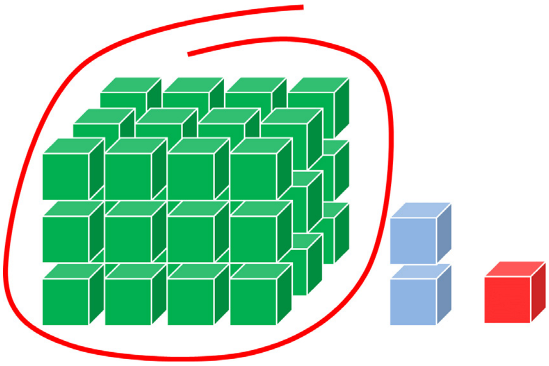


Figure 201: High Runner vs Low Runner (Image Roser)

All of the previous actions are not easy. If you are just starting with JIT, then you should focus on your high runners and your expensive or large parts. High runners are frequently purchased goods, and hence have much less fluctuation than low runners. Through its larger quantity alone, the fluctuation is already reduced, making it easier for you to do JIT.

Also, the benefit will be larger for expensive or large-sized parts. The expensive parts have a bigger benefit in terms of tied-up capital, whereas the larger parts have a bigger benefit when it comes to the space around your production processes.

27.7 Convince Your Suppliers

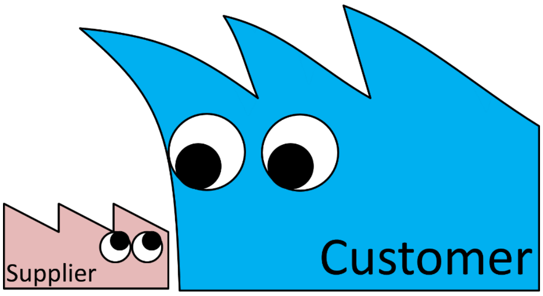


Figure 202: Customer over Supplier (Image Roser)

To implement JIT, you need to work together with your suppliers – and your supplier with you. Quite a bit of the effort is usually on the supplier's side. Hence, you need to convince them to join the efforts. There are usually two strategies common in industry.

First, if you are a large or even the largest customer of your supplier, you have a lot of market power over them. Hence, the supplier has an interest to keep its biggest customer (you) happy. For the supplier, it is also an economy of scale, as it is easier to deliver JIT if you have larger quantities of goods to deliver. A common example is the automotive industry and their suppliers, although even then a brute-force approach rarely works.

Second, if you are only a small customer of your supplier, you have to give them other incentives. This is usually a bit more difficult, as "incentive" usually means "money." You need to share the benefits of JIT with the supplier. Even then, there is a risk that this may not be worth it for a supplier for whom you are only a small customer.

What usually does not work is a small customer trying to force a supplier to do JIT. Of course, the supplier will not tell you so, but it will use lots of sweet words that sound like cooperation. In reality, however, the supplier will try to get away with minimal effort, which usually is not good enough.

27.8 What Is Not Necessary (but may be good anyway)

After all these different things you could do, I would like to mention a few things that may not be necessary, even though other literature mentions them sometimes (e.g. a book I highly appreciate, Factory Physics by Hopp and Spearman). Here, it seems like a lot of different topics of lean manufacturing are pooled under the header of JIT. While the topics are good, some may be less necessary than others for a good JIT.

Some authors mention that single source is necessary for Just in Time (i.e., there should be only one supplier). I think this is not really necessary. While there is a small additional effort in coordinating two suppliers, I think this effort is not prohibitive. Simply schedule the deliveries as you need them, sometimes from one, sometimes from the other supplier.

The disadvantage would be smaller quantities from each supplier, and hence a tad more fluctuations for each. You also would have to make sure to alternate the delivery sources as much as possible. If you do one month from one supplier and then a month from the other supplier, then you make it more difficult for both of them.

On the other hand, dual source or even multi-source have the advantage of a more stable supply in case of disruption, strike, technical problems, bankruptcy, and so on. For this reason, many companies try to source important parts from two suppliers.

Many other things have been mentioned as a necessity for JIT, like preventive maintenance, visual management, cellular manufacturing, and so on. While they surely do not hurt, I personally think they are not a key factor for a successful JIT implementation. In any case, I hope this three-part series will help you in understanding and implementing Just in Time. So, **go out, get your parts exactly when you need them (but not earlier or later), and organize your industry!**

28 How to Prioritize Your Work Orders – Basics

Christoph Roser, July 12, 2016, Original at https://www.allaboutlean.com/how-to-prioritize-work-basics/

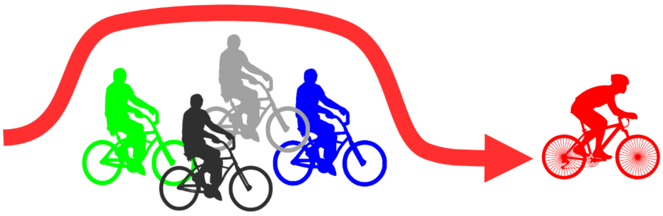


Figure 203: Prioritize Overtake (Image Roser)

Any manufacturing system has production orders, some of which are urgent, others of which are less so. Hence, you may need to prioritize some orders over others. There are different ways to prioritize your orders – and merely telling your people to rush a job creates more chaos than it helps. Luckily, in a kanban loop, there is one spot to prioritize your production orders: before the first process. Done correctly, this allows you to create a smoother and more efficient production system. Let's go into more detail. In this first post of a longer series, I go through the basics: **why, where, and how not to prioritize**.

28.1 Why Do We Need Priorities?

Figure 204: A perfect world… (Image Tevaprapas under the CC-BY 3.0 license)

In a perfect world, there would be no fluctuation. The customer would order like a Swiss clock, the manufacturing would produce like another Swiss clock, and there would always be products to sell to the customer.

In reality, however, there are fluctuations. Sometimes the customer orders more … or less … or earlier … or later. Same with your production system. Sometimes products are produced on time, sometimes not. Most of these fluctuations can be taken care of by having buffers (see Why Do We Have Inventory?). Yet, we cannot buffer made-to-order parts. In this case the customer has to wait for the products. In other cases we can increase or reduce the capacity (see The Three Fundamental Ways to Decouple Fluctuations).

However, there may be times when these measures are not enough. Even with buffer stock, there may be fluctuations that are larger than your buffer. Hence, you may sometimes be in danger of running out of stock. For made-to-order parts, the customer may complain about the delay and take his business elsewhere. And, ramping capacity up and down may also be too slow.

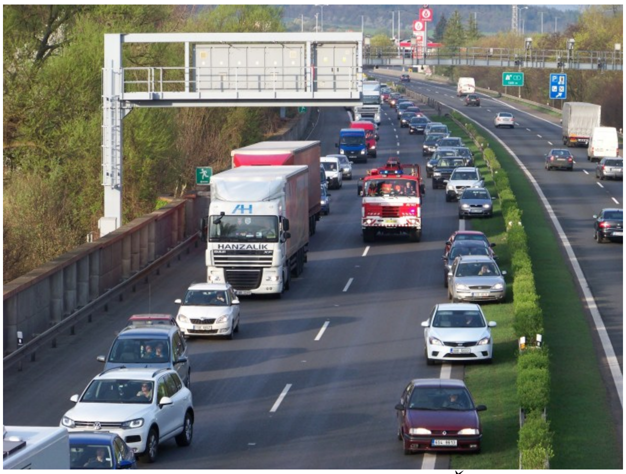


Figure 205: Clear priority for the fire engine! (Image ŠJů under the CC-BY 4.0 license)

In these cases you may opt to prioritize some orders over others to ease the pain. You may prioritize work orders for parts that are running out of stock, or you may generally prioritize made-to-order products. **By prioritizing certain products or orders, you reduce their lead time, and they will be completed faster.** This can help ease your pain and make it easier to produce the goods you need most urgently. Just be aware that **whenever you prioritize one product, you automatically de-prioritize the other products!** If your priority products have a reduced lead time, some other parts must have a longer lead time.

28.2 How NOT to Prioritize

Before we look at different ways to prioritize products, let's first look at how NOT to do it, and its subsequent consequences.

Figure 206: The wrong way to prioritize …. (Image Romolo Tavani with permission)

A prioritization approach popular with upper management is to merely call the shop floor and tell them in no unclear terms that product 08/15 is urgent and must be produced NOW. Upper management even feels good about it, since they've now "*fixed*" the problem. Unfortunately, they rarely know the consequences of their "*fix.*" First of all, changing production while producing is a mess. The new material has to be brought to the line, the old material has to be removed, the production plan has to be changed, and so on. It is a mess, believe me.

A second effect is that **other products are de-prioritized**. Yet, upper management rarely has a good overview of all the products and their priority, hence other products with equal or even bigger needs may fall behind simply because management does not know about them.

In sum, upper management simply telling manufacturing to produce 08/15 ignores so many other factors that this leads to chaos. It would be much better to tell manufacturing about the priority, and to let manufacturing decide how to prioritize the product among all the other (also important) products.

28.3 Where to Prioritize – Basics

In a pull production using kanban or CONWIP cards, **there is really only one place where you can prioritize your production sequence: right before the first process**. This is illustrated in the diagram below using VSM notation. This is the only point where the sequence of the kanban or CONWIP cards should be changed. A change anywhere else in the process will create more trouble than it is worth. Hence, changes elsewhere (e.g., in the FiFo lanes) should be reserved for dire emergencies. If you have such dire emergencies on a daily basis, then your system is not set up correctly.

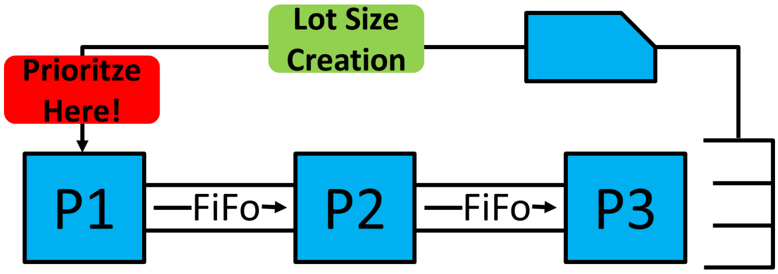


Figure 207: 3 Process Kanban Loop Prioritize (Image Roser)

When the kanban card comes out of the supermarket, there is an optional place where lot sizes are generated (i.e., if you produce a minimum lot size of five identical kanban, then at one place the first kanban of a type has to wait for four more before proceeding). This has nothing to do with prioritization; it is merely a grouping of kanban.

The actual prioritization of the kanban card needs to happen right before the first process (P1 above). Ideally, this happens right before P1 becomes available and needs a new card, but for practical reasons this may happen whenever a kanban arrives, or anytime in between arrival and processing. All the discussions below focus on this spot.

For simplicity's sake, I will in my subsequent posts on this series use a lot size of one kanban, although this is similar for larger lot sizes.

Figure 208: VIP Label (Image Roser)

In subsequent posts I will also describe how to prioritize your work orders, and the simplest approach is through a VIP lane. In this lane you add the kanban cards that are prioritized. I will also go into greater detail on different prioritization strategies (i.e., which tasks to prioritize and which ones not). In the meantime, **go out, start with the important jobs, and organize your industry!**

P.S.: This series of posts is based on a question by Agus Santoso.

29 How to Prioritize Your Work Orders – The VIP Lane

Christoph Roser, July 19, 2016, Original at https://www.allaboutlean.com/how-to-prioritize-work-vip/

Figure 209: VIP Label (Image Roser)

In my previous post I went through the basics of prioritization of your work orders. The easiest way to prioritize these orders is through a VIP lane: a lane for very important parts. In this post I will discuss what you need to make your VIP lane work – and how you can completely mess up a priority system. In my next post I will describe different prioritization strategies that can be used.

29.1 No Prioritization

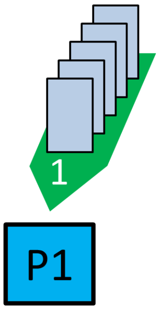


Figure 210: A single Kanban Queue (Image Roser)

The easiest way, so to speak, is not to prioritize at all. The kanban and/or CONWIP cards are simply processed in the sequence they arrive. Hence, the processing is strictly on a first-come first-served basis.

This is illustrated here. Depending on the physical form of the kanban (electronic, paper, box, etc.), different solutions are possible to form a queue. For commonly used rectangular paper or plastic kanban, it is often a simple slide. Hence, in the image here I sketched a green slide with a number of kanban cards on it. Newly arriving kanban are added to the back in the order they arrive. If process P1 has completed a process and needs a new work order, it simply takes the first kanban out of the system.

This system is the easiest to manage, but it has no prioritization at all.

29.2 The VIP Lane

29.2.1 Basic VIP Lane

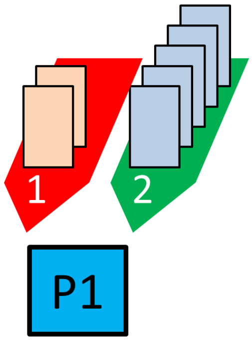


Figure 211: Two Kanban lanes (Image Roser)

A version with prioritization needs at least two lanes. This is also shown in the image. The first lane (green) is for normal cards. The second lane (red) is the VIP lane. (Note: the term "VIP lane" is not an official name but illustrates the point well). These **VIP** lanes are for **V**ery **I**mportant **P**roduction orders, similar to the gold member or the first-class lane at airport check-in.

The operator at process P1 has the following simple priority rule: Whenever there is a card in the VIP lane, then the first card in the VIP lane is the next one to be processed; only if the VIP lane is empty should the first card of the normal (green) lane be processed.

29.2.2 What Do We Need to Make It Work?

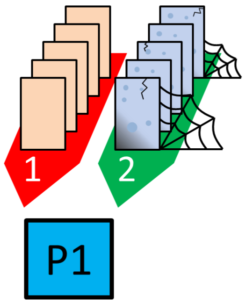


Figure 212: Two Kanban lanes with insufficient capacity (Image Roser)

It is easy to see that this system can under certain situations get clogged up. For example, if you have not enough capacity, then the line will get longer and longer. In the worst case, you will never get around to doing a non-priority kanban.

This, however, is not the fault of the priority system but due to insufficient capacity. Regardless of the prioritization system, **if you don't have enough capacity, you will not be able to make enough parts!**

A second problem, however, may be less obvious. You may be tempted to do something good for your products by upgrading them to VIP status. However, this VIP system works only if there are not too many VIPs.

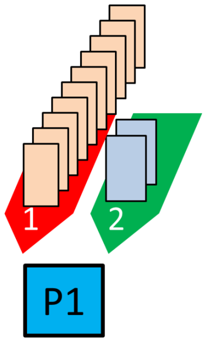


Figure 213: Two Kanban lanes with too many VIP (Image Roser)

This is the same as at the airport. If everybody is a gold member, then no one has an advantage of the membership. Or, **if everybody is special, then no one is!** Hence, try not to give too many cards the VIP treatment.

Even worse, while your (many) priority orders will have only a small advantage, your few de-prioritized orders will have a much longer and – worse – a much more variable lead time.

Take for example a supermarket checkout, working on a first-come first-served basis. If there would be a VIP lane at the checkout, this would be no problem if there were only a few VIPs (although I would be terribly annoyed). However, if everybody but you is a VIP, then your checkout time becomes very long and random, since you would have to let every other customer go in front of you. Hence, **a priority system only works if there are only a few prioritized orders.**

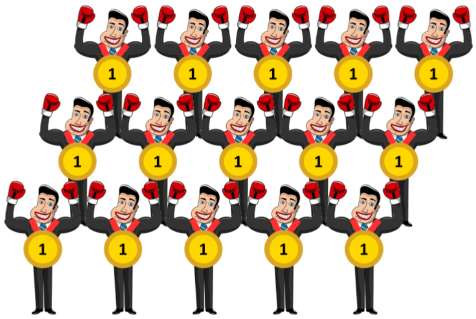


Figure 214: Everyone is special … of course … (Image canbedone with permission)

In my experience, if you have 10% VIP cards, then your VIP cards have a significantly reduced lead time. Having 20% VIP cards may also still be doable, although the advantage is smaller. With 30% VIP cards, the benefit may no longer be worth the effort of a VIP lane. And again, if all cards are VIP cards, then there is even a disadvantage compared to a system without any prioritization. Hence, **make only a small fraction of your products special, or there will be no positive effect for the VIP but a large negative effect for the non-VIP!**

29.3 Multiple VIP Lanes

29.3.1 The Über-VIP Lane – Three Lanes

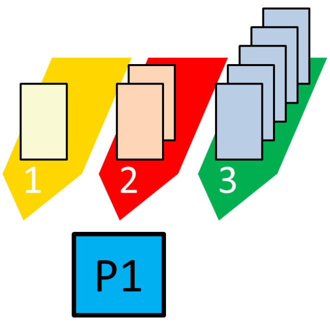


Figure 215: Three Kanban lanes (Image Roser)

Sometimes there may be a temptation to add an additional lane. After all, you have normal jobs, important jobs, and even more important jobs.

Just like at the airport, there are silver members and higher ranking gold members – both of which of course are treated better than the regular run-of-the-mill passengers. Hence, you could add another kanban lane for those extra important Über-VIP jobs.

Please resist the temptation to add a third lane! A third even higher priority lane brings little to no benefit. The whole prioritization system aims to reduce the lead times for higher priority jobs. For this to work, the VIP lane should mostly be empty, and you should not have more than 10%-20% VIP tasks. Hence, in a two-kanban lane system, a newly arriving Über-VIP task probably would not have to wait anyway, because the VIP lane is empty.

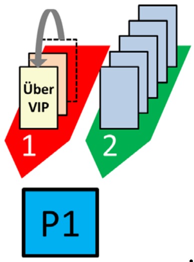


Figure 216: Two Kanban lanes with Über VIP (Image Roser)

Even if there is a job in the VIP lane, then the Über-VIP would have to wait at most for one or two cycles more, which is usually not worth the complexity of a third Über-VIP lane. In the rare case of this being critical, just do a manager intervention and put it at the front of the VIP lane. If it happens only rarely, then it should be perfectly fine.

Overall, a third lane is rarely worth the effort of an additional rule. Hence, **KISS – Keep it simple, stupid!**

As for the airport example, these bronze, silver, and gold status cards on top of "normal" customers are not there to provide a significantly faster boarding for these customers; they have another purpose. It is not so much the minimal faster boarding. Instead, the customers pay for feeling special and receiving different treats. Hence, rather than reducing the lead time, these cards aim to improve profits. After all, the airplane lands at the same time with both first class and economy ☺.

29.3.2 The Ultra-Über-Mega-VIP Lane – Four or More Lanes

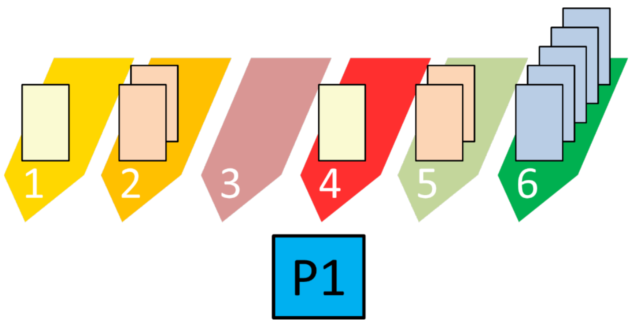


Figure 217: Multiple Kanban VIP lanes (Image Roser)

Having warned you against a three-lane VIP system, I must warn you even more against a system with more than three lanes. Embarrassingly, I can talk from my own experience ☹.

A long time ago I designed a priority system, and the operators in the workshop started adding more and more VIP lanes to make the priorities "*clearer.*" We ended up with a total of four lanes, and rather confusing rules. In the end, since the system was so confusing, the operators did whatever job they wanted to do – which was what they probably wanted in the first place. Hence, I was outsmarted by the operators (again).

Having since learned that there is pretty much no benefit for the lead time, but a large penalty through confusion, I strongly advise against too many VIP lanes. Learn from my mistakes.

Figure 218: This is important! (Image Romolo Tavani with permission)

This post discussed how to establish and organize a VIP lane. However, there is also the question of which tasks to prioritize. There are different strategies to prioritize your work, depending on the particularities of your production. In my next post I will discuss make-to-stock prioritization strategies, followed by make-to-order and mixed prioritization strategies. In the meantime, **go out, do important tasks first, and organize your industry!**

30 How to Prioritize Your Work Orders – Prioritization of Made to Stock

Christoph Roser, July 26, 2016, Original at https://www.allaboutlean.com/how-to-prioritize-mts/

Figure 219: Prioritization strategy for emergency vehicles … (Image LosHawlos under the CC-BY-SA 4.0 license)

In my last two posts I described why and how to establish a system for handling priority work orders. This post discusses how to actually prioritize your different work orders.

Hint: **It has a lot to do with the quantity of a particular product ordered.** The more frequently a product is ordered, the easier it is to provide the parts through inventory rather than rush orders. But … I rush ahead 🙂.

There are different strategies available, depending on your production mix – in particular your mixture of made-to-order and made-to-stock products. Let's first focus on made-to-stock production.

Prioritization is a tool to reduce your lead time (i.e., the time between the production order and the completion of the product). You do this by prioritizing some products, and hence de-prioritizing others. Your priority products will be faster, your de-prioritized products slower.

A faster lead time can help you to react faster to changes in customer demand. However, if you produce only stock-keeping units, then you should be able to buffer most, if not all, fluctuations simply by having them in stock. Here there may be two reasons to prioritize.

30.1 Prioritize to Reduce Inventory of Large or Expensive Parts

Figure 220: Fat Mouse (Image Bigplankton in public domain)

Assume you have only made-to-stock parts. In this case you could start prioritizing the most expensive products, or the products that take up a lot of space. If you prioritize these products, then you may need less inventory for these expensive and/or large products. This may reduce your inventory cost and free up some space. Just keep in mind that you gain this benefit with a slightly increased inventory needed of all other non-prioritized (smaller and/or cheaper) products.

Overall, this prioritization may be quite a bit of effort, with a benefit that is in sum not too large. Hence, if you prioritize only for this reason, it may or may not be worth the effort. But **it may be a suitable approach for some sections of your value stream with particularly expensive products to reduce the overall inventory.**

30.2 Prioritize to Cover Emergencies

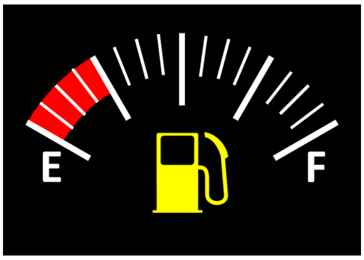


Figure 221: Fuel Gauge Red (Image Roser)

A much more sensible way of prioritization is to prioritize products when you are in danger of running out of stock. Especially when running out of stock, many supermarkets may have an early warning system indicating a potential stock-out. The supermarket has some color markings in red (or more colors). If the inventory level reaches the red mark or goes below it, it is a signal that a stock-out is imminent and this product needs to be prioritized to replenish the goods before a stock out. Hence, the manager can move some of the cards for this product to the VIP lane to speed up production.

This is actually a good use of prioritization if you have only made-to-stock products. Even if you have a mixture of made-to-stock and made-to-order, this approach is sensible. While your inventory covers most fluctuations, the largest fluctuations require a prioritization of urgent products.

This way to prioritize your orders for your VIP lane is usually done through manual prioritization. A manager or supervisor that has a good overview of the current needs of the market can select certain jobs for a higher priority. This person could pick work orders that are particularly urgent for the customer or upper management, or could prioritize orders where there is a danger of running out of stock.

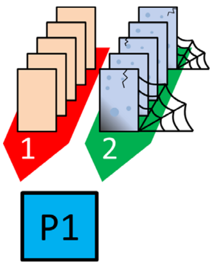


Figure 222: Two Kanban Lanes with insufficient capacity (Image Roser)

Such management intervention has to be handled with care. An empty VIP lane may be a temptation for the manager or supervisor to give some jobs the VIP treatment. However, for the system to work, the VIP lane must frequently be empty or the non-VIP lane would again collect dust. Hence, **the executive VIP treatment also has to be used sparingly, or the effect vanishes or even becomes worse.**

There is a second risk with this management-priority system. I sometimes got the feeling that supervisors used this system as an excuse to do whatever they felt was right. They simply prioritized whatever they wanted to do next. While doing this with the best intentions, it totally invalidates the second non-priority queue. And for me, the automatic sequence of the kanban is often a better prioritization than even a well-intended manual system. Hence, be wary about too much intervention, as it may make things worse.

30.3 Prioritize Exotic Parts over High Runners

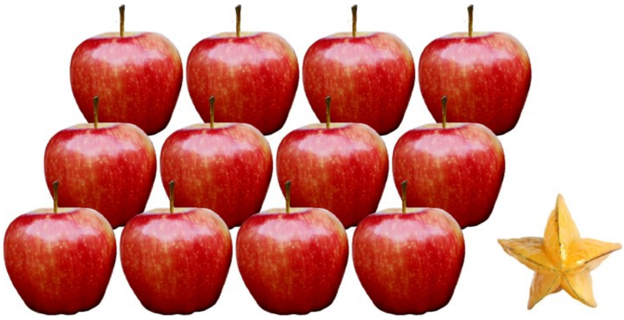


Figure 223: Common and Exotic Fruit (Image Ana Santos & SMasters under the CC-BY 2.0 license)

One of the easiest ways to distinguish is by production quantity. You have high runners, and you have exotic parts. Often – according to the Pareto principle – 20% of your parts is 80% of the workload. Now you could distinguish between VIP and non-VIP simply based on the part being a high runner or not. The question is: Should you make the high runners as VIP (since they are only 20% of the parts), or should you make the exotics VIP (since they are only 20% of the work)?

There is a very clear answer to that! **The exotic parts should be VIP!** This may sound counter-intuitive for some. Normally, the high runners are the most important products, and hence it is sometimes (mistakenly) believed that they should get the VIP treatment. This is terribly wrong!

If you would make the high runner into the VIP, then 80% of the work in the system would be priority, and hence there is not really any advantage. Even worse, the exotic parts (20% of the work but 80% of the part numbers) would have a much, much longer lead time, since they always have to wait on the (many!) high runner parts. In addition, not only would the lead time increase, but also the fluctuation thereof.

Assume you're at the airport as a non-gold-status member, and 80% of the other passengers would be gold status. Your waiting time would be not only much longer, but the fluctuation of this waiting time would also significantly increase. Sometimes you would have to wait long, sometimes longer, and sometimes extremely long. To cover this longer and highly fluctuating lead time for the exotic products, you would need an insane amount of inventory.

It is much, much (MUCH!) better to make the exotics into priority products. Since we are talking about only 20% of the work, the lead time for the exotic parts would be significantly reduced. Hence, the inventory for the exotics may be reduced. This, of course, also means that the lead time for the high runners would be slightly increased. But they are high runners. You already have a high demand, and a high demand usually means a stable demand. Hence, there would be only a small increase in fluctuation. Your total overall inventory (high runners and exotics combined) may be less than before if you prioritize the exotics only!

There is a similar effect on fluctuation. By prioritizing your exotics, you can reduce fluctuation of the lead times (i.e., the parts will be produced not only faster but also more consistently). This comes at a cost of not only higher lead time but also higher fluctuation of the lead time for the non-prioritized parts. Yet, if you prioritize only a small part your your orders (10%-20%), the benefits for the prioritized parts will outweigh the (small) disadvantage for the non-prioritized parts.

Hence, this type of high runner vs. exotics prioritization often has benefits. It can also be implemented as part of the regular standard. It is more work and effort for the people, hence I would not implement it everywhere but only where there is a pressing need.

In my next post I will focus on made-to-stock items and mixed systems. Until then, stay tuned, and **go out and organize your industry!**

31 How to Prioritize Your Work Orders – Prioritization of Made to Order

Christoph Roser, August 02, 2016, Original at https://www.allaboutlean.com/how-to-prioritize-mto/

Figure 224: Made to Order Only (Image Morio under the CC-BY-SA 3.0 license)

In my previous posts I went into great detail on how to prioritize your work, with a focus on made-to-stock-type production. In this last post of my series on work prioritization, I look at made-to-order systems and mixed made-to-order and made-to-stock systems.

Figure 225: Here's your order… (Image Markburger83 and Lauro Sirgado under the CC-BY-SA 3.0 license)

If you only produce made-to-order products, you may not need a VIP lane. After all, every product is custom made, and the customer wants it as fast as possible. Additionally, this priority changes frequently. Any important order may be superseded by an even more important new order. Hence, the importance changes frequently.

The best way to prioritize this in pull production is through the use of a CONWIP system. I have explained the CONWIP system in more detail before (see my series on CONWIP starting with [Basics of CONWIP Systems](#)). This time let me look only at the prioritization of the CONWIP cards.

You probably have a backlog of open orders. Remember, a CONWIP card is merely the permission to start the next open order. Hence, we have a backlog of open orders, which we attach to any arriving blank CONWIP card. Whenever an order is completed, an empty CONWIP card comes back and gives permission to start the next order. The image below shows this backlog also as a queue. However, in reality **it may be much more sensible to attach not the first but the most urgent card to the next arriving blank CONWIP card**.

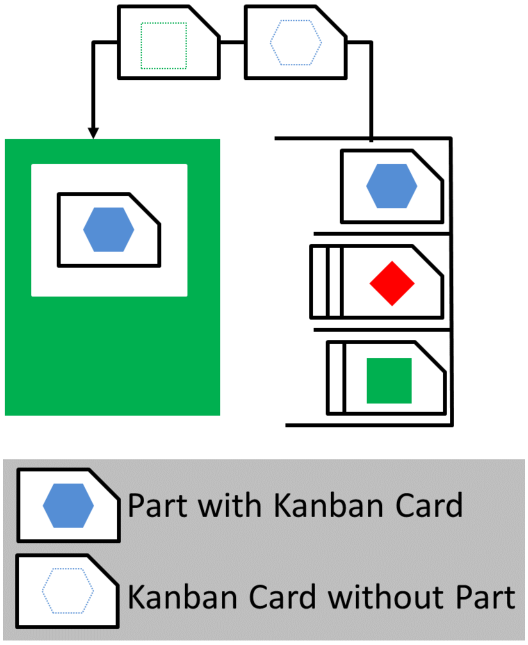


Figure 226: Schematic CONWIP system with cards (Image Roser)

31.1.1 Prioritize Whenever the Next Job Can Be Started

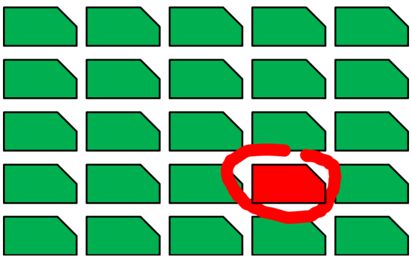


Figure 227: Select the priority (Image Roser)

Ideally, exactly when the next CONWIP card comes back, a manager decides which of the many open orders is the most urgent and high-priority one, attaches this order to the CONWIP card. He then hands the card over to production.

31.1.2 Prioritize a Small Batch

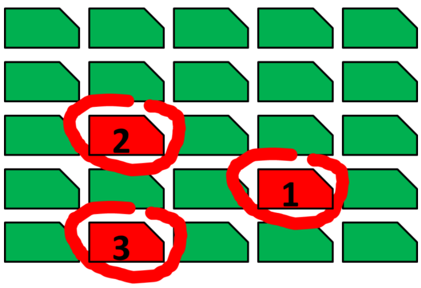


Figure 228: Select Multiple Kanban Card (Image Roser)

This prioritization whenever there is an opening for a new job (a blank CONWIP card) is the best prioritization approach. However, it may not be possible that a manager or supervisor is available whenever a new slot opens up. In this case, you could also prioritize a small batch of cards for the operator rather than only one card. In this case you would have a single (short) queue that contains only the next few cards that cover the time until the manager can come back and prioritize again.

31.2 Mixture of Made to Order and Make to Stock

31.2.1 Less than 30% of the Work is CONWIP

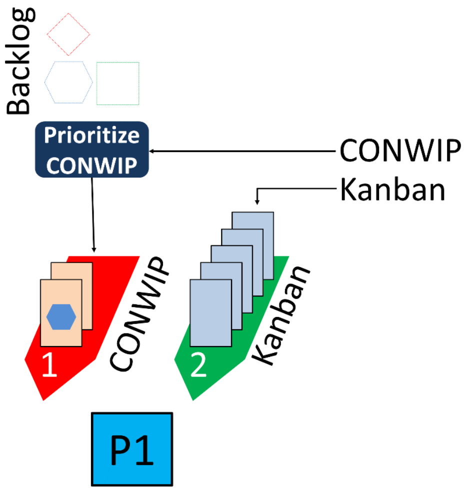


Figure 229: Mixed Kanban and a few CONWIP (Image Roser)

A priority system similar to the high runner and exotics can be set up if you have a mixture of made-to-order and made-to-stock production. In this case, you may have a hybrid kanban & CONWIP system. You use kanbans for made-to-stock products and CONWIP for made-to-order products. In this case your VIP lane would be your CONWIP cards, and your non-VIP lane would be your kanban cards.

Of course, you would need more inventory with the kanban cards, but the lead time for the CONWIP cards would be reduced. How much faster depends on what percentage of your work is made to order. If you have 80% made to order, there will be little change. However, if you have only 20% made to order, the made-to-order products will be delivered much faster. Hence, **this may only be worthwhile if your made-to-order products are only a small part of your total production, and you can accept a slightly higher made-to-stock inventory in exchange for a much faster lead time of your made-to-order products**.

This can also be implemented as part of the regular standard. If set up correctly, this type of system needs no management intervention. However, especially with the CONWIP-type pull system, it is common and useful to also prioritize the open order backlog.

31.2.2 More than 30% of the Work is CONWIP

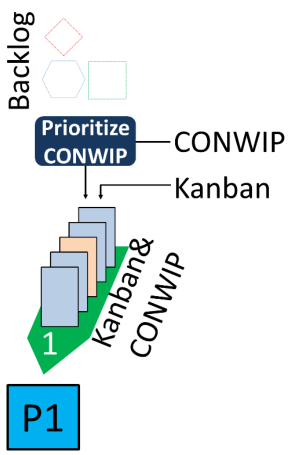


Figure 230: Mixed Kanban and many CONWIP (Image Roser)

It becomes more tricky if you have more than 30% of your work in the form of CONWIP or made-to-order cards. In this case there is a risk of kanban cards having to wait for a long time, which also fluctuates heavily. You would need quite some inventory in your kanban (i.e., more kanban cards) to cover this. **The higher your CONWIP workload compared to the kanban workload, the higher your kanban inventory would have to be, with little benefit for the CONWIP.** This may not make economic sense.

Hence, in this case it may be better to treat CONWIP and kanban with equal importance, and merely process them on a first-come first-served basis. You would still prioritize your CONWIP cards similar as for a made-to-order-only system. Every new CONWIP card gets the highest-priority job. However, after the job is attached to the CONWIP card, the CONWIP card goes to the back of the mixed CONWIP/kanban queue. In effect, you would have no prioritization.

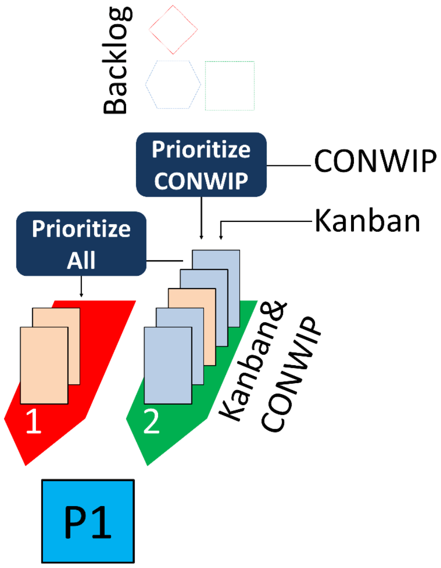


Figure 231: Mixed Kanban many prioritized CONWIP (Image Roser)

If you still think you need some prioritization, you can do that too. In this case, however, you would need a two-stage process, where you first prioritize the open orders as described above. Only as a next step would you put selected orders in the VIP lane.

These can be both kanban and CONWIP, as long as there is not too many of them. It should be no more than 10%-20% of the workload going through the VIP lane. Please note, this does not mean than the priority lane can be 20% of the length of the non-priority lane, but that 80% of total number of cards **entering or leaving** the queues should be non-priority. As you can see, it gets tricky. Do this only if you really, really need it.

Yet again I set out to write a short 1000-word post on prioritization, and here we are, 4000 words later, and I still have ideas for more. But, I think I have covered the most important aspects of prioritization, both for made to stock, made to order, and mixed systems. I hope this covers most situations that you may encounter in industry. So, **now go out, get your priorities straight, and organize your industry!**

32 Good and Bad Ways to Calculate the OEE

Christoph Roser, August 09, 2016, Original at https://www.allaboutlean.com/bad-oee-formula/

Figure 232: Ups and Downs (Image Roser)

There are different ways to calculate an OEE. I know of at least three different ways. However, some of them are easier and more practical than others.

Maybe you have seen a formula similar to OEE = A x P x Q. **I see this formula often, but for me it is a very impractical way to calculate the OEE.** Let me show you why by comparing the three different ways to calculate an OEE.

32.1 Example Data

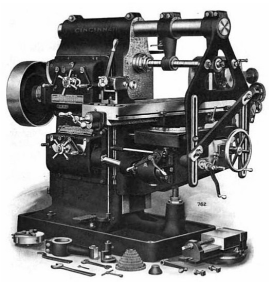


Figure 233: Just a machine… (Image Cincinnati Milling Machine Company in public domain)

Throughout this post I will be using examples. To calculate an OEE, we need a few data points. Our example process will be as follows:

- **Total Time**: Total time the process is scheduled to work, 5 days with 24 hours each or a total of 7200 minutes
- **Downtime**: Machine stopped for whatever reason: 1440 minutes
- **Cycle Time**: Needed to produce one unit: 1.5 minutes/unit
- **Good Units**: Total number of good parts produced during the 5 days: 2880 pieces
- **Defective Units**: Total number of defective parts produced during the 5 days: 240 pieces

32.2 The Impractical Formula

Figure 234: It doesn't feel right … (Image Nevit Dilmen under the CC-BY-SA 3.0 license)

In literature you sometimes find the following formula for the OEE:

$$OEE = A \cdot P \cdot Q$$

Where

- A is the **availability rate**, the ratio of the time the machine is running vs. the total time in consideration.
- P is the **performance efficiency**. This is calculated based on the ideal time needed to produce the parts (including defective parts) divided by the total running time of the process.
- Q is the **quality rate**. This is simply the number of good parts divided by the total number of good and bad parts produced.

A, P, and Q for our example are calculated below.

$$A = \frac{Total\ Time - Downtime}{Downtime} = \frac{7200\ min - 1440\ min}{7200\ min} = 80\%$$

$$P = \frac{(Good\ Units + Defective\ Units) \cdot Cycle\ Time}{Total\ Time - Downtime} =$$

$$= \frac{(2880\ pcs + 240\ pcs) \cdot 1{,}5\,\frac{pcs}{min}}{7200\ min - 1440\ min} = 81.25\%$$

$$\mathrm{Q} = \frac{\text{Good Units}}{\text{Good Units} + \text{Defective Units}} = \frac{2880\text{ pcs}}{2880\text{ pcs} + 240\text{ pcs}} = 92.31\%$$

Hence the overall OEE according to the APQ formula is:

$$OEE = A \cdot P \cdot Q = 80\% \cdot 81.25\% \cdot 92.31\% = 60\%$$

You can already see that this is quite a bit of work to calculate.

32.3 The Easy OEE by Pieces

Figure 235: Much easier that way … (Image Nevit Dilmen under the CC-BY-SA 3.0 license)

If you need only the OEE, there are much easier ways to calculate it. One is by using the ratio of good parts produced vs. the number of parts that could have been produced. Hence

$$OEE = \frac{Good\ Units}{\left(\frac{Total\ Time}{Cycle\ Time}\right)} = \frac{2880\ pcs}{\left(\frac{7200\ min}{1.5\ min/pcs}\right)} = \frac{2880\ pcs}{4800\ pcs} = 60\%$$

32.4 The Easy OEE by Time

Above we calculated the OEE by dividing the good units by the total number of units that could have been produced. You can calculate the OEE similarly by using time. You divide the duration that you would have needed at a minimum by the time you actually needed.

$$OEE = \frac{Good\ Units \cdot Cycle\ Time}{Total\ Time} = \frac{2880\ pcs \cdot 1.5\ min/pcs}{7200\ min} = \frac{4320\ min}{7200\ min} = 60\%$$

32.5 Why A x P x Q is bad

32.5.1 Much More Complex

It is easy to see that the calculation through pieces or through the time is much easier and simpler. The A x P x Q approach is much more complex, and hence has a much higher likelihood of mistakes. The formula is error prone not only because there are more calculation steps, but also because you have to always pay attention when you use the total time, or only the time the machine is actually running, when to use all parts, and when to use only the good parts, and so on. I find it very confusing (but admittedly I used the other way much more frequently).

32.5.2 Same Result

Additionally, if we put the entire complex formula together, we can easily cancel out many terms.

$$OEE = \frac{Total\ Time - Downtime}{Downtime} \cdot \frac{(Good\ Units + Defective\ Units) \cdot Cycle\ Time}{Total\ Time - Downtime} \cdot \frac{Good\ Units}{(Good\ Units + Defective\ Units)}$$

Rearranging this gives us:

$$OEE = \frac{Total\,Time - Downtime}{Total\,Time - Downtime} \cdot \frac{(Good\,Units + Defective\,Units)}{(Good\,Units + Defective\,Units)} \cdot \frac{Good\,Units \cdot Cycle\,Time}{Total\,Time}$$

Many of the terms cancel out easily, which leaves us with

$$\mathrm{OEE} = \frac{\text{Good Units} \cdot \text{Cycle Time}}{\text{Total Time}}$$

which is exactly the formula we had for the Easy Way by Time above.

32.6 What about the Losses?

Figure 236: Losses … (Image StefanieB with permission)

Your OEE is below 100% due to losses. These losses are typically grouped in **availability losses**, **speed losses**, and **quality losses**. To know how big your losses are will help you with actually improving the system.

With the A x P x Q formula, you get something that at least sounds similar – the **availability rate**, **performance efficiency**, and **quality rate**. I think breaking down the OEE in these three terms is the reason the calculation is done the way it is in the first place. However, I still think it is impractical.

You could hope that the corresponding terms sum up to 100%. Unfortunately they do not! Only the availability rate and the availability losses together give 100%, but the speed loss is not complementary to the performance efficiency, and the quality rate is again not complementary to the quality losses. They are completely different numbers! Let's do the math.

32.6.1 Availability Losses and Availability Rate

Figure 237: Availability loss … (Image James Salmon in public domain)

The availability losses are the part of the losses that you lose due to stopped machines. This is usually calculated by time, since the total time and the stops are usually given as times.

$$\text{Availability Losses} = \frac{\text{Downtime}}{\text{Total Time}} = \frac{1440 \text{ min}}{7200 \text{ min}} = 20\%$$

It is also possible to calculate this through the number of parts, but since this usually involves more math, the above way is easier. In any case, the losses are the same. Below, for reference, is the marginally more complex calculation using the number of parts:

$$\text{Availability Losses} = \frac{\frac{\text{Downtime}}{\text{Cycle Time}}}{\frac{\text{Total Time}}{\text{Cycle Time}}} = \frac{\frac{1440 \text{ min}}{1.5 \text{ min/pcs}}}{\frac{7200 \text{ min}}{1.5 \text{ min/pcs}}} = 20\%$$

The availability losses and the availability rate together give exactly 100%.

$$Availability\ Losses + Availability\ Rate = 20\% + 80\% = 100\%$$

32.6.2 Quality Losses and Quality Rate

Figure 238: One defect … (Image svetamart & bajinda with permission)

The quality losses is the time lost due to defective parts. This can also be done either by calculating through the time or through the quantity. Let's do the calculation by lost time first:

$$Quality\ Losses = \frac{Defective\ Parts\ \cdot Cycle\ Time}{Total\ Time} = \frac{240\ pcs \cdot 1.5\ min/pcs}{7200\ min} = 5\%$$

The calculation by lost quantity is equally simple and gives the same number:

$$Quality\ Losses = \frac{Defective\ Parts}{\left(\frac{Total\ Time}{Cycle\ Time}\right)} = \frac{240\ pcs}{\left(\frac{7200\ min}{1.5\ min/pcs}\right)} = 5\%$$

However, the quality losses and the quality rate are no longer complimentary.

$$Quality\ Losses + Quality\ Rate = 5\% + 92.31\% = 97{,}31\% \neq 100\%$$

32.6.3 Speed Losses and Performance Efficiency

Figure 239: Running Rabbit (Image Malene Thyssen under the CC-BY-SA 3.0 license)

Finally, the speed losses. I kept these losses for last, as the speed losses are simply the remainder to 100%.

$$Speed\ Losses = 100\% - Availability\ Losses - Quality\ Losses - OEE =$$
$$= 100\% - 20\% - 5\% - 60\% = 15\%$$

Again, the speed losses and the performance efficiency are no longer complimentary.

$$Speed\ Losses + Performance\ Efficiency = 15\% + 81.25\% = 96.25\% \neq 100\%$$

32.7 Overview of Losses

Here's a quick overview of the different values, and it is easy to see that they differ. **The different losses or efficiencies are not complementary** (except for availability).

Easy Oee		**A×P×Q = OEE**	
Availability Losses	20%	80%	**Availability Rate**
Speed Losses	15%	81.25%	**Performance Efficiency**
Quality Losses	5%	92.39%	**Quality Rate**
OEE	60%	60%	**OEE**

In fact, they must differ. After all, the A x P x Q formula is a multiplication, and the other one sums up to 100%

$$OEE = Availablity\ Rate \cdot Performance\ Efficiency \cdot Quality\ Rate$$

$$OEE + Availablity\ Losses + Speed\ Losses + Quality\ Losses = 100\%$$

For me, it is quite obvious that summing up the losses has significant benefits. It is easier to see which part of the losses contributes how much to the total losses. This also makes it much easier to estimate how much a system will improve based on different improvement actions. Below is a simple waterfall bar chart showing which part of the losses contributes how much to the overall OEE losses.

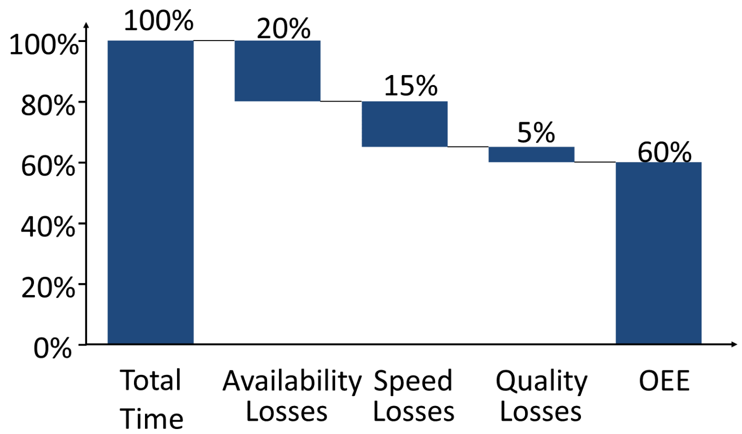


Figure 240: OEE Waterfall Chart (Image Roser)

Regarding the product in the A x P x Q formula, however, I fail to see any benefit. Hence my recommendation: Do not use the A x P x Q formula! If you know of any reasons, please enlighten me. Until then I will continue to advise you to **avoid the A x P x Q formula, and instead use one of the two easy ways described above**. Now, go out and organize your industry!

33 The History of Manufacturing – Part 1: Prehistory to Antiquity

Christoph Roser, August 16, 2016, Original at https://www.allaboutlean.com/firstlecture_hom_1/

Figure 241: Roman Flour Mill (Image Roser)

Most of our prosperity and wealth is based on our ability to manufacture faster, better, and cheaper than ever before. To announce the publication of my first book "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, I would like to start a four post series where I explore this story and tell you a **brief version of the History of Manufacturing**. In this first post I would like to talk about **prehistory, division of labor, mechanization, and manufacturing during antiquity**.

This series is actually a transcript of my *first lecture*, a German academic tradition where a new professor after a year or so gives a public lecture on a topic of his choice. The video of the entire lecture (in German with Subtitles) is available on YouTube.

The Video by AllAboutLean.com is available on YouTube as "History of Manufacturing (subtitles)(First Lecture Prof. Christoph Roser June 4th 2014)" at https://youtu.be/W0ciuc10Bcg

33.1 Prelude

Ladies and gentlemen, we live in an age of unprecedented prosperity. No generation before ours has had as many material goods as we have. That is thanks in large part to production. The story I would like to tell here is how production developed over thousands and millions of years.

One small part of this is: How can you produce something?

That is just a small part. That is more the history of technology: How can I do something? Much more importantly for production: **How can I do it faster? How can I do it better? And most important, how can I do it cheaper?**

Therefore, through production becoming faster, better, cheaper, we have achieved a large part of the prosperity that we enjoy today. However, let us start from the beginning.

33.2 The Six Manufacturing Techniques – DIN8580

Figure 242: Stone axe (Image Guyassaf in public domain)

Let us go back two and a half million years, to the first production. In this case the production of stone hand axes in the Stone Age. *Homo habilis* produced these. They were also the very first representation of the genus *Homo*, to which we also belong as *Homo sapiens*. It is no coincidence that *habilis* comes from Latin, meaning toolmaker or handyman.

Homo habilis was the first who really engaged in production. Now we know very little about production at that time, but we have learned a couple of things. For example, the longest-producing manufacturing site in the world is a place in Africa, at which stones were processed for about a million years.

The manufacturing site was between two mountains. Ten kilometers in one direction was one mountain, and ten kilometers in the other direction was the other mountain. We have also learned that there was one corner where new hand axes were produced. The pieces at that location are consistent with stones that were manufactured into new hand axes. Nearby, old hand axes were re-sharpened. The pieces at this site are consistent with the splinters of used hand axes that were reworked and refurbished.

You may of course ask the question, why were the new hand axes in one location but the used ones in another? The logical conclusion would be, they already had the first division of labor. It is not certain, but it is probable that some had already specialized in making new hand axes. Others specialized in reworking old hand axes. Finally, others who were not so skilled with their hands specialized in getting stones from ten kilometers away and bringing them back to the site.

That is already the first evidence of the division of labor. The division of labor makes it possible for us to learn faster. We learned faster how to do something. Through that we became faster, better, and – okay, in the Stone Age it was not so relevant – but … altogether cheaper too. That means that through the division of labor, we had already optimized production in the Stone Age.

We usually divide manufacturing methods into six groups. Producing stone tools was the first technique: **cutting**.

Figure 243: Schöningen Spear (Image H. Pfarr with permission)

The second technique was **changing material properties**, 120,000 years ago. What you see here is the tip of a spear. Wooden spears already existed long before, but this spear tip is hardened. When you put wood into a fire, it burns. However, when you place wood carefully into a fire, turn it, and do not leave it in too long, then the water and moisture evaporate, and the spear becomes harder. That means that already 120,000 years ago, the manufacturing technique of "changing material properties" existed. [Side note: Since the presentation I learned that there is even an older technique that treated stone with heat for better stone tools.]

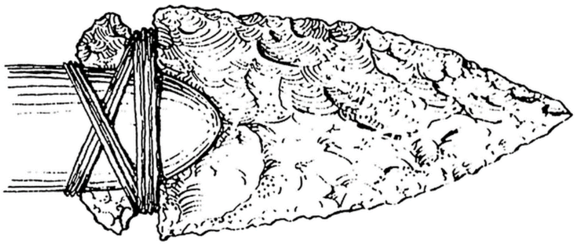


Figure 244: Flint Arrowhead (Image unknown author in public domain)

The next technique was **joining**, 72,000 years ago. At that time, arrowheads were attached to the wooden arrow shaft with resin and other materials. They made one part out of two and joined the parts together.

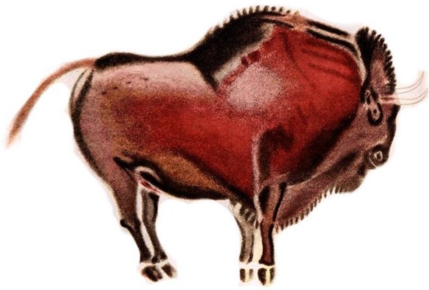


Figure 245: Cave painting (Image Henri Breuil and Émile Cartailhac in public domain)

Coating has existed for about 30,000 years, for example in the form of cave paintings. **Molding** has existed for 25,000 years. The figure was formed from bone dust and clay, and then burned.

Figure 246: Venus of Dolni (Image Petr Novák, Wikipedia under the CC-BY-SA 2.5 license)

Figure 247: Native Copper (Image Robert M. Lavinsky under the CC-BY-SA 3.0 license)

Forming has also existed for almost 10,000 years. For forming, we typically need metal. Metal is a malleable material. Already 10,000 years ago, small beads and pendants were formed from metal.

If you are a little bit familiar with history, you'd say, "Wait a minute! For metal, we definitely need metalworking, and that is from the Bronze Age. But that hadn't even started yet ten thousand years ago!"

Correct. The metal is a so-called native metal that comes in a pure form in nature. Not often, but occasionally, there's a piece of copper found in nature. They hammered on these pieces. Before they knew how to liquefy or extract it, they struck it and formed things that way.

Hence, all of the six manufacturing techniques that we know of were applied in one form or another during the Stone Age. Of course, significant technological progress has happened since then.

33.3 Division of Labor in Ancient Times

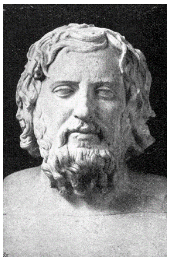


Figure 248: Xenophon (Image unknown author in public domain)

Let us go a couple of million years ahead into ancient times. In the Stone Age, we can only guess at the existence of the division of labor. However, in ancient times, we have written reports. For example, the Greek philosopher and politician Xenophon already observed the division of labor.

> *In a small city the same man has to build beds, chairs, ploughs and tables and often even to build houses. […] But in the big cities [an artisan will get] his living merely by stitching shoes, another by cutting them out, a third by shaping the upper leathers, and a fourth will do nothing but fit the parts together*

He determined that in a small city, craftsmen must actually do everything that even remotely comes under their general area of knowledge.

In a large city, however, they specialized. An example from shoemaking: One worker specialized in sewing the shoe soles; another cut the leather; the third did nothing but place the leather upper, and the fourth did nothing but put the final pieces all together. That means that at that time there was also a relatively good division of labor. As mentioned before, the division of labor makes production faster, better, and cheaper.

33.4 Mechanization and Energy Sources

Figure 249: Egyptian Potter Wheel (Image unknown author in public domain)

Figure 250: Egyptian Lathe (Image unknown author in public domain)

There were also the first machines in ancient Egypt. Thousands of years ago, the pottery wheel already existed. The Egyptians also had the first lathes, at that time of course operated by hand. On the right, you can see a man who is operating the lathe with two cords, and on the left, a man who is holding the instrument in place and ultimately turns it.

Figure 251: Roman Flour Mill (Image Roser)

We human beings are – in terms of living things – very skilled. However, we have no power. Compared to us, animals such as horses have considerably more power than we do. In that respect, it was of course logical that we came up with additional sources of power. For example, the Romans made use of horses and cows relatively early on. Here we have a picture of a Roman flourmill, in which a mule walks in a circle and turns the mill.

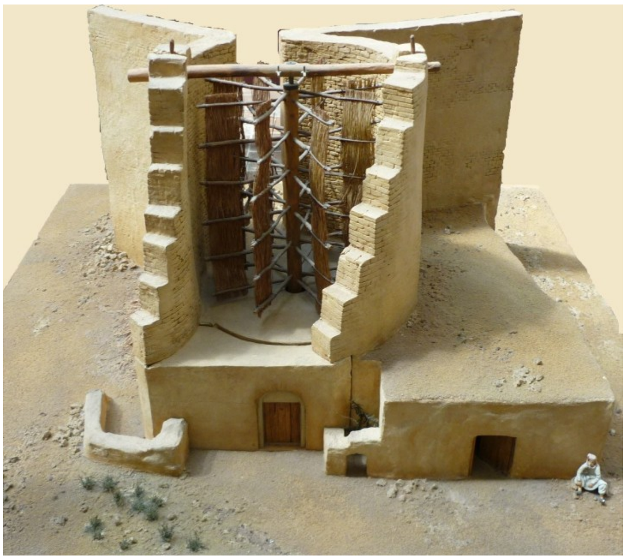


Figure 252: Persian Horizontal Windmill (Image Saupreiß under the CC-BY-SA 3.0 license)

Natural energy sources were also used early on. Here we have a picture of a Persian windmill utilizing wind power. This of course does not look like a Dutch windmill. The wind blows through the middle, and the shaft is vertical, rotating a millstone at the bottom. At that time, they did not yet know how to convert a vertical rotation into a horizontal rotation by using gears.

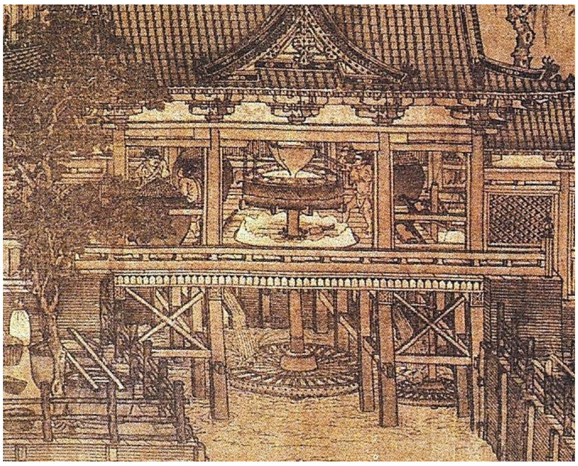


Figure 253: Chinese Water Mill (Image PericlesofAthens in public domain)

It was a similar story with waterpower. The next picture shows a Chinese water mill. You can see how the water flows through underneath and the millstone is on top. Again, for the lack of gear technology, there is just one axle.

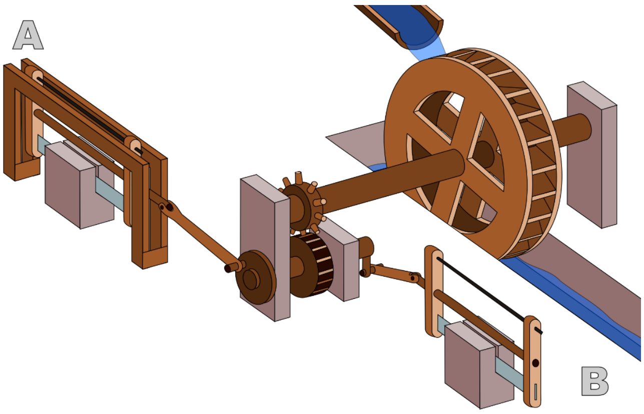


Figure 254: Roman Saw Mill (Image chris 論 under the CC-BY 3.0 license)

Finally, the Greeks and Romans developed gears. The Romans were also the first to transform a rotation into a back-and-forth movement. Here is an example of a Roman sawmill, where through waterpower a saw is moved back and forth.

The Romans were also well known for their agriculture. They bred animals and plants at a never-before-seen level of productivity. Only in the modern era were we again able to reach that level of cultivation of such an animal size and productivity.

33.5 Prestige of Craftsmanship in Antiquity

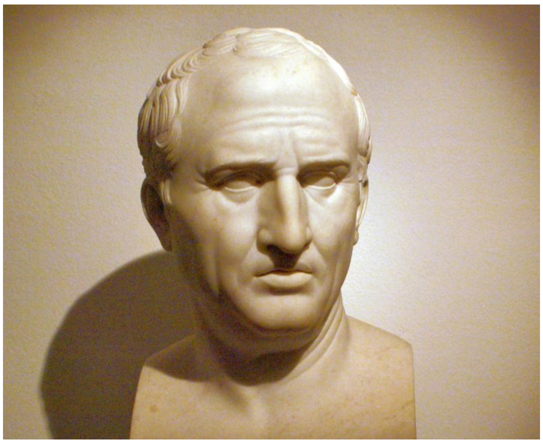


Figure 255: Marcus doesn't like manufacturing… (Image Gunnar Bach Pedersen in public domain)

Had the Romans done the same with production, who knows? Maybe we would have already had the Industrial Revolution a thousand years ago. This raises the question: Where would we be now if we would have already had the steam engine a thousand years ago? Unfortunately for the Romans, that was not the case. As for the reason, I will leave that to the best-known Roman orator, Marcus Tullius Cicero, to explain.

> *Unbecoming to a gentleman, too, and vulgar are the means of livelihood of all hired workmen whom we pay for mere manual labour, not for artistic skill; for in their case the very wage they receive is a pledge of their slavery. [...] And all mechanics are engaged in vulgar trades; for no workshop can have anything liberal about it.*

"All mechanics are engaged in vulgar trades, for no workshop can have anything liberal about it." I repeat, "**No workshop can have anything liberal about it!**"

Most of you earn your money through a craft related to production or manufacturing. In ancient Rome, you would not have been popular. You would not have been invited to any parties. Also, on the marriage market, you would have to settle for the leftovers. **The Romans had a very clear opinion of craftsmanship: it was vulgar!** Similar for the Chinese, trades and commerce together were not reputable.

Subsequently, "young potentials" would not have gone into manufacturing. You would have gone into politics, agriculture, or the military, but not into manufacturing. Because of that, not much got accomplished in manufacturing. This started to change only in the Middle Ages, as I will show in my next post. Now go out, learn the lessons of history, and **organize your industry!**

34 The History of Manufacturing – Part 2: Middle Ages to Industrial Revolution

Christoph Roser, August 23, 2016, Original at https://www.allaboutlean.com/firstlecture_hom_2/

Figure 256: Medieval Blacksmith (Image unknown author in public domain)

Most of our prosperity and wealth is based on our ability to manufacture faster, better, and cheaper than ever before. To announce the publication of my first book "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond here is the second of a four post series where I would like to explore this story and tell you a **brief version of the History of Manufacturing**. In this second post I would like to explore **how the middle ages prepared the industrial revolution and the appearance of the steam engine**.

This series is actually a transcript of my *first lecture*, a German academic tradition where a new professor after a year or so gives a public lecture on a topic of his choice. The video of the entire lecture (in German with Subtitles) is available on YouTube.

The Video by AllAboutLean.com is available on YouTube as "History of Manufacturing (subtitles)(First Lecture Prof. Christoph Roser June 4th 2014)" at https://youtu.be/W0ciuc10Bcg

34.1 Advancement during The Middle Ages

Here I have a political map of central Europe around 1400. You can see a small black arrow in the middle; that is where we are [*the lecture was held in Karlsruhe, Southern Germany*], in the margravate Baden-Baden. We are surrounded by such distinguished and well-known lands like the Bishopric of Speyer, the Electoral Palatinate, the Countship of Württemberg, the Countship of Hohenberg, Bishopric of Strasbourg, the Countship of Hanau, and the House of Fleckenstein. As for *Flecken*stein, the name already says it all; they are nothing other than a spot on the map [German *Flecken* for stain or blotch]

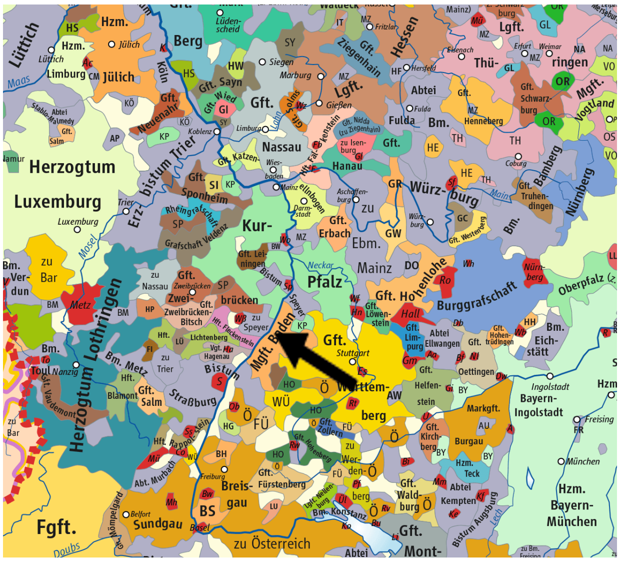


Figure 257: Political maps of Europe were very colorful around 1400 (Image Ziegelbrenner under the CC-BY-SA 3.0 license)

If the emperor of China or the emperor of Rome had said, “Craft is vulgar,” then that was the case for the whole world. In the Middle Ages, when the Lord of Hanau said, “Craft is vulgar,” things may have looked quite different only ten kilometers away.

Of course, some cities said, “Craft is vulgar,” but others furthered manufacturing and commerce. When manufacturing and commerce were promoted, the city prospered and the economy grew. Cities where manufacturing and commerce bloomed became rich. And over time, either by peaceful means or not-so-peaceful means, the cities that had manufacturing trade and commerce were taken over by the wealthy ones.

That means that the Middle Ages were the heyday of craftsmanship. An artisan was now somebody important. They were invited to parties. They also had good chances on the marriage market. As an artisan, they now had respect and were esteemed.

34.2 The Industrial Revolution, 1715

[If you are interested please see my previous post How a Little Bit of Industrial Espionage Started the Industrial Revolution for more details on this juicy story]

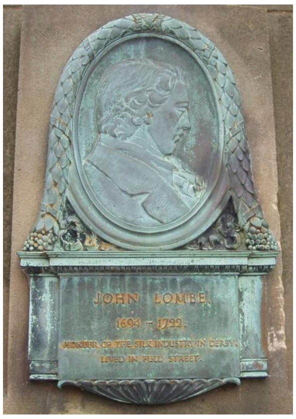


Figure 258: John Lombe (Image Steve Bowen in public domain)

The next major step forward was the Industrial Revolution. There are differing opinions about when the Industrial Revolution started. In my opinion, it began in about 1715. In England, a Mr. Lombe wanted to build a silk-spinning mill. At that time, spinning was the bottleneck in the textile manufacturing chain of production.

Lombe knew that there was already a similar machine in Italy. They had mechanized silk looms, though only on a small scale. Naturally, Lombe was interested. He learned Italian and traveled to Livorno, Italy. He bribed a priest in order to get a job in a factory, and then bribed the foreman so he could also work nights. During the day he worked in the factory, and at night he made drawings of the construction. This was classic industrial espionage.

That was not exactly the safest thing to do at the time. Italy wanted to protect its intellectual property. As was common at the time, such crimes were punished by death. Mr. Lombe's espionage was discovered, but he still made it on an English ship. The ship was just fast enough to escape an Italian warship. Eventually, both the drawings and Mr. Lombe arrived safely in England.

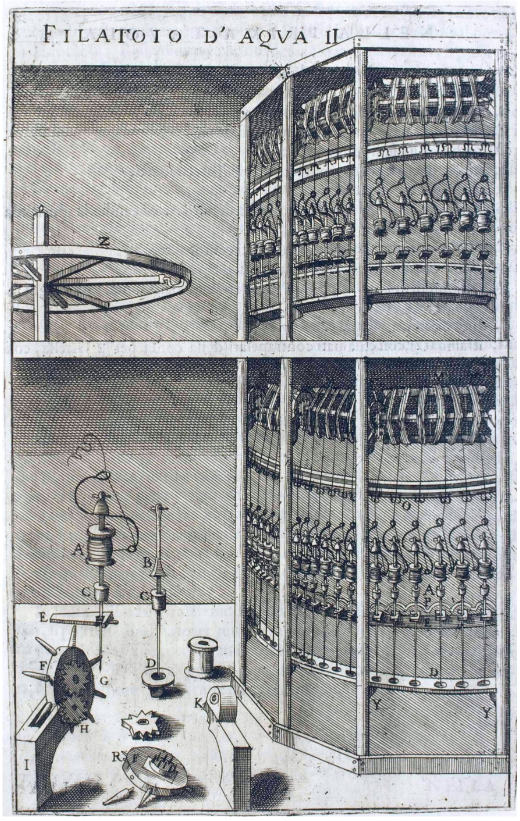


Figure 259: All there in the book… (Image Vittorio Zonca in public domain)

In hindsight, he would not have had to go through all that trouble. Someone already had published a book one hundred years earlier with quite detailed drawings of these machines, as seen in the picture on the right. The book was also available in the Oxford University Library, and Mr. Lombe could have checked it out there at anytime. Anyway, the knowledge and technology had successfully arrived in England. Naturally, Mr. Lombe then had "*his*" invention patented.

That did not sit well with the Italians. Shortly thereafter, a beautiful Italian woman showed up in England, became an employee of Mr. Lombe, and befriended him after that. Soon thereafter, Mr. Lombe died very young, very painfully, and under mysterious circumstances.

Public opinion knew immediately what happened: "The Italian witch poisoned him!" Luckily for the Italian woman, the English justice system was already quite advanced, using the presumption of innocence, "innocent until proven guilty." Since the court could not prove anything, they acquitted her. The woman then returned speedily to Italy.

Lombe's brother took over the company. Unfortunately, after a year, he was also dead. However, in this case the Italians could not be blamed, since Lombe's brother shot himself in the head.

The technology was in England. However, silk back then was a luxury good just as it is today. The volume market was cotton. Yet cotton has much shorter fibers, and therefore is more difficult to spin.

Figure 260: Sir Richard Arkwright (Image Mather Brown in public domain)

The first to improve the technology to spin cotton was Mr. Richard Arkwright, later knighted Sir Richard Arkwright. He took over Mr. Lombe's invention, improved it, and of course patented his improvement. He built the first water-powered cotton spinning mill, Cromford Mill, near Birmingham.

It was a smashing success. Arkwright became immensely rich. His son was the richest man in England. In a very short time, he had five other mills built, and a number of friends, acquaintances, relatives, and pretty much everyone who had money at the time followed his example. Within a few years there were about twenty mills built throughout the valley. Similar to today's Silicon Valley in America, this was – so to speak – the Cotton Valley.

The English also wanted to protect "*their*" intellectual property. Hence, as was common at the time, the export of machines, drawings, or skilled workers were forbidden, under penalty of death.

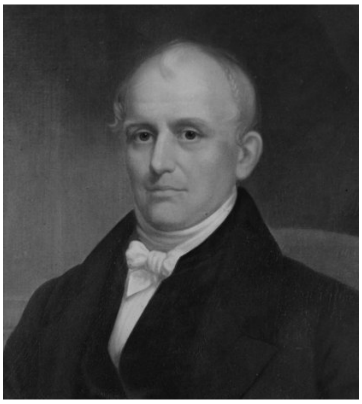


Figure 261: Samuel Slater, a Traitor? (Image James Sullivan Lincoln in public domain)

However, that did not stop everyone. For example, there was a Mr. Samuel Slater, who was a colleague of Mr. Arkwright. He was not just anybody; he was one of the engineers, and he knew the machines well.

Slater, against the law and under a false name, went to America. There he found a partner and built the first American spinning mill. Hence, Slater is revered as one of the fathers of the Industrial Revolution in America. The English, on the other hand, have another nickname for him: Slater the Traitor. From whichever perspective you look at him, he is either a hero or a traitor. In any case, the technology was in America.

Figure 262: Johann Gottfried Brügelmann (Image unknown author in public domain)

Germany jumped on the bandwagon too. Mr. Johann Gottfried Brügelmann also wanted to start cotton spinning. History repeats itself. He went to England, got a job at Arkwright's Cromford Mill, worked there during the day, made drawings at night – you know the story already – and brought the technique back to Germany.

As a German, I am especially happy to tell you that Brügelmann has been the only one to honor his source. Because of Brügelmann, there is now a Cromford Mill in the Ruhr area in Germany, named for its role model, Cromford Mill in England.

Due to the mechanization of spinning, one could now spin much faster. It was more efficient, the quality was better, and therefore it was also cheaper.

Finally, it is estimated that at its peak, half of all the cotton that is made in the world was processed in England. This means that cotton from India was shipped halfway around the world to England, where it was spun and woven. Then the finished cloth was shipped back halfway around the world to India, where it was sold. That was cheaper than spinning it by hand in India.

Faster, better, cheaper! That is, in my opinion, the beginning of the Industrial Revolution.

34.3 The Steam Engine, 1775

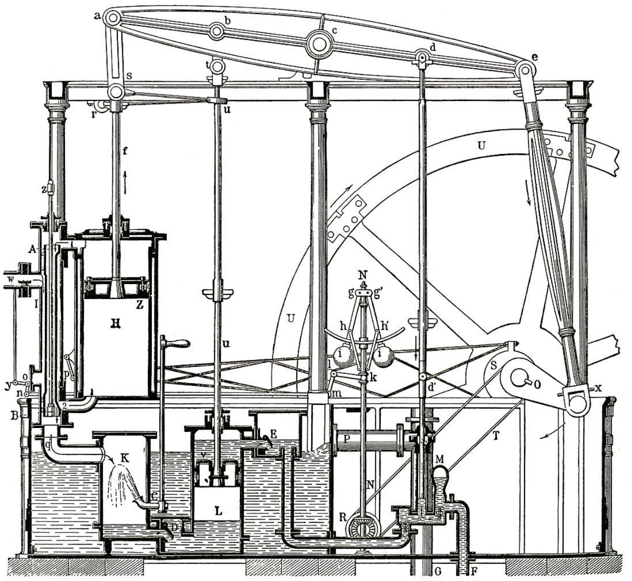


Figure 263: Steam Engine (Image Ulrich.fuchs in public domain)

The second important event in the Industrial Revolution was of course the steam engine. There had been other steam engines before, but they were not particularly effective. The first truly effective steam engine was invented by Mr. James Watt, patented in 1775. Together with his partner, Matthew Boulton, founder of the Soho Factory, they produced and sold steam engines. Protected by their patent, they were soon able to dominate the world market. Boulton and Watt were the most important and significant producers of steam engines.

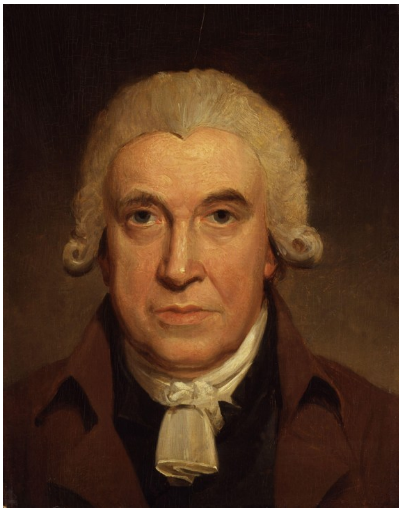


Figure 264: James Watt (Image Henry Howard in public domain)

Mr. Watt was a quirky sort of inventor. Often he buried himself in his office for weeks and conducted experiments, for example to find out how he could make a gasket just a bit better.

Figure 265: Matthew Boulton (Image unknown author in public domain)

On the other hand, however, he was not exactly socially adept. When he was in a particularly bad mood, he was known to fire even key employees. Boulton, however, caught them at the factory gates and told them to stay, keeping them out of sight from Watt for the next two weeks. Boulton, so to say, stopped the “brain drain” from happening.

Boulton and Watt had one challenge with the manufacturing of steam engines. That was the cylinder. The technology to drill a good cylinder did not yet exist. The cylinders were hammered out or forged. If you can imagine having to forge a cylinder with a hammer … that is pretty inaccurate.

Figure 266: John Wilkinson (Image Lemuel Francis Abbott in public domain)

The first to get it right was John Wilkinson, nicknamed "Iron Mad." He was the first to build good cylinder-boring machines, and therefore was soon the main supplier for Boulton and Watt's Soho Factory.

Mr. Watt was very proud of Wilkinson's cylinders. For example, he stated that the cylinders were so good, so precise, and the gap between the cylinder and piston was so perfect, that he could not stick even a coin in it! Just to show you an example about the expectations on precision at that time.

The steam engine changed the world. Earlier, with water or wind power, you were limited either to where water or the wind was, and then hoped that no drought or dead calm came, and that the wind blew and the water flowed. That means that production was utterly dependent on environmental conditions.

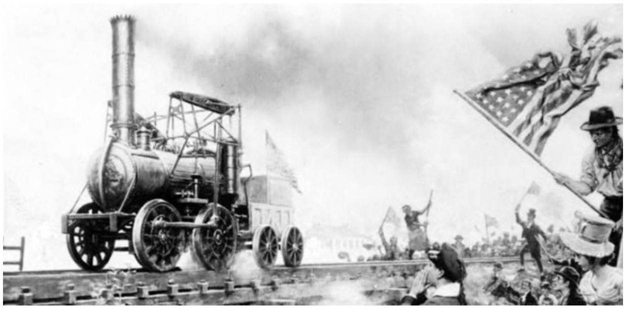


Figure 267: Stourbridge Lion (Image Clyde Osmer DeLand in public domain)

However, with the steam engine, energy was available everywhere. With the steam engine, you had power and energy for operating machines anywhere. The steam engine also had huge synergies. For example, there was now a need for metalworking.

Thus, metalworking rapidly improved. Similarly, the steam engine was also soon strong enough to transport itself. Hence … railroads! If you had a train, then you also needed rails, resulting in a demand for metal, especially iron and steel. Ironworking developed quickly. Many different techniques evolved based on the steam engine and spinning machines. Because of that, production became better, faster, and above all, cheaper.

All this technical advance made life a lot easier for many. However, it also threatened the livelihood of many others, as you will see in my next post.

In this series of post I only give a rough overview of the history of manufacturing. If you would like to read more about this history, then check out my book on the history of manufacturing:

> *Roser, Christoph, 2016. "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, 439 pages, 1st ed. Productivity Press.*

Now go out, learn the lessons of history, and **organize your industry!**

35 The History of Manufacturing – Part 3: Luddism to Henry Ford

Christoph Roser, August 30, 2016, Original at https://www.allaboutlean.com/firstlecture_hom_3/

Figure 268: Ford assembly line 1913 (Image unknown author in public domain)

Most of our prosperity and wealth is based on our ability to manufacture faster, better, and cheaper than ever before. To announce the publication of my first book "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond here is the third of a four post series where I would like to explore this story and tell you a **brief version of the History of Manufacturing**. In this third post I would like to talk about the **social problems caused by the industrial revolution and its outburst of Luddism before moving on to the achievements of Henry Ford and his assembly line, but also how his firm was overtaken by GM.**

This series is actually a transcript of my *first lecture*, a German academic tradition where a new professor after a year or so gives a public lecture on a topic of his choice. The video of the entire lecture (in German with Subtitles) is available on YouTube.

The Video by AllAboutLean.com is available on YouTube as "History of Manufacturing (subtitles)(First Lecture Prof. Christoph Roser June 4th 2014)" at https://youtu.be/W0ciuc10Bcg

35.1 Social Unrest: Luddism

Figure 269: The Leader of the Luddites (Image unknown author in public domain)

All this technical advance was altogether a good thing, making products faster, better, and cheaper. Unfortunately, not everyone benefited.

Mainly the workers that made their living by weaving had a drop in social hierarchy. This happened not slowly, but very quickly. Within ten to twenty years, the income of weavers was halved. Half of their money was gone. At the same time, prices skyrocketed because of inflation.

Altogether, this meant that a weaver who had been a respected member of middle class ten or twenty years ago was now poor pauper. He fell from the middle class into the lower social class. The weavers were of course not happy with that. As always, when people are unhappy, there is an uprising. They destroyed mechanized looms and spinning machines, they burned down factories, and they even murdered some of the factory owners.

Figure 270: George likes his head, too! (Image Allan Ramsay in public domain)

The king of England at the time was actually a rather liberal and cosmopolitan man. However, his French colleague had also had a revolution a few years earlier: the French Revolution. And we all know how that went for the French king – off with his head. And the English king was definitely not THAT liberal.

Hence, the king set a massive army and police force of 40,000 men in motion to try to stop the revolution. At that time, 40,000 men would have been enough to attack another country.

These 40,000 men put down the revolution violently. There were a couple of death sentences, and a few were banished to Australia. Ultimately, the Luddites had failed to reach any of their goals. They wanted a fair wage, a ban on machines, and essentially the return to their former status quo before mechanization. However, they did not achieve any of their goals.

On the other hand, however, you have to say, "*Thank goodness they didn't!*" The shirt that I am wearing now cost about fifty Dollar. EUR 49.95, to be exact. Because it is machine spun, machine woven, and machine sewn. If that shirt was hand spun, woven, and sewn, it would not be fifty Dollar. It would be more like five thousand Dollar for such a shirt. And believe me, in this case I would have a lot more space in my closet. Ultimately, mechanization made it faster, better, and cheaper, hence that this shirt cost only fifty Dollar rather than five thousand.

35.2 Henry Ford and Mass Production

Figure 271: Henry Ford and Model T (Image Ford Motor Company in public domain)

Another step forward was Henry Ford and his Model T, probably the most famous car in history. Henry Ford optimized production through efficiency and productivity. For example, in a motor block, different holes have to be drilled. Until Ford, a different drill was used for every different hole, meaning each hole was drilled separately.

Henry Ford, however, built a drilling machine that had twenty drill bits in the right places, at the right length, and with the right diameter. That means that on the motor block, with one down-and-up movement, twenty holes were drilled perfectly.

With such an approach, Henry Ford enabled great improvements, allowing him to reduce the price of the Model T. His greatest achievement in production, and for which he is best known, was the assembly line. Ford was not the first to use the assembly line. There had been earlier factories with assembly lines. However, he most consistently implemented it for a technically complex high-end product.

Figure 272: Ford assembly line 1913 (Image unknown author in public domain)

The picture shown is the assembly of the alternator. We are not entirely certain where the first Ford assembly line was installed, but it could have been for the alternator. There the workers on the assembly line worked in a row. That means that Ford could regulate the speed and could give each worker a smaller task. With a small amount of work and a predetermined speed, the people learned faster, worked faster, and it became faster, better, and cheaper.

Through that, Ford could lower the price of the Model T dramatically. In 1908, when the Model T first came on the market, it cost about 25,000 Dollar in today's prices. The car was not really luxury class, but not exactly cheap, although at that time it was one of the cheapest cars that you could buy. All others were closer to a million Dollar, similar to a Rolls Royce.

Ford therefore consistently worked toward making it cheaper, and twenty years later you could have the same car for 4,500 Dollar. And 4,500 Dollar for a car is not that much money. The model therefore sold well, and Henry Ford with his Model T was the largest automobile manufacturer in the world, with over 50 percent of the market share.

35.3 Relevance of Flexibility

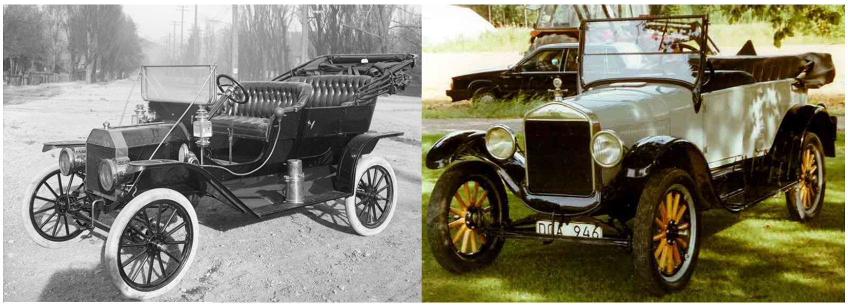


Figure 273: Ford Model T 1910 and 1926 (Image Harry Shipler in public domain and Lars-Göran Lindgren Sweden under the CC-BY-SA 3.0 license)

Ford's concept, however, did have weaknesses. Here I have two pictures of the Model T. The top one is a 1910 version, and the bottom one is the 1927 version.

Technically, they are practically identical. The most important technical change was changing the lamps from acetylene, which had to be lit with a lighter, to electric. Otherwise, it was exactly the same car aside from a couple of cosmetic changes to lower production costs and make the cars less expensive. Beyond that, there were no major changes.

In order to start the vehicle, you had to get out and turn a crank, and hope that it did not backfire – which could have broken your wrist. That is how they started engines back then. In 1908 that was acceptable. However, in 1927 it really was not anymore. Nevertheless, from Ford's perspective, the Model T was the car for eternity. There would always be Model T's. If things had gone Ford's way, then you could go to a Ford dealer today and buy a brand-new Model T with the best technology from 1908.

By 1927, however, that was outdated. Imagine if I were to try to sell a twenty-year-old mobile phone today. After twenty years of rapid development, customers just do not want the old stuff anymore. Eventually, and with a heavy heart, Ford gave up the Model T and introduced the Model A.

However, he still had parts for the Model T to last another six months. He could not just throw them away, so for another six months he had to keep producing outdated Model T's. Finally, the parts were used up and Ford could rebuild the factory.

However, he needed six months to reconfigure manufacturing. Every machine was optimized for the Model T. Some of the machines he could only throw out. Few of them could be remodeled. Just one quarter of the machines were usable as they were. That means that for six months, Ford did not produce a single car. Imagine, in your industry, not making a single product for six months! However, Ford had money. He survived the six months financially, and the Model A became his new car for eternity.

But it was not quite as eternal as he envisioned. Just three years later, the sales figures dropped and Ford introduced the Model B. The rebuilding went much more quickly and did not take six months, but the manufacturing site stood for five months without producing a single car. Hence, flexibility was not one of Ford's strengths. His vision was more about a car for eternity.

The competition, General Motors, did it quite differently. GM, under the leadership of Alfred P. Sloan, celebrated each new model. Every year a new model came out. In 1927, the Series

AA Capital was the first car to take away a significant portion of Ford's market. Then a year later came the Model AB, AC, AD, AE, BA … every year a new model.

Figure 274: Chevrolet Models 1927-1932 (Images Lars-Göran Lindgren Sweden under the CC-BY-SA 3.0 license)

GM celebrated those new models. Where Ford had consistency and permanence, GM always had something newer, better, and more glamorous. Of course, they did not construct a completely new car. However, there were updates that were presented as newer, better, and more glamorous. Therefore, those cars sold better. Relatively quickly, GM became the largest car producer in the world. GM remained in that top spot for decades. It was only in 2012 that Toyota took over that title.

Now Toyota is the largest car manufacturer in the world. Yet Toyota also did something special with their production system, as you will see in the next post.

In this series of post I only give a rough overview of the history of manufacturing. If you would like to read more about this history, then check out my book on the history of manufacturing:

> *Roser, Christoph, 2016. "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, 439 pages, 1st ed. Productivity Press.*

Now go out, learn the lessons of history, and **organize your industry!**

36 The History of Manufacturing – Part 4: Toyota and Lean

Christoph Roser, September 06, 2016, Original at https://www.allaboutlean.com/firstlecture_hom_4/

Figure 275: Toyota Logo (Image Toyota for editorial use)

Most of our prosperity and wealth is based on our ability to manufacture faster, better, and cheaper than ever before.To announce the publication of my first book "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond here is the fourth and last post of a series with a brief version of the History of Manufacturing. In this post I would like to talk about Toyota and its Toyota Production System, the archetype of lean Production, and also about computers and automation.

This series is actually a transcript of my *first lecture*, a German academic tradition where a new professor after a year or so gives a public lecture on a topic of his choice. The video of the entire lecture (in German with Subtitles) is available on YouTube.

The Video by AllAboutLean.com is available on YouTube as "History of Manufacturing (subtitles)(First Lecture Prof. Christoph Roser June 4th 2014)" at https://youtu.be/W0ciuc10Bcg

36.1 Lean Production since 1950

Figure 276: Japanese Warrior Spirit (Image Felice Beato in public domain)

Toyota developed a new concept of "lean manufacturing." Toyota recognized that inventory was a major cost factor for production. Consequently, they reduced waste, and the largest waste of them all was excess material. By optimizing this excess, Toyota developed lean production. Many different influences shaped the Toyota Production System. For one, the Japanese have a very strong work ethic, a certain drive to perfection. It does not matter if it is a tea ceremony or the construction of a car – they want to do it perfectly. Ford also was a major influence. Toyota learned a lot from what Ford did wrong.

Figure 277: We Can Do It! (Image J. Howard Miller in public domain)

During World War II, America also had a "Training Within Industry" program (TWI). For example, in the picture, the woman flexing her muscles is Rosie the Riveter. TWI was an American program designed to improve the quality of airplanes so that they could be built faster and better.

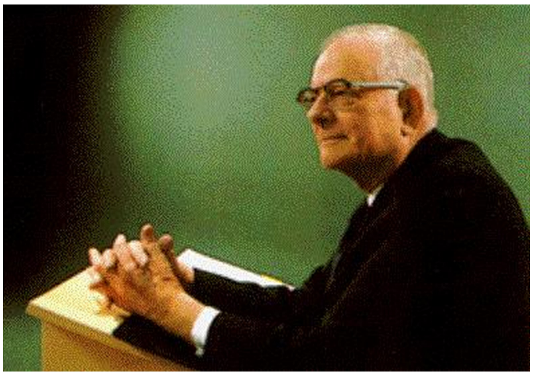


Figure 278: W. Edwards Deming (Image FDA in public domain)

That program was highly successful. However, after the war was over, the program just died. Everyone went back to the old system. All of the consultants who had taken part in the program were looking for new projects. This includes one Mr. Deming. He went to Japan and brought the TWI methods to Toyota. This also influenced Toyota's production system.

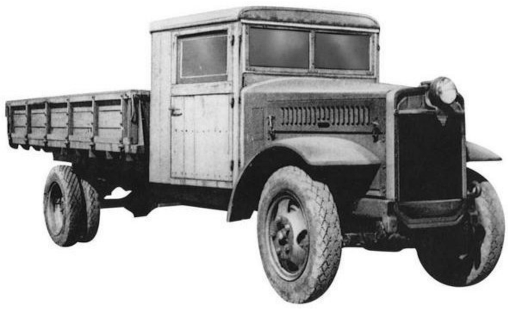


Figure 279: Toyota KC Truck (Image unknown author in public domain)

Figure 280: B-29 over Japan (Image United States Army Air Force in public domain)

Another influence was the constant lack of materials in Japan before, during, and after the war. That means that Toyota had to learn how to produce with fewer materials. This approach was of course cheaper. This picture of a truck is one example. If you look closely, you will see that there is only one headlight. If you could look inside, you would see that the brakes were only on the front axle, but not the rear axle.

The folks at Toyota were not at all happy about that. They would have rather had two headlights. However, Toyota learned to work with few materials, and created a very efficient, lean, and productive production system. Using this system, they produced faster, better, and above all, cheaper.

It was around 1970 that Toyota steamrolled their products into the American market. The Americans rubbed their eyes with bewilderment. Thirty years earlier, they ultimately and definitely defeated the Japanese with two atomic bombs. Now Toyota was bringing cars into the American market that were better and cheaper than those of U.S. makers. A better quality with lower costs. That could not be!

That led to a major study by the Massachusetts Institute of Technology (MIT), with the goal of finding out what had changed. MIT compared different car manufacturers from around the world and determined that Toyota required half the man-hours to build a car in comparison with other manufacturers.

General Motors, for example, needed twice as many people as Toyota to build a car. Germany's results did not turn out any better either. The study determined that for every worker who built cars, another worker was needed to correct all the mistakes that had gone wrong during the initial production.

Toyota did not need that. That means that the people at Toyota could produce considerably faster, better, and cheaper. Through that, Toyota ultimately rolled into the American market. The idea of the Toyota Production System is recognized today as the best production systems. Of course, it is not called the "Toyota Production System" today, but rather "lean production."

If you are working in or with industry, you will certainly have encountered the term "lean production." Industry tries to imitate what Toyota did – to produce leaner, faster, better, and cheaper.

Of course, there were also other important influences for production. We have already discussed mechanization of weaving looms and spinning machines.

36.2 Computers and Automation

Figure 281: Bell 47 (Image unknown author in public domain)

Another important step forward was automation through computers. Here I show you two examples. The first is the numerical control (NC) machine. The first NC machine was developed by John Parsons. He worked in helicopter manufacturing.

Calculating a good shape of the rotor blade was possible, but actually manufacturing this complex shape was difficult. John Parsons was the first to do it. They calculated a table of X and Y positions. One worker was dictating numbers while the other was setting these numbers on a drill and drilled the holes. Using two hundred holes, such a form was formed preliminary and then reworked. Through this, Parsons was the first to control manufacturing with a computer.

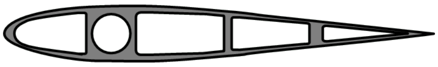


Figure 282: Helicopter Profile (Image Roser)

However, it was quickly found that setting those numbers by hand was cumbersome. This could also be done by computer. To solve the technical details, John Parsons teamed up with the Massachusetts Institute of Technology to advance computer-controlled machines. MIT thought the idea was so great that they tried to force John Parsons out of the project. They wanted it to be MIT's idea, and not John Parsons'! Parsons was not even invited to the presentation of his own product to the customer.

For twenty or thirty years, Parsons was squeezed out by academia, since it was "an MIT idea." Only thirty years later was his effort recognized, and John Parsons is now considered the father of the NC machine.

Figure 283: Unimate (Image Roser)

Another important subject is industrial robots. The first of these was invented by George Devol around 1954. He built UNIMATE, the first industrial robot. This does not look like a modern industrial robot with a hand and joints, but more like something that can move up and down, right and left, and forward and backward. However, it was able to move parts on a production line. In particular, the robots moved freshly cast and still blazing hot motor blocks in a General Motors factory. In general, robots soon took over whatever was difficult or uncomfortable for humans.

However, it took some time before that was cost effective. The first important customer for the NC machine was, for example, the United States Air Force. After World War II, the U.S. Air Force had nearly unlimited funds, and money was not a problem. Industry, on the other hand, had to make sure that it was profitable. It took a rather long time for computers in manufacturing to become truly cost effective.

Figure 284: GM Logo (Image General Motors for editorial use)

An important player was the head of General Motors, Roger Smith. Smith had a vision of automation. In 1980, a Japanese wave of cars swept through America. His vision was to counter this economic onslaught with automation and robots. Automate as much as possible! Use as many robots as possible! Smith put (in today's numbers) 100 billion – not million – 100 billion Dollar into the robotization of his factories. And, with cocky confidence, everywhere at once rather than bit by bit.

Unfortunately, that did not work out at all. The factories were extremely unproductive. The robots did all kinds of shenanigans but produce. Someone called it computerized chaos. Smith wasted 100 billion Dollar and eventually lost his job. Thereafter, however, the robot industry did work well. Thanks to Smith, there were lots of workers qualified in the implementation and use of robotics. They had made their mistakes elsewhere and now knew how to do it better.

Robotization has not yet reached its end. We are still in the middle of automation. Every year there is more. Every two years, the speed of computers doubles. There are estimates that within twenty years, half of all jobs will be replaced by computers.

Maybe interesting for you: Jobs lost are not so much industrial or mechanical engineers, but rather shop floor operators, taxi drivers, and truck drivers that will be replaced by computers. It will be very interesting to see how the future develops.

I have told you a lot about manufacturing now. The most difficult thing for me was to decide what NOT to talk about. I could also have told you stories for three hours straight, but I think that would have been too much for you.

36.3 Want More?

Anyway, if this topic is of interest to you, I am currently writing a book about the history of manufacturing. This will tell you many more stories that happened in manufacturing history. Besides that, on this blog "All About Lean," I also talk about the history of manufacturing in addition to the core topic of lean production. If you're interested, then check out the "History" category on my blog.

Otherwise, my sincerest thanks for your attention. I hope that it was as interesting for you to listen [*read*] as it was for me to talk [*write*] about it. Thank you.

In this series of post I only give a rough overview of the history of manufacturing. If you would like to read more about this history, then check out my book on the history of manufacturing:

> *Roser, Christoph, 2016. "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, 439 pages, 1st ed. Productivity Press.*

If you are interested only in lean history, see:

Roser, Christoph. "The Origins of Lean Manufacturing and Lessons for Today. **Keynote Presentation**." In Proceedings of the European Lean Educators Conference. Buckingham, England, 2016.

Now go out, learn the lessons of history, and **organize your industry!**

37 Happy 3rd Birthday AllAboutLean.com

Christoph Roser, September 13, 2016, Original at https://www.allaboutlean.com/3rd-birthday/

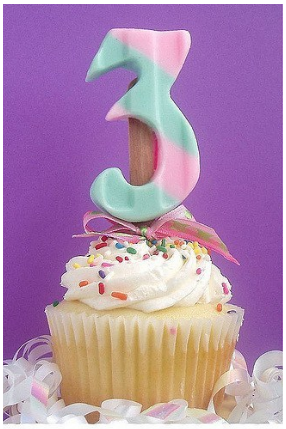


Figure 285: 3rd Birthday (Image soapylovedeb under the CC-BY 3.0 license)

Yayyy! AllAboutLean.com is now 3 years old! Three years ago on September 1, 2013, I became a professor and wrote the first post on my blog. Now, 163 blog posts and one book later, I am still enjoying it immensely!

I feel that after three years of weekly (longer) postings, I am now no longer a newbie but a part of the established crowd. Thanks to all my readers for reading 🙂, and time to look back at the last year!

37.1 Most Popular Posts

Figure 286: Top 10 (Image Roser)

The most popular posts during the last 365 days are unsurprisingly mostly about hands-on topics on lean manufacturing, plus one about a major current hype in the industry. Here are the ten most popular posts on AllAboutLean.com:

- Basics of CONWIP Systems (Constant Work in Progress): How does a good pull system work for low-quantity high-variety parts? CONWIP is a good contender here.
- SMED – Creative Quick Changeover Exercises and Training: Yes, the good old SMED. What would lean be without it?
- A Critical Look at Industry 4.0: Now this is a major hype, especially in Germany. However, if you look behind the scenes, you will find not much besides flowery language. The implementation is much more difficult than the ideas behind it.
- How to Measure Cycle Times: It is surprising how much you can do wrong with such a (seemingly) simple and common measurement as the cycle time.
- Theory of Every Part Every Interval (EPEI) Leveling & Heijunka: Leveling: Very popular, often difficult, and (unfortunately) also in many instances counterproductive.

- All About Swim Lane Diagrams: The value stream map for the office ☺
- Overview of Value Stream Mapping Symbols: The value stream map for manufacturing ☺
- Ten Rules When to Use a FIFO, When a Supermarket – Introduction: My own research, which I haven't seen anywhere else. Frankly, I am quite proud of it. ☺
- The (True) Difference Between Push and Pull: This one was a bit controversial. I am still convinced that pull means an upper limit to the inventory, but there are many other opinions out there.
- How Many Kanbans? – The Kanban Formula: The most popular post is about the mathematics for the kanban formula – which is far from easy. Despite the perceived accuracy of a complex formula, the kanban formula is only marginally better than guesswork!

37.2 Selected Praise

- I really like how easily you describe Lean Management topics. This is for use one of the best Lean Management blogs for me.
- Enjoyed reading this. A crucial topic. look forward to the next installment.
- A great help – thank you, very clear explanations too.
- This is very helpful. Huge thanks to this.
- Important concept. Well explained. Well done.
- It was really wonderful reading your blog. Very nicely written !
- such an abundant shared knowledge.. I will surely share this one too... Thanks to this article.
- It is really interested topic. What a nice blog is that ! I should have known about it for a while!
- Your posts are of awesome quality. Thank you so much.

37.3 What Else is New?

Well, of course, my book is out. A detailed look at the history of manufacturing! If you are even remotely interested in how modern manufacturing came together, then this book is for you ☺.

> *Roser, Christoph, 2016. "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond, 439 pages, 1st ed. Productivity Press.*

I also greatly expanded my glossary. At the time of writing, it included 310 different terms related to Toyota and lean manufacturing. With 16,000 words, it is almost a (thin) book on its own. And, I still regularly add more terms as I come across them. If you think I miss something, let me know.

My offer to answer manufacturing-related questions also turns out to be popular, and I get regular questions from practitioners in the field. Luckily, so far I can still manage the workload. Of course, I also get tons of messages from people wanting to sell me Facebook contacts, optimize my website, and monetize my content, but those I mostly ignore.

I write AllAboutLean.com not to get rich or to make money, but to spread knowledge on lean manufacturing. Hence there is only a little and hopefully unobtrusive advertisement, although this does not even cover the running costs.

37.4 Reader Statistics

Figure 287: I love my readers! (Image Roser)

The number of clicks is (unfortunately) no longer growing exponentially. Hence, World Domination by me though exponential growth is now postponed. But I still get 1000 to 2000 page views per day (depending if you believe the WordPress or the Google statistics). Almost 1000 people subscribed my email list with updates of new posts, with more on LinkedIn and other social network sites.

What I particularly like is that less than 10 percent of the visitors leave after seeing only one page (whereas the bounce rate of comparable sites is over 50 percent). It seems AllAboutLean.com is something that is of interest. The average reader also spends almost 3 minutes on my site per visit, which is much more than other comparable blogs.

37.5 Summary

With every post I write, I learn something new. I also have lots of interactions with my readers (You! 😘😘😘) on my blog and on LinkedIn. This is still the reason I write. To learn, and to get to know people in the field. I am looking forward for the future! In the meantime, **go out and organize your industry!**

38 The Many Different Flavors of the OEE

Christoph Roser, September 20, 2016, Original at https://www.allaboutlean.com/oee-flavors/

Figure 288: Variants of the OEE (Image Roser)

If imitation is the sincerest form of flattery, the OEE (Overall Equipment Effectiveness or Efficiency) is indeed one of the most appreciated measures in lean. **I counted at least eight different variants and adaptions of the basic OEE – although let me tell you that I am not impressed with all of them.** Many of them seem to be theoretical academic constructs with little meaning for your shop floor. Also, identical acronyms and similar terms are often used in a completely different way, adding quite a bit to the confusion. On top of that, I think the OEE is used way too much in industry where it does not make sense, and many OEE numbers are heavily fudged. Anyway, let me show you the many different flavors of the OEE.

38.1 OEE and Synonyms for the OEE

Figure 289: All synonyms (Image Roser)

The OEE is is the relation of the number of **parts produced on a machine versus its theoretical maximum capacity.** Or, alternatively, the OEE is the relation of the minimum time required to produce a number of goods versus the actual required time. Both approaches will lead to the same number. For more on OEE, see my series of posts starting with What is OEE? – Definition of OEE.

$$OEE = \frac{Actual\ Good\ Units}{Maximum\ Good\ Units}$$

Note: In German, the abbreviation GAE for *Gesamtanlageneffektivität* is also used as a synonym for OEE.

38.1.1 OPE: Overall Process Efficiency

Figure 290: Clearly not machines! (Image Cherie A. Thurlby in public domain)

The OEE stands for Overall Equipment Efficiency (i.e., a focus on the *"equipment"*). However, you can also calculate an OEE for operators (i.e., people). The underlying calculations are the same, although it is a bit more difficult to get good data, not to mention the cooperation of the operators.

Anyway, since this OEE was not for equipment but for people, it was named OPE for Overall People Efficiency or Effectiveness. However, the workers soon complained about being *reduced to a number*, and the *Overall People Efficiency* was quickly renamed to the much more neutral *Overall **Process** Efficiency,* where a process could be a machine, a worker, or pretty much anything else. The calculations are unchanged to the OEE.

38.1.2 OAE: Overall (Production) Asset Efficiency

Yet another term that (as far as I know) is synonymous to OEE.

38.2 Utilization Variants for a Process

The OEE by itself is a sort of utilization. What you produced on a machine versus what could you have produced. A few OEE variants stick with this basic approach.

38.2.1 TEEP: Total Equipment Effectiveness Performance

Figure 291: Open 24/7 (Image Roser)

TEEP was introduced to fix a perceived problem of OEE. The availability losses are the losses due to process stops. However, sometimes you turn off your process intentionally (e.g., when your plant closes at night or on Sundays). The OEE gives you the option to include or exclude this time (more on this at How to Measure OEE). Naturally, excluding times makes your OEE look better – although your system is unchanged. Nowadays many plants also exclude planned maintenance and other planned stops – which I disagree with.

The TEEP is an attempt to fix this number fudging by simply requiring a 24-hour-7-day-a-week time basis. Any and all times are included for the OEE calculation, no matter what.

Personally, while I like the direction, I think this is overkill. First, you can already do this with the normal OEE. Secondly, if your plant is really closed, then in my view it is often not sensible to include these times. In any case, the TEEP is the OEE with an around-the-clock time basis.

38.2.2 PEE: Production Equipment Efficiency

Figure 292: PEE … (Image Pbrundel under the CC-BY-SA 3.0 license)

PEE is a most unfortunate abbreviation, I must say. Anyway, remember the three loss groups – availability, speed, and quality losses? Sometimes you see a formula where the OEE is calculated by multiplying the availability rate, performance efficiency, and quality rate. The formula is then:

$$OEE = A \cdot P \cdot Q$$

First of all: I do not like this formula and find it a bad way to calculate the OEE. For more on this, see my post Good and Bad Ways to calculate the OEE.

The PEE then introduces the weights k1, k2, and k3 to the different factor.

$$\mathrm{OEE} = \mathrm{A}_{\mathrm{k1}} \cdot \mathrm{P}_{\mathrm{k2}} \cdot \mathrm{Q}_{\mathrm{k3}}$$

where $0 \leq k_n \leq 1$ and $\sum_{n=1}^{3} k_n = 1$

The idea is that you can give more weight to the factor (availability, efficiency, quality) that you consider more important. I didn't like the original formula to begin with, and adding arbitrary weights makes no sense at all to me. Luckily I have not yet seen this formula used in practice. Don't let your factory be the first to start *PEEing* around!

38.3 Utilization Variants for an Entire System

Figure 293: More than one process … (Image unknown author in public domain)

The OEE is a tool to show the utilization of a process and (more importantly) to point out how to improve this process. Naturally, there is the desire to also have a sort-of OEE for an entire line or an entire factory. Let's look at the metrics.

38.3.1 OTE: Overall Throughput Efficiency

This is also sometimes Overall Throughput Effectiveness, which is a direct expansion of the OEE to the whole factory. The OEE can be calculated as follows:

$$\text{OEE} = \frac{\text{Actual Good Units of Process}}{\text{Maximum Good Units of Process}}$$

The OTE simply expands this to the whole factory:

$$\text{OEE} = \frac{\text{Actual Good Units of }\textbf{Factory}}{\text{Maximum Good Units of }\textbf{Factory}}$$

This makes sense. The thinking behind this OTE equation is sound. The problem is: What is your maximum number of good units for your factory? If it would be flow production (e.g., an assembly line), I would use the cycle time of the slowest process to calculate the maximum number of parts possible. Unfortunately, this does not work for job shops and complex factories. There are research papers out there with a lot of complex math to do this – but I don't trust these calculations very much. Hence garbage in, garbage out for an otherwise sensible metric.

As well, while the metric may be sensible, it is difficult to determine the sources of the losses. It is hard to determine exactly why you produced less than possible. Understanding the complex interactions of many processes is nearly impossible. Therefore, in my view it is difficult to use the OTE for actual improvement processes.

38.3.2 OLE: Overall Line Efficiency

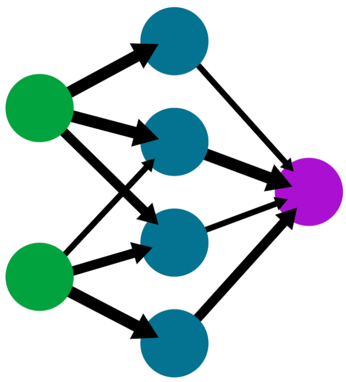


Figure 294: Neural net (Image Wiso in public domain)

The goal is – again – to represent the utilization of a line. This OLE approach uses the OEE of the individual processes, and merges them together in a joint number. There are different ways to merge the individual OEEs into an OLE – but all of them seem to be mostly academic. One approach uses fuzzy logic while another uses neural networks and learning algorithms. In my view, both are unsuitable for the shop floor.

38.3.3 OFE: Overall Factory Efficiency

This originates from semiconductor fabrication, and hence is also sometimes called Overall (semiconductor) Fab Efficiency. The OFE claims to be a further development based on the OEE that looks at the entire factory. However, the underlying metrics are completely different. While the good old OEE looks at parts produced and times required, the OFE looks almost exclusively at cost. Hence, it has little to do with the original utilization-related OEE but is more of a cockpit or dashboard with many different metrics related to the factory.

You then distribute weights to your different cockpit KPIs, multiply the KPI with a weight, and create a overall sum. It is somewhat similar to the PEE above, but with many, many more variables. Which ones you pick is up to you.

$$\mathrm{OEE} = \mathrm{A}_{\mathrm{k}1} \cdot \mathrm{P}_{\mathrm{k}2} \cdot \mathrm{Q}_{\mathrm{k}3} \cdot \mathrm{OnTimeDelivery}_{\mathrm{k}4} \cdot \mathrm{InventoryTurnRate}_{\mathrm{k}5} \cdot \mathrm{ProductionVolume}_{\mathrm{k}6} \cdot \ldots$$

Again, I don't see the benefit of this at all. If for some reason you want to mash everything together in a number, this is a possibility, but … why? The number is un-understandable and has next to no meaning.

38.4 MCE: Manufacturing Cycle Efficiency

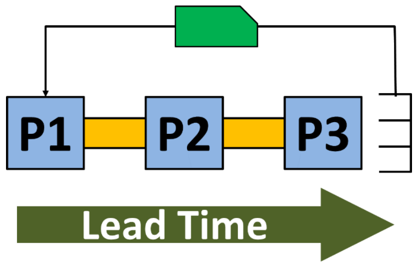


Figure 295: Lead Time (Image Roser)

The MCE is something different. Rather than looking at the number of parts produced, this looks at the lead time of a system. The MCE is the time an individual part was actually worked on (i.e., the value-added time) through the total time the part was in the system (i.e., the lead time).

$$\mathrm{MCE} = \frac{\text{Value Add Time}}{\text{Lead Time}}$$

This is a useful metric if you are more interested in the lead time than the takt time (production rate). A similar metric is already in use in value stream mapping, where the percentage of the time in value add is calculated. However, don't expect large numbers of 70%-90% like for the OEE. The MCE is usually rather low, often around 0.05%, meaning a part is worked on only 1/2000th of the time it is in the system; 99.95% of the time the part is waiting around.

38.5 Summary

As you have seen, there are lots of different OEE variants and flavors. OPE and OAE are merely synonyms. TEEP is also almost the same, with the limitation of around-the-clock as a time basis. For an entire line, you could use OTE – if you manage to get the required data on the maximum capacity of the line. If your focus is lead time rather than production quantity, then MCE is a possibility. Stay away from OLE, OFE, and PEE. Now **go out, figure out where your system has its losses, and organize your industry!**

39 Can you tell your Bottleneck from your Inventory?

Christoph Roser, September 27, 2016, Original at *https://www.allaboutlean.com/bottleneck-direction-inventory/*

Figure 296: Hourglass (Image Nile in public domain)

On the shop floor it is common wisdom to find the bottleneck based on the inventory. If the buffer is full, the bottleneck is downstream. If the buffer is empty, the bottleneck is upstream. **Is this true?** My student Carolin Romeser and I spent quite some time verifying this, and found some interesting results. In general it is true, but … the devil is in the details.

39.1 Introduction

First, we need to define a bottleneck exactly:

> *Bottlenecks are processes that influence the throughput of the entire system. The larger the influence, the more significant the bottleneck*

In a production system (or also other systems), **a buffer fills up if the bottleneck is downstream and the buffer empties if the bottleneck is upstream** as shown in a) and b) below. The bottleneck is the cause, and the buffer behavior is the effect.

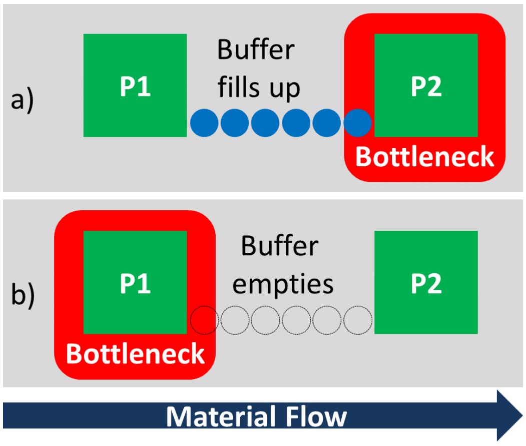


Figure 297: Buffer Bottleneck Relation (Image Roser)

Now, in industry and also many academic papers and methods (mine included), this relation is then used to find the bottleneck:

- If the buffer is (rather) **empty**, then the bottleneck must be (probably) **upstream**
- If the buffer is (rather) **full**, then the bottleneck must be (probably) **downstream**

It is easy to imagine examples where the above industry relation is not true. Take the example below. Initially, process P1 is the bottleneck, and the subsequent buffer is empty. If the bottleneck shifts to P2, the buffer starts to fill up. Now, assume that the buffer becomes full just before the bottleneck shifts back! Process P1 would never have to wait for P2.

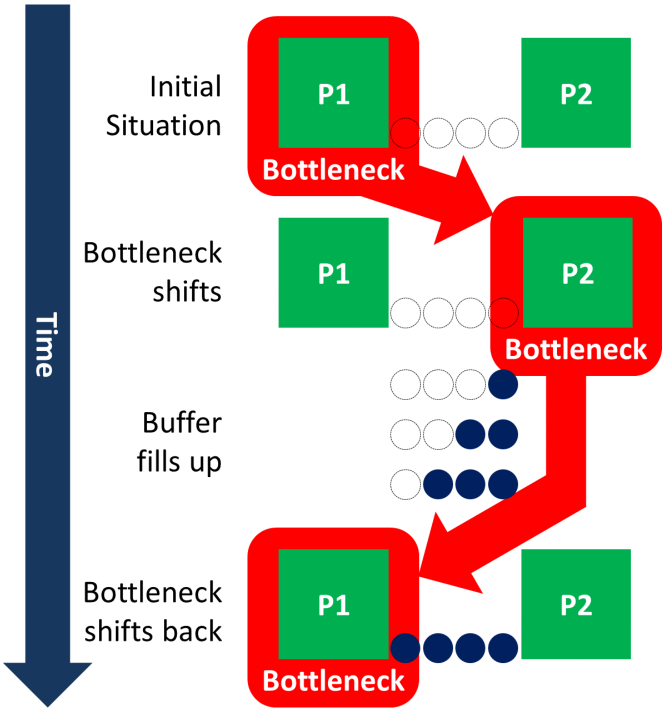


Figure 298: Shifting Bottleneck Inventory (Image Roser)

I marked the processes above as bottleneck. However, according to our definition of the bottleneck above, the bottleneck has to influence the overall throughput of the system. Yet, in the example above, it was always P1 that influenced the entire system. **Just before P2 would have an influence, the bottleneck shifted back to P1. Despite a completely full buffer, P2 was actually never the bottleneck!**

Granted, this is an extreme but quite possible situation. Hence, even with a completely full or empty buffer it can never be said with certainty where the bottleneck is, only with a probability.

39.2 The Theoretical Expectation

In theory, you would expect that the probability of the bottleneck being upstream or downstream is directly related to the inventory level. If your buffer is full, you can be almost sure that the bottleneck is downstream. If your buffer is empty, you can be almost sure that the bottleneck is upstream. For any inventory level in between you have a linear relationship. If your buffer is exactly 50% full, then the bottleneck may be equally likely up- or downstream.

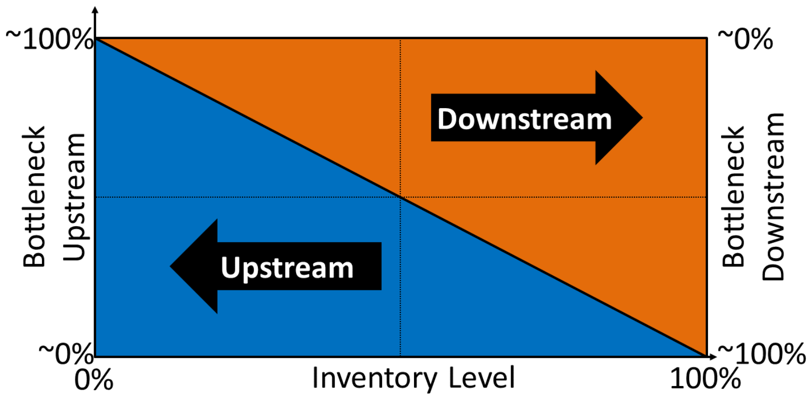


Figure 299: Bottleneck Direction based on Inventory – Theory (Image Roser)

39.3 The Yardstick: Active Period Method

Despite quite a bit of literature research, we did not find any prior research. Lots of people both in industry and academia use this assumption to find bottlenecks, but so far no one has checked if this is actually true. Hence, we set out to test this hypothesis.

There is a conundrum. To test the relation of the inventory level and the bottleneck direction you would need to find the momentary shifting bottleneck. However, most methods use exactly this relation to find the bottleneck. Hence, it would be a self fulfilling prophecy if you measure the accuracy of a tool using exactly this tool.

Luckily, I developed an alternative method to detect shifting bottlenecks: the **Active Period Method** (read more on my post [Mathematically Accurate Bottleneck Detection 2 – The Active Period Method])

Process is inactive if waiting for another process

Process is considered active otherwise

The Process with the longest uninterrupted active period is the bottleneck at this time

Overlap of longest periods are shifting bottlenecks

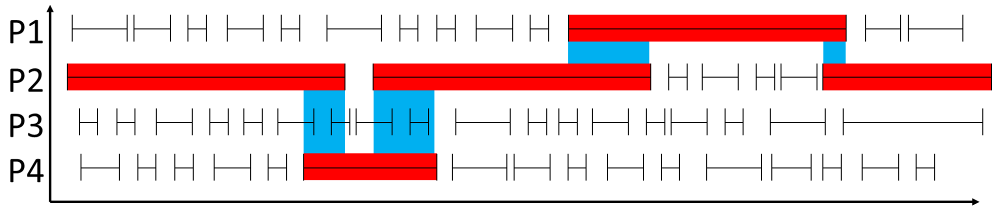


Figure 300: Active Period Bottleneck Detection (Image Roser)

Now we can say at any given time where the bottleneck is, or if the bottleneck is shifting.

39.4 Simulation System

We used a simple simulated system with infinite supply and demand, two processes with random cycle times, and a buffer in between.

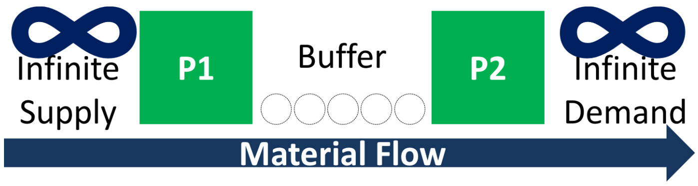


Figure 301: Buffer direction inventory Simulation System (Image Roser)

We run the simulation and recorded both the buffer level and the bottleneck location. In fact, we repeated this for many different systems with e.g. different mean cycle times (from equal to one process being 20% of the other), different random distributions (exponential, erlang, …) and different buffer levels (capacity ranging from three to 100 parts).

39.4.1 Reasonable Symmetric System

For a reasonable symmetric system where the cycle times of both processes are similar, the simulation result is very close to the theoretical result. Below are the results for a system with two identical exponential distributed process cycle times and a buffer capacity of 10. The confidence intervals are also shown.

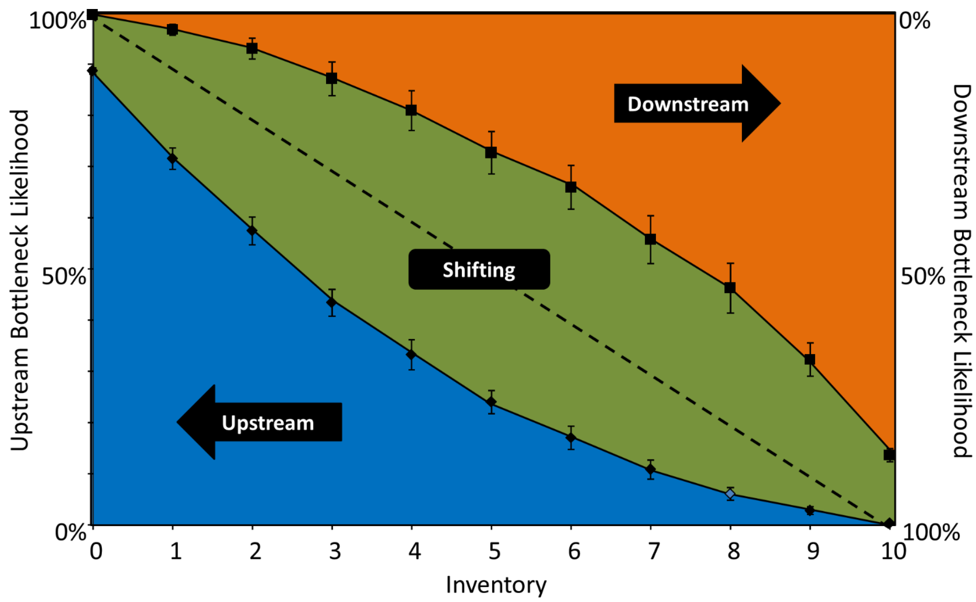


Figure 302: Bottleneck directory simulation results for a balanced system (Image Carolin Romeser under the CC-BY-SA 4.0 license)

The results are as expected: If your buffer tends towards empty, it is much more likely (but not certain) that the bottleneck is upstream. Similarly, if the buffer tends towards full, it is much more likely (but not certain) that the bottleneck is downstream. Due to the active period method sometimes having a shifting period, we did not always know the bottleneck. The green area in the center represents this shifting period.

Hence, if you find 2 out of 10 pieces in the buffer, then there is an ~55% chance that the bottleneck is upstream, still a ~7% chance that the bottleneck is downstream, and a remaining ~38% chance were the active period did not give a result due to shifting of bottlenecks.

Hypothesis confirmed, you would say? Not so fast!

39.4.2 Lopsided System

We also run simulation experiments with lopsided systems, where one process was faster than the other process. Now, our theoretical model breaks down. Below are the simulation results for process P1 having 20% of the cycle time of P2, hence P1 was much, much faster.

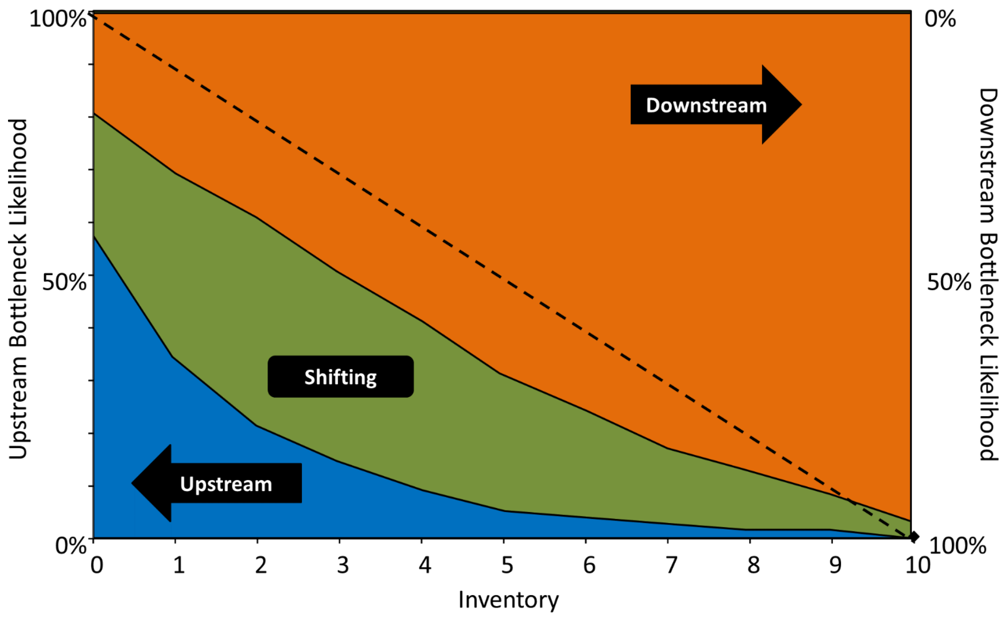


Figure 303: Bottleneck directory simulation results for an unbalanced system (Image Carolin Romeser under the CC-BY-SA 4.0 license)

Clearly, it is no longer symmetrical. No matter what the inventory, the bottleneck is almost always downstream. Take for example an inventory level of 2. Rather than a likelihood of 55% upstream and 7% downstream, we now have only a much smaller chance of around 20% upstream and a much larger chance of 40% downstream (and a remaining 40% of shifting). No matter what your inventory level is, the bottleneck is much more likely to be downstream in this lopsided example. Hence, unfortunately, **the hypothesis that the bottleneck direction is linearly related to the inventory is not true!**

39.5 What does this mean?

In sum, you can use the inventory levels to find the bottleneck best for systems with similar cycle times. It does not work very well for systems with very different cycle times.

This is a bit of a bummer. Finding the bottleneck through the inventory is just so very convenient. Luckily there is a way out. You see, if one process is a stronger bottleneck than the others, then most of the time the inventory method will still show towards this strong bottleneck.

Take for example the lopsided graph from above. This graph shows you the likelihood of the direction, but not how often an inventory level actually happened. In fact, it took quite a long simulation to get even a few inventory levels of 0 and 1. Most of the time the inventory level was between 8 and 10.

Hence, you can still find the bottleneck using the inventory levels, you just should not rely on only one observation! Now go out, look at your inventories, find your bottleneck, and Organize your Industry!

39.6 Sources:

- Romeser, Carolin: "Richtung des Engpasses in Abhängigkeit vom Füllstand eines Bestandes", Master Thesis Karlsruhe University of Applied Sciences, October 6th 2015.
- Romeser, Carolin., Roser, Christoph. Direction of the Bottleneck in Dependence on Inventory Levels, in: Proceedings of the International Conference on the Advances in Production Management System. Presented at the International Conference on the Advances in Production Management System, Iguassu Falls, Brazil, 2016.

40 Volkswagen Supplier Relations Failure

Christoph Roser, October 04, 2016, Original at https://www.allaboutlean.com/volkswagen-prevent/

Figure 304: Volkswagen Cartoon Fight (Image Roser)

In the last months, there has been an unprecedented power struggle between Volkswagen and its suppliers. Two of the suppliers stopped delivering, leading to a full stop of multiple production lines at six Volkswagen plants, including its main plant Wolfsburg. This whole mess comes on top of the separate problems Volkswagen has had with its *Dieselgate*. In this post I would like to look in more detail at what happened.

40.1 The Shutdown

Figure 305: ES Automobilguss Logo (Image ES Automobilguss for editorial use)

Volkswagen obtains one of its transmission parts from ES Automobilguss, and at one point ES Automobilguss stopped supplying. Almost simultaneously, another supplier, CarTrim, stopped delivering seat components. Both suppliers were single source, meaning Volkswagen had no alternative supplier for these parts. **Hence, since these parts were missing, Volkswagen could not produce anything.**

Figure 306: CarTrim Logo (Image Car Trim for editorial use)

This led to the shutdown of the Golf's production in the main plant Wolfsburg on Saturday, August 21. Shortly thereafter, other plants stopped producing due to lack of parts: the Passat line in Emden, the Passat and Golf lines in Zwickau, transmission assembly lines in Kassel, engine production lines in Salzgitter, and lines in the Braunschweig plant. These lines were stopped for one week before the suppliers agreed to supply again.

The cost of stopping a line is enormous. The cost of stopping multiple lines in six plants is gargantuan. The losses at Volkswagen are probably in the hundreds of millions of euros. Volkswagen undertook legal action, trying to force the suppliers to supply parts again and also trying to impound the available parts, although neither move was successful before the end of the supply stop. This is unprecedented in German industry.

In any case, the suppliers are now supplying again, and all plants are running.

40.2 The Official Reason

The official reason for the delivery stop is, of course, money. CarTrim had a development cooperation with Volkswagen. According to CarTrim, Volkswagen canceled these cooperations without prior notice and without proper reason, leaving CarTrim with a lot of development costs. CarTrim wants around 58 million euro from Volkswagen. Naturally, Volkswagen begs to differ, seeing these claims as shady and immoral.

CarTrim also transferred some of these claims to ES Automobilguss, resulting in ES Automobilguss also stopping its deliveries. Even the German government got involved when the state of Lower Saxony asked the suppliers to provide parts – but then, the state owns 20% of Volkswagen and hence is hardly unbiased. In any case, after a nineteen-hour negotiation marathon on Tuesday, August 23, 2016, the suppliers agreed to deliver again.

Not much is known about the deal that was made. The suppliers got a contract for the next six years, with a second source outside limited to 20% of the total volume. According to the official press release, they agreed "*in the form of a mutual, trusted and improved partnership in all areas*" after an "*amicable and fair agreement.*" Yeah, right. Trusted and amicable … my ass!

40.3 A Bit of Background

prevent.
Materials. Seats. Interior.

Figure 307: Logo of the Prevent group (Image Prevent group for editorial use)

If you think it's strange that both Car Trim and ES Automobilguss stopped delivery at the same time, it's not. While the companies claim to have no connection, both are part of a nontransparent but larger network of suppliers controlled by the Prevent Group and its subgroup, Eastern Horizon. Hence, this delivery stop was probably orchestrated behind the scenes.

40.4 Volkswagen Procurement Ethics – or Lack Thereof

The 58 million euro claim was also probably only the straw that broke the camels back. Volkswagen has an extremely shitty reputation with its suppliers. It is known to squeeze the last cent out of its suppliers. Contracts are made in sort of an auction style, so-called *Mehrraumverhandlungen* (multi-room negotiations). All interested suppliers have to come to the same place but different rooms. Volkswagen gets the cheapest offer and then asks all others if they can undercut this offer. Rinse and repeat, until one last supplier is the winner, although "*winner*" would in my opinion be the wrong word here. Oh, by the way, if the supplier decides to quit too early, he risks being cut off from Volkswagen completely.

Volkswagen is also known to issue one-sided demands (e.g., a price reduction of x% from next month). This is not really a request but more of an order, and Volkswagen expects the supplier to comply. It is said that Volkswagen wanted to reduce the damages from *Dieselgate* by handing the costs down to its suppliers and cutting their prices even more.

There are rumors of canceled contracts after the supplier has spent lots of its own money in the hope of future business. People in the purchasing department are also rumored to be extremely rude, and yelling and cursing seems to be common.

A survey of supplier satisfaction with their customers shows Volkswagen regularly at the bottom of the barrel, along with General Motors. By the way, on the other end of the spectrum you will find Toyota as one of the most popular customers for suppliers, with a reputation of tough but honest and fair. From the view of many suppliers, Volkswagen cannot be trusted, and even written contracts and government laws do not always hold weight.

40.5 A Bit of History of Volkswagen Procurement

40.5.1 Hiring from the Military

Figure 308: Volkswagen entering supplier negotiations… (Image Bundeswehr-Fotos under the CC-BY 2.0 license)

In 1990, the Cold War ended and the German army was drastically reduced in size. To help the soldiers in finding new jobs, the German government asked larger companies to hire former officers from the German armed forces. Rumor has it that Volkswagen hired a large number of officers for its purchasing department.

In the army, the command structure is clear. The superior gives an order, the inferior rank follows the order. That is how these officers operated.

Now apply this command-and-control approach to purchasing. You will end up with something similar to Volkswagen. A supplier is not expected to disagree with Volkswagen, just as a private is not expected to disagree with an order from a superior officer.

40.5.2 The Wolfsburg Strangler

Figure 309: The Wolfsburg Strangler (Image Roser)

Just about the same time, Volkswagen hired another top manager, José López, from General Motors. At General Motors he was known for his extremely rough treatment of suppliers, achieving unprecedented concessions from the suppliers.

He continued this strategy after starting at Volkswagen in 1993 as the head of production optimization and procurement. Treating his own production workers as poorly as he did his suppliers, he soon earned the moniker "*Würger von Wolfsburg*," the "*Wolfsburg Strangler*." He also had a lot of strange habits. He ordered his people to wear their wristwatch on the right wrist rather than the usual left one as sign of their loyalty, and ordered them to drink lots of water. He also called his people not employees, but warriors ("*Krieger*"). But then, many of them were ex-military anyway …

He was able to drastically reduce prices for sourced parts. However, as prices went down, so did quality, and defects increased. Hence this effect of getting crap if you pay crap is now known as the "*López Effect*" in Germany.

López did not stay long at Volkswagen, as he happened to take boxes upon boxes of confidential material along from his previous employer, GM. In the resulting big-picture lawsuit where even President Bill Clinton and Chancellor Helmut Kohl intervened, he was forced to step down 1996.

40.5.3 Another Tough Cookie

Figure 310: Herbert Diess (Image RudolfSimon under the CC-BY-SA 3.0 license)

In 2015 Volkswagen hired another tough cookie from the competition, Herbert Diess. Before he became head of procurement at BMW, BMW had an extremely good reputation with its suppliers. Diess changed that, and BMW is now at the bottom of the rankings by the suppliers.

One of his popular methods to reduce prices was re-negotiation. A contract with a supplier was open for re-negotiation whenever BMW felt the need to, which meant the contract was not worth much for the supplier.

In any case, he is now a member of the board at Volkswagen, and I don't think he has changed his ways. He will continue to squeeze prices in any way he can, so he will fit in well with Volkswagen …

In any case, as the shutdown of the Volkswagen plants shows, the treatment of suppliers by Volkswagen is not sustainable. The whole approach goes against the lean idea of *respect for people* or *respect for humanity*. Volkswagen has little respect for its suppliers. Toyota, on the other hand, is still one of the most popular customers among automotive suppliers. They also regularly generate cost savings, but they split them with the suppliers. It is just a so much different philosophy, which Volkswagen or GM seem to be incapable of.

In any case, I hope this article was interesting for you. **Now go out, be nice to others, and organize your industry!**

40.6 Update Two Years Later March 2018

As expected by all insiders, Volkswagen just hit back. All contracts with the suppliers ES Automobilguss, Car Trim and Prevent Foamtech were cancelled without notice. About 700 employees face reduced hours or termination. According to the Wirtschaftswoche, Volkswagen is willing to pay **over 200 Million euros** of additional expense for switching suppliers and legal costs to get rid of Prevent. So much for the "*mutual, trusted and improved partnership in all areas".* But of course, the legal battle continues and Prevent is going to court.

40.7 Update May 2018 … The Thriller continues

According to the news, Prevent through a sub company *Castanea Rubra Assets GmbH* bought a steel foundry *Neue Halberg Guss* in Germany, which is a major supplier to Volkswagen for crank cases, crank shafts, and cylinder heads. These are all parts which Volkswagen cannot get elsewhere in a hurry. And, Prevent just **increased the prices up to tenfold (yes, 1000% more)**. This may cause additional costs for Volkswagen of up to 180 Million euros. In the medium term the ca. 2000 employees of *Neue Halberg Guss* may lose their jobs if nobody does business with them anymore. Just for good measure, Prevent is also threatening to sue Volkswagen for possibly 1 Billion Euro. Somehow, this story has the fascination of a train wreck. It is very bad, but also very interesting…

41 “Lean Standard” ISO 18404 – A Questionable Idea …

Christoph Roser, October 11, 2016, Original at https://www.allaboutlean.com/iso-18404/

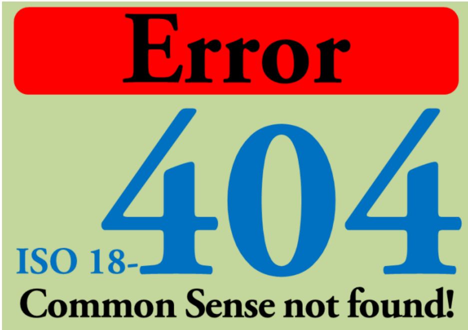


Figure 311: The missing common sense in ISO 18 404 (Image Roser)

Recently I learned about a new ISO 18404 standard certifying lean and Six Sigma organizations. **I think this is a highly questionable idea, with little benefit for the quality of lean manufacturing.** This certification madness won’t make much difference for the quality of lean but will mostly siphon off money to the International Organization for Standardization and connected bodies for certifications of little practical value. Let me show you the details …

41.1 What Is the ISO 18404 About?

Figure 312: Six Sigma (Image Roser)

The ISO 18404, published December 2015, aims to certify both organizations and individuals in either [Six Sigma](#) or lean, or both. Please note that this is not *lean Six Sigma*, but *lean* **AND** *Six Sigma*. Both lean and Six Sigma certifications come in three levels:

Lean	Six Sigma
Lean Practitioner	Green Belt
Lean Leader	Black Belt
Lean Expert	Master Black Belt

The roles of the green/black/master black belts are copied from Six Sigma, being a participant, leader, and coach in Six Sigma implementations. The role of the different lean levels are the same as the equivalent Six Sigma levels, only for lean instead of Six Sigma.

For each they list a number of competencies that the person or organization should have. Here’s a selection, most of which are often subdivided into more detailed points in the full description.

41.1.1 The Six Sigma Competencies (Selection of 23 Points)

- Business process improvement
- Change management
- Leadership development (self and others)
- Creativity thinking
- Customer focus

- Decision making
- Motivating others
- Numeracy (???)
- Project management
- Six Sigma
- Statistical tools
- Presentation skills

41.1.2 The Lean Competencies (Selection of 18 Points)

- Understanding benefits of lean
- Lean principles
- Measurement of process performance
- Creativity thinking
- Visual management
- Analysis of data
- Risk analysis
- Motivating others
- Lean techniques
- Presentation skills

To me, this is a very odd list. While most entries are things that I would like to see in a practitioner of lean, I find it nearly impossible to audit for these qualities. How do you, for example, audit "motivating others," "customer focus," and "leadership development"? You may as well audit the riding of a bicycle purely based on paperwork without watching the person ride.

41.2 Why Did They Make It? (Official Reason)

Figure 313: Get your Six Sigma certificate here … (Image Nancy Wombat under the CC-BY 2.0 license)

Well, the official reason why they created an ISO 18404 standard for lean and Six Sigma is due to the bad quality of some of the certificates handed out by some organizations. This is more of a Six Sigma issue than a lean issue, since there are many organizations handing out Six Sigma belts, while to the best of my knowledge there is no lean certification that comes even close to the widespread use of Six Sigma belts.

I agree that **many of the six sigma certificates handed out are not worth the paper they are printed on**. For example, I found a *one-hour Six Sigma Master Black Belt online course for only USD 29* (Get a USD 15 discount with the automatic promotion code). Yes, within only one hour, you can get the highest Six Sigma belt available, or any other belt from Six Sigma, from green belt to champion. Just don't expect me to be impressed. Yet, according to the website, thousands are certified every week. For that price I would even believe that. (I did not add the link since I don't want to advertise such a crappy service).

Of course, there are also more credible courses out there, but unless you have a deep knowledge of those certification agencies, you cannot tell the difference.

41.3 Why Did They Make It? (My Guess at the Additional Unofficial Reason)

Figure 314: Pile of 100 Dollar Bills (Image Jericho under the CC-BY 3.0 license)

Of course, in my view there is another reason why they created the ISO 18404 standard. Money! Certificates are a big business, especially if there is such a well-known organization behind it like the International Organization for Standardization.

From the International Organization for Standardization side of view, the ISO 9001 is a great success. Millions of companies have been certified in ISO 9001. Many automotive companies require their customers to be ISO 9001 certified. With at least a couple thousand dollars per certification (not including preparation), we are talking about billions in licensing fees.

Don’t get me wrong, the ISO has made many great and necessary standards, from paper sizes to screw types. In that, I am all for standardization. Yet, in my view, such a complex body of knowledge and experience like lean cannot be squeezed into a standard.

41.4 Analogies

Figure 315: ISO 9001 at the Tsukiji Fish Market, Tokyo (Image Chris 73 under the CC-BY-SA 3.0 license)

It is not the first time that the International Organization for Standardization has created a certification for a rather fuzzy topic. The most famous one is probably ISO 9001, part of the ISO 9000 series on quality. If you are in industry, you must have surely come across ISO 9001 somewhere. They also have others like the ISO 14001 environmental management system, the ISO 39001 for road safety, or the ISO 50001 for energy management.

As for the original goal of improving quality, the results are more mixed. Opponents claim that the whole thing is mostly paperwork. A certificate shows only that the standards are (probably) followed, and gives no clue on how good the standards are. As long as you document it, you (probably) can get certified.

The time required for documentation and certification is not to be underestimated. There will be lots of paperwork, with the risk of managers being even more remote from the actual shop floor.

41.5 What Will Happen

Okay, back to the ISO 18404 on lean and Six Sigma. I believe the situation will play out similar to ISO 9001, but slower. A few early adopters will jump on the bandwagon. These may be companies selling Six Sigma belt certificates or firms that want to have another ISO label to put on their letterhead or website. In all likelihood, this will not increase their "lean-ness" but only their paperwork.

Figure 316: Let's get one more … (Image Cybjorg under the CC-BY-SA 3.0 license)

I hope it stops at that, with only a few companies getting certified and the rest of the lean world doing business as usual. But the temptation of putting another label on the resume or homepage will probably be too big, and more people and companies will get certified.

The holy grail (from the ISO point of view) is when large companies require their manufacturers to be ISO 18404 certified similar to ISO 9001 nowadays. If that happens (and I hope it doesn't), then the ones without an ISO 18404 will have a clear disadvantage and may be forced to do the ISO 18404 paperwork, effort, and licensing fee with little benefit other than not being excluded. But then, I still hope it will not happen.

I was wondering myself if I should write about the ISO 18404. Personally, I would prefer that everybody just forgets about it. I am fully aware that by writing a blog post – even a critical one – I am actually spreading the word. It is quite possible that a few readers are now thinking about where and when to get certified. Please don't. **Instead of starting a lot of wannabe paperwork, go out, do some real improvement, and organize your industry!**

41.6 Response by Prof Tony Bendell

The blog post was inspired by a presentation by Prof. Tony Bendell, and I also kept him in the loop on this post. Since Tony has a more favorable view of the ISO 18404, he wrote a blog post in response to mine. Please check out his view in "It's Always Good To Question, But It's Always Bad To Ignore Reality", so you can make up your own mind. (Update: Since publication this article was unfortunately removed around April 2019, hence I removed the link)

41.7 Selected Source

I first learned about ISO 18404 from the following presentation, which presented a favorable view of the standard:

Bendell, Tony: "*Does Lean need an ISO Standard*", European Lean Educator Conference, September 14 2016, Buckingham, UK

42 Toyota’s and Denso’s Relentless Quest for Lot Size One

Christoph Roser, October 18, 2016, Original at
https://www.allaboutlean.com/toyota-lot-size-one/

Figure 317: Just when you need it … (Image tableatny under the CC-BY 2.0 license)

A famous step toward perfection in a lean production system is a lot size of one. However, few people realize what **enormous effort and rigor** Toyota applies to achieve this goal. During my visit to a Toyota plant and the APMS conference in Tokyo in 2015, I saw quite a few stunning examples of this quest. Let me show you …

42.1 Introduction

Figure 318: Be flexible! (Image Kennguru under the CC-BY 3.0 license)

While in traditional cost accounting, smaller lot sizes usually mean higher changeover cost or effort, Toyota realized long ago that this cost is more than offset by the gained flexibility and reduction in inventory. With smaller lot sizes, you need less inventory, and hence you can react faster to changes in the production system. While the Western world often also aims for smaller lot sizes, there seems to be many cases where further lot size reduction is considered too expensive. Well, not for Toyota and Denso.

42.2 Automated Guided Carts

Figure 319: Two typical AGVs (Image Employee of Fa. E&K-Automation in public domain)

During my 2015 visit to a Toyota plant in Japan, I noticed something curious. I am sure you all know about automated guided vehicles (AGVs), computer-controlled vehicles for material transport. They usually have a certain size, and then you fit as much material on it as possible.

However, at Toyota I noticed a curiously small AGV. It was much smaller than a normal AGV, only the size of a large suitcase. It carried exactly one front bumper and one back bumper.

Figure 320: Automated guided cart illustration (Image Employee of Fa. E&K-Automation in public domain and Sasukekun22 under the CC-BY 3.0 license)

Later I learned that Toyota calls these things Automated Guided *Carts* (AGCs) rather than Automated Guided *Vehicles* (AGVs). I have also seen videos of different carts for other parts in use at other locations within the Toyota group, namely Denso.

Since I was not allowed to take pictures at Toyota, the image here is a photo-shopped version of another shop floor, to give you a feeling for the size of the AGC.

42.3 Dantotsu

Figure 321: Katsuhiko Sugito at the APMS 2015 in Tokyo (Image Roser)

The following examples are from a presentation at APMS 2015 by Katsuhiko Sugito, Director of Production Innovation Center at Denso. Denso is part of the Toyota group, and in my view has implemented the Toyota Production System even better than Toyota.

Denso aims for what they call *Dantotsu*. This is a mashed-together word from *Danzen* (断然 for firmly, absolutely, definitely, extremely) and the English word *Top*. Their goal is to be the absolute best; they won't accept second place. (Please note that Dantotsu is a Denso-internal word, and not [yet] part of the Western lean vocabulary.)

One of these goals is to have true one-piece flow everywhere. Whenever parts are needed, then there is one machine that makes exactly one part whenever this part is needed. Sound simple? **Then apply this to aluminum casting!**

42.4 One Piece Flow Casting

Normally, casting is a batch operation. A large number of aluminum ingots are melted, a larger number of parts are cast, and then the whole batch is put into a heat treatment oven. Reducing this operation to a lot size of one and attaching it directly to the assembly line sounds crazy. Hence I was quite surprised and amazed to learn that Denso did this!

Figure 322: Illustration of ingot size (Image Romary under the CC-BY-SA 3.0 license)

Denso radically reduced everything to lot size one. For the melting of the aluminum they could not use the industry standard bars, which typically weigh around 5 kg and are around 70 cm long. For their products they needed much smaller ingots.

It was quite an effort, but finally they found a supplier that provided them with pyramid shaped mini-ingots weighting only 100 grams and with a length of around 6 cm. The image here is for illustration only. The shown large ingot is a stock image, and the smaller a draft by me, as Mr. Sugito asked us not to publish his images.

As a result, they also needed only one much smaller machine to melt the aluminum, reducing the occupied volume (length by width by height) by over 300-fold. Surprisingly, the small machine also turned out to be more energy efficient.

They also had a much smaller die casting machine. The occupied volume of the machine was reduced to 1/5th. The new electric die-casting machine also not only used much less energy than the previous hydraulic machine, but the quality was also significantly better.

Finally, the heat treatment furnace was also changed from a large batch-type oven to a smaller gravity fed chute (*karakuri*). Since the parts entered the oven still hot, the process was faster and also used less energy. The size was also reduced more than 40 fold.

Overall the new system was significantly smaller than the old system and used half of the energy, not to mention the better quality, less inventory, higher flexibility and shorter lead time.

42.5 One-Piece Flow Forging

Similar to the casting, they reduced the size of the forging machine. They changed from a general-purpose large press to a much smaller press that produced just one part when needed.

42.6 One-Piece Flow Cutting

Figure 323: Illustration of machine tool size difference (Image Nathaniel C. Sheetz under the CC-BY-SA 3.0 license)

Yet another example was the cutting tool. They replaced a normal-sized CNC tool with a much smaller tool 1/4th the size and 1/3rd the price.

The image here is again my own illustration based on stock photos, not original Denso machinery.

There were more examples in the presentation of similar reduction in machine size to achieve one-piece flow, like lathes, surface treatment, and joining machinery. The material flow has also been overhauled, with the AGC from above being only one example.

42.7 The cost, the cost …

Figure 324: Accountant and lean … (Image Minerva Studio with permission)

In all likelihood, if you present any of the above suggestions to cost accounting in your plant, the accountant will probably burst more than just a vein or two. Traditional cost accounting is highly unsuited for lean improvements. As explained in a previous post, cost accounting measures the cost very well but is ill-suited to measure the benefits. And, if the accountant can't measure it, then he will set the benefit to zero (and probably even believe it).

However, the benefit is definitely there. Denso reports multiple benefits that exceed the cost, like flexibility, inventory reduction, reduced energy consumption, more available floor space and hence less transport distance, and many more. Most of them are hard to quantify, but Denso strongly feels that they are on the right path to become the-best-of-the-best *"Dantotsu,"* and I agree.

Of course, this does not necessarily mean that you should immediately aim for one-piece flow casting. One-piece flow in casting has little benefit if the rest of your plant has a lot size of 500. As always, start with the easy low-hanging fruits. If you are a typical Western plant, you probably have quite a few easier options to improve before you go for a one-piece casting machine.

Think about it. What improvement project gives you the best bang for your buck in your current situation? Got one? **Now go out, start this most beneficial and urgent improvement, and organize your industry!**

43 Reddit: I am Chris Roser, a professor studying the past, present, and future of manufacturing, and just published my first book. AMA!

Christoph Roser, October 25, 2016, Original at https://www.allaboutlean.com/reddit-ama/

Figure 325: Reddit logo (Image Reddit for editorial use)

On September 27, I did my first Reddit: "I am a … ask me anything." With almost four hundred comments, I consider it a quite successful AMA.

I am Chris Roser, a professor for production management; a lean expert; a Toyota, Bosch, and McKinsey alumnus; and I'm interested in the past, present, and future of manufacturing. I lived and worked for multiple years in the USA, in Japan, and in Europe. I run a blog, AllAboutLean.com, and just completed my first book, "Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond.

The full AMA can be found on Reddit. Since it is the length of over ten blog posts, I chose a few questions and answers on two selected topics.

43.1 Losing Jobs through Automation and Computers?

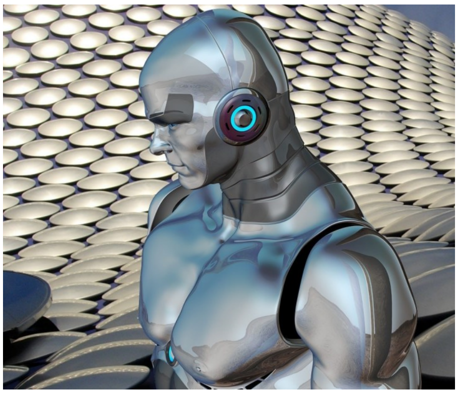


Figure 326: Modern Man with Background (Image DrSJS and Mcginnly in public domain)

Question: Do you think that engineers can be replaced by automation? More specifically AI and robotics? What are some jobs that will always need human input? (Mecheng1993)

Answer: I am convinced that in time engineers will be replaced by computers. This may happen faster than we expect (Moore's law of doubling approximately every two years), and will probably take us by surprise. For example, Google's Alpha Go beating a human world champion hands-down surprised the GO community, which thought this was still decades off in the future. If you are at the beginning of your career, don't expect your job to be around as long as you do.

Jobs for humans: In manufacturing, probably everything can be automated. What probably will happen is that we will be willing to pay extra for "made by human." In the case of very expensive cars like a Rolls Royce or an AMG sports car, the companies have one guy building a single engine. This is not cheaper or more efficient, but is sold to the customer as "something others don't have/can't afford." Instead, you get the guy's signature engraved on the engine. Already, "handmade" is prominent in some advertising for products, even though "machine made" would probably be better and cheaper. If like for me an AMG is out of your budget, you still can go for handmade soaps, clothing, jewelry, and other items.

Figure 327: Jan Vermeer – The Art of Painting (Image Johannes Vermeer in public domain)

> ***Question****: I think it will be the individualized economy that humans retain. For example, the individualized creativity of a caricature is not replaceable by a machine or algorithm. It requires a level of perception wand creativity.*
>
> *Another would be individualized art. The Etsy economy will survive, as everyone tries to be "unique". Not just based on "because it's more expensive", but because "this one is mine, and it's not replaceable". (tolman8r)*

Answer: Disagree. There are already computers that create art that looks like it's human made (for example, Google AI Music or a Computer generated Rembrandt Picture). For me, our brain is a connection of nodes (neurons) with electrical signals. No reason why a computer couldn't do something similar in a few years.

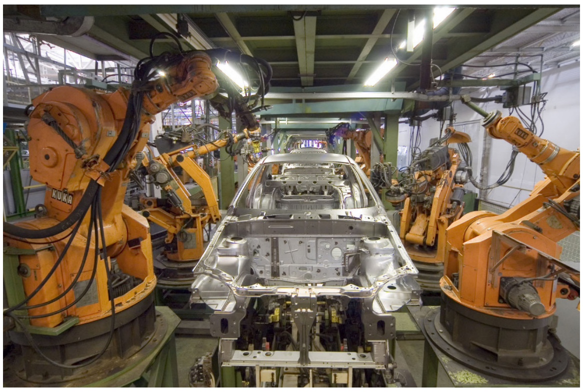


Figure 328: Kuka Industrial Robots assembling car bodies. Image by Mixabest from Wikipedia and available under the CC-BY-SA License (Image Mixabest under the CC-BY-SA 3.0 license)

> ***Question****: Hi Chris, thanks for doing an AMA. What impact do you think mass automatization will have on manufacturing jobs worldwide? And as a follow up, do you think Universal Basic Income is a way to resolve mass unemployment brought on by mass automatization? (skip-skip-vomit)*

Answer: Mass automation will make lots of people jobless, but the products will be cheaper than ever before. It will come, and I don't think we can prevent it.

Universal basic income is a solution, but the transition will be a problem. As I said earlier, we can put our trust in the politicians that they will manage this process well, or we can accept that we are facing an enormous social crisis within the next twenty to thirty years. For an individual, I think there are two ways out: be wealthy, or have a tenure-style job. (For me, I have tenure, so I am probably on the safer side).

43.2 Data in Manufacturing and Industry 4.0

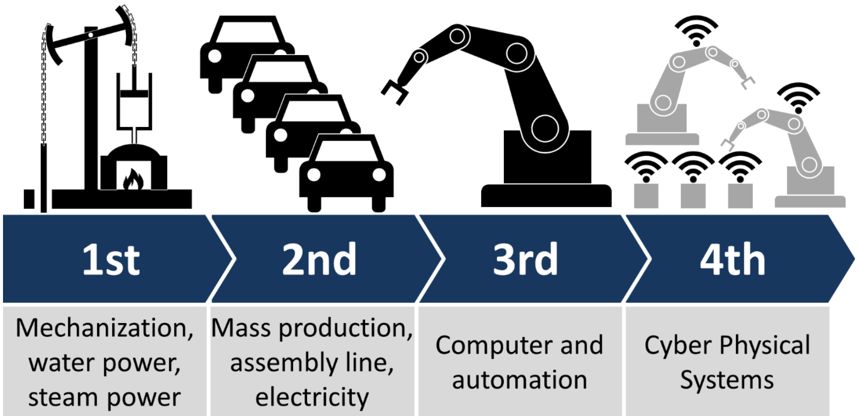


Figure 329: Industry 4.0 (Image Roser)

> ***Question***: *Hi Chris, Thank you for doing AMA. I would like to ask for your opinions on industry 4.0. 1. When will it be implemented on a global scale? 2. How will it impact society and economy? would it solve the problem of poverty? (Tommynhon)*

Answer:Oh boy … Industry 4.0. For me it is a buzzword that is already in decline. Most professionals I speak with are rather skeptical of this term. For my full opinion, check my blog post on Industry 4.0.

What you probably mean is the continuing and increasing use of computers in industry. This implementation is already ongoing. As for the impact on society, it is (and will be) HUGE! I believe that in the future we may not have to work anymore at all. The problem: Where do we get our salary from? As I said earlier in this AMA, a basic guaranteed income may be the solution, but the transition will be difficult.

In the intermediate phase, it will increase poverty. To become a modern, service-oriented society, a country must go through an industrialization phase. So far countries have industrialized by having cheaper labor, hence attracting business, hence generating wealth, until they also made the transition to a service economy (examples inclue South Korea [done] and China [in progress]). But with automation, a robot in the US/Europe will be cheaper than cheap labor in the Third World, and this gate to prosperity through manufacturing will no longer be available for poor countries.

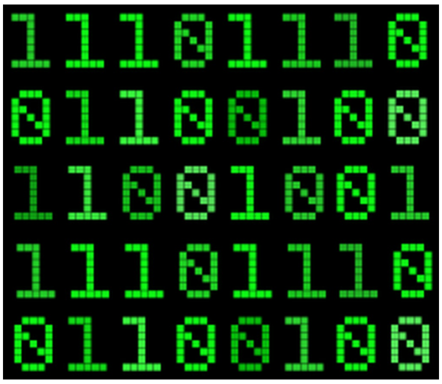


Figure 330: Binary Code Data Representation (Image MdeVicente in public domain)

Question: Hey Chris, Thanks for doing the AMA. This is an awesome topic, and one I've always been interested in. I studied applied mathematics, but I was always interested in the operations research and statistics side of things.

What is the role of "Data Science" in manufacturing today? I know that it is primarily the tech industry which has adopted this term, but are you beginning to see the manufacturing industry also use this term? If so, what do you think are the primary differences (if any) between how a tech sector data scientist would work versus a manufacturing sector data scientist? Finally, can a company's ability and reliance on analytics be used as a litmus test for their future?

Finally, a little more open ended: how serious do successful companies treat data versus experience? Thanks again! (EriqLaplus)

Answer: Data science, often also called Big Data: There is much potential in it. Industry collects an enormous amount of data but then does very little with it. If you have a lot of data, you can go through it and try to find correlations, maybe even causations. But this requires a lot of effort.

Currently this is missing a "killer app" in manufacturing. When you have something like this on Amazon or Facebook, the companies can analyze millions of users and generate a big benefit from it. In industry, the expense is similar but the benefit may be smaller. Also, manufacturing historically lacks the expertise for this, and does not have the right people to do it. Hence there are only few companies that are using it. Yet, as computers get smarter, they may be able to investigate data on their own without a human pulling all the strings. Then it will probably spread in industry like wildfire.

Figure 331: Data Graphic (Image Comfreak in public domain)

Question: I know that Amazon hires web developers to develop applications that compiles reports automatically. It isn't even that hard to do. What do you mean that there's no expertise? What manufacturer needs to do is first hire a dev to give them a scope of work. That is, 1. We want to be able to track XYZ, 2. We have this much money to do it, 3. Is it feasible and doable?I think there's plenty of people who can answer those questions in the U.S., you just need the c-suite in the manufacturers to know the benefits and existence of this service. (bktechnite)

Answer: No expertise in the manufacturing firms. Also, (often) not yet the right mindset. Managers in manufacturing think in material and processes, not so much in data patterns. People use the tools they are used to and had previously good experience with. The manufacturing managers still lack this experience and may not see the need. This is slowly changing but still quite a ways away from the mad rush of companies like Google, Facebook, and Amazon competing for the best available talent (this also means that any analyst is probably expensive to hire for manufacturing companies). Also, I am not sure if a web developer is the right person to analyze big data. This is, in my opinion, more complicated than an automated report.

To use your words: "*We want to be able to track XYZ*" – Manufacturing managers usually don't even know what XYZ to track.

43.3 Other Questions:

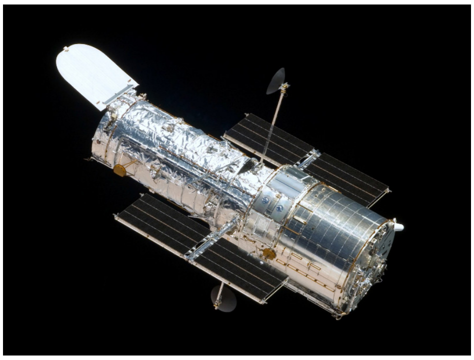


Figure 332: The Hubble space telescope was also mentioned (Image Ruffnax (Crew of STS-125) in public domain)

There were also some other topics discussed. Pretty much anything related to manufacturing and the future was on the table:

- Problems with ERP
- Big Data and its analysis
- Sustainable manufacturing
- Self-driving cars
- Advice for young professionals/people starting their career
- Wrong use of lean/how to "sell" lean
- How to bring back manufacturing to the US
- 3D printing
- Emerging technologies
- US presidential election
- Intercultural conflict when moving production abroad
- Industrial architecture
- Augmented reality
- Human relations at work
- Manufacturing history

Again, the full Reddit AMA is here: I am Chris Roser, a professor studying the past, present, and future of manufacturing, and just published my first book. AMA!. Overall I had quite some fun, and may do this again sometimes. In the meantime, **go out and organize your industry!**

44 Loss of Material: Theft!

Christoph Roser, November 01, 2016, Original at https://www.allaboutlean.com/loss-of-material-theft/

Figure 333: Thief (Image Clker-Free-Vector-Images in public domain)

Most of the material you purchase eventually goes (hopefully) to the customer. Some will be waste, others may be scrap. Yet a small part is also likely to be stolen, probably by your own employees.

In this post I will look at the effects of theft and give you some industry examples.

44.1 Where Does Your Material Go?

In classical business management theory, there are three possible ways your purchased material can end up:

- **Purchased by the customer**: Ideally you sell the material you purchase at a higher price to the customer.
- **Waste**: As part of the production process, you remove some material or otherwise generate waste as, for example, chips in milling. Of course you still try to get some money from it if you can by selling the waste as byproducts or for recycling. Minimizing such waste and smart selling of the remaining waste can make quite a difference for the bottom line.
- **Scrap**: Your production goofed up, and the part has to be thrown out. Like with waste, you try to recycle the scrap too.

What business management books usually miss is a fourth way how material can leave your plant: Theft!

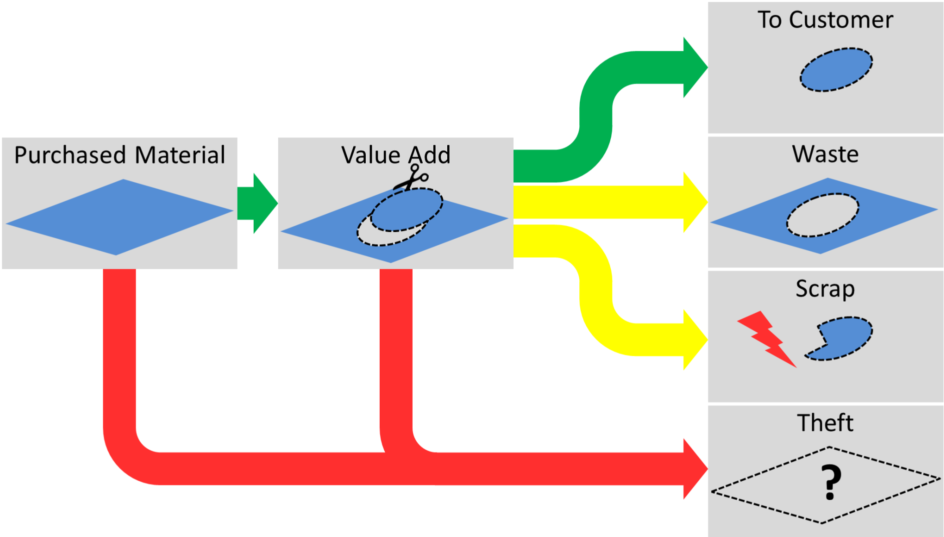


Figure 334: Material Use Waste Scrap Theft (Image Roser)

44.2 Who Is the Culprit?

Figure 335: Who? Me? (Image fakezzz with permission)

In all likelihood, the material gets stolen by your own employees. Nobody knows the internal details as well as the people who work there. Only in retail is theft by others a larger part of the shrinkage. Even if the goods are stolen in transit, it is likely that an insider snitched which shipment to steal.

Detailed statistics are rare, as most companies are not even aware of the issue. Even if they are, this is not something they make a press release about. Of course not every employee is a thief, but I believe most larger plants suffer at least somewhat from theft. Also, while the following examples are mostly operator-related, please be aware that being a manager does not make someone honest automatically, although in my experience higher-ups usually prefer accounting tricks with, for example, travel expenses rather than stealing from the shop floor. In any case, it is usually the minority that steal, and most employees are honest.

Historically speaking, this theft was (at least from the workers' point of view) a regular and accepted part of the salary. No matter if it was a paper mill or a weaver in the putting-out system, material theft was widespread. Often, due to lack of supervision, the worker produced goods for his own ends using time, material, and tools by the employer.

It is estimated that in the Arsenal of Venice, the largest industrial site in Europe during the Middle Ages, around 60% of all wood for shipbuilding was stolen before it made it into a ship. Other large shipyards even had a rule that the worker was allowed to take wooden chips home. Mind you, a "chip" was any piece of wood with a dimension of less than 1 meter! Plus, the workers interpreted the rule as "every member of the family of the worker could carry away any wood shorter than 1 meter." No surprise that all windows, doors, benches, etc. in the neighborhood were just about 1 meter wide.

44.3 Why Is It Stolen?

44.3.1 For Own Use

Figure 336: Zip ties are quite useful! (Image NorGal with permission)

Often, most stolen parts are small things for own use. For example, zip ties have a low perceived value but are quite useful. Plus, they fit in any pocket. Hence, they have a habit of disappearing. Some plants routinely order more zip ties than they need to make up for the shrinkage. Many employees don't even realize that taking even such little things as zip ties is theft!

Even more common is the theft of stationary. Pens and paper seem to vanish with astonishing frequency. Stationary stores would probably double their revenue if everybody would by their own pens. Another example I know of was the theft of cutlery, on the average the equivalent of three spoons per employee per year.

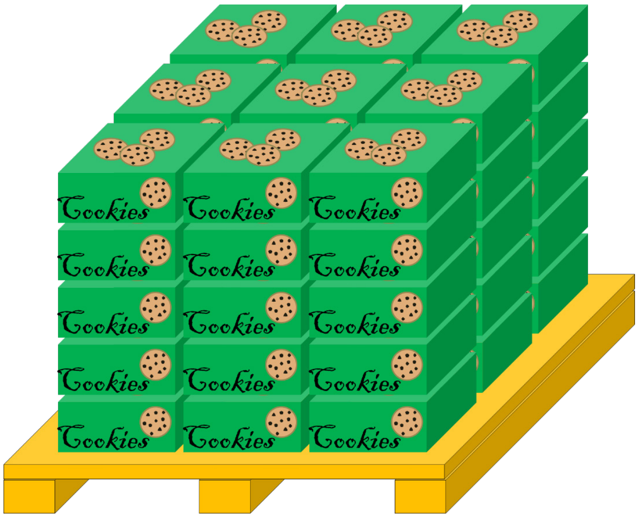


Figure 337: Half a ton of cookies … ooops! (Image Roser)

Another example was a commercial logistics center shipping all kinds of goods for many different customers. When I arrived at the site, I was surprised to see a full pallet of **chocolate cookies** in the middle of the office, with around 500kg of cookies on it. I was informed that this fell off the forklift, was now an insurance case, and the employees just helped with an environmentally friendly disposal of the damaged goods.

You would be surprised how quickly half a ton of cookies disappears. It took just about two weeks. Just when it was all used up, a pallet of **Belgian waffles** unfortunately fell off a forklift. This was again paid by the insurance, and the employees again merely helped with the clean up. After this half ton of Belgian waffles was cleaned up two weeks later, an pallet of **German chocolate bars** was damaged, and so on. You get the drift.

44.3.2 For Resale

Theft of small items for personal use can be considered ignorance, and companies may go easy on the offenders – although it still is a criminal act. However, if someone steals in order to sell the items elsewhere, few companies would not start legal actions. Especially since these cases can reach quite some sums.

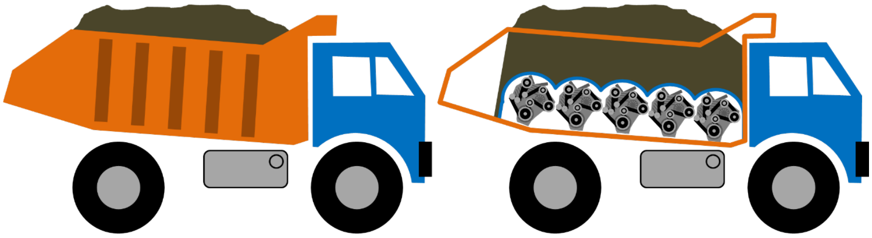


Figure 338: X-Ray vision of a dump truck heist (Image Roser)

One example I have heard was from a plant making diesel engines for trucks. The plant expanded, and during the construction, dump trucks went in and out of the plant to haul away the excavated earth. Management received a tip and decided to check one of these trucks leaving the plant.

It turned out that below the earth there was a tarpaulin, and below the tarpaulin were five completed heavy vehicle diesel engines, each worth around $10,000. Hence, the thieves tried to get away with over $50,000 worth of goods. It was not entirely clear if this was the first time they did this. It was certainly the first time they go caught. Of course, for these sums both the thieves and the inside collaborators were prosecuted, and the involved employees fired.

If you cruise through eBay or other auction and secondhand sites, you will also find many industrial goods and items of dubious origin. One company noticed a large number of spare parts for their CNC machine tools being available online, while missing these parts in their warehouses.

While small thefts are often ignorant individuals, many of the larger thefts are committed by organized crime gangs, often with inside help.

44.3.3 Intra-Company Theft

Figure 339: From right pocket to left pocket … (Image Kuha455405 under the CC-BY-SA 3.0 license)

Another form of theft I encountered was – strangely enough – the company stealing from itself. This takes a moment to understand. You may argue that it would be impossible to steal money from yourself, since, after all, you have the same money before and after the "theft."

True. But in a larger organization, the goods would not be where you expected them to be.

In this particular case, manufacturing and development was in the same plant. Whenever development needed parts for prototypes, they just waited till the shop floor shift was over, went downstairs, and helped themselves to anything they needed to work on the prototype. Of course, the next day production would run out of parts, since according to the computer these parts were still available, but in practice they were missing. While there was not a loss of material within the company, there was a financial loss due to a production stop, delayed shipments, and overall extra effort to straighten things out.

44.4 What Is the Effect?

This brings me to the effect of theft for the company. For one thing, there is the expense to replace the lost material. However, often worse is the fact that the material is not there when you need it. Since thieves usually do not update the ERP system, your ERP system still claims to have the parts. Yet when you need them, you will find out that they are not there. Production will grind to a halt, both work time and machine capacity will be wasted, and logistics has to go into overdrive to either organize some parts or pull forward the production of the next goods (for which hopefully parts will be available). In any case, it is usually chaos, and chaos is usually costly.

44.5 Countermeasures?

Depending on how significant the problem of theft is in your plant, you may think about countermeasures. These could be along the lines of prevent, detect, and prosecute.

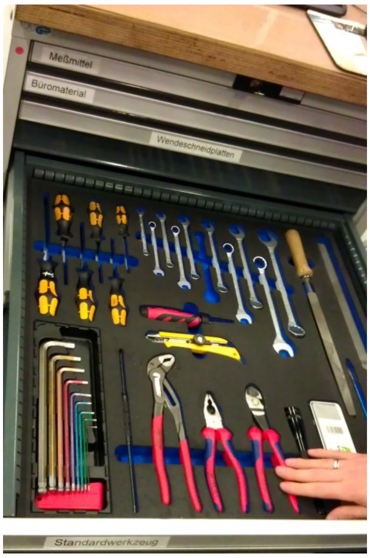


Figure 340: Is something missing? (Image Tasma3197 under the CC-BY-SA 3.0 license)

Prevent: Try to prevent thefts in the first place. Educate your employees about the problems of theft for the company, and the legal implications for the thief. Establish work standards that make theft more obvious and hence less likely to happen.

Detect: Try to detect theft. Some companies make sample searches of the bags of people leaving the plant. Others install video surveillance in critical locations. However, try not to overdo it. If your company becomes a police state, morale will suffer and the company will be worse off than with some smaller thefts.

Prosecute: If you find a thief, you should take action. Depending on the significance of the theft, this may range from a warning up to termination of employment and legal prosecution. Legally speaking, a thief may be fired even for small thefts. I have heard of cases where people were fired for the theft of a leftover hamburger from a buffet, the equivalent of $1.50. However, in these cases the company wanted to get rid of this particular employee anyway and was looking for an excuse to overcome the inconveniences of the local labor laws.

In sum, keep an eye out for vanishing material. If material is missing, it may be an honest mistake like a booking error or a misplacement. However, it could also be intentional theft. However, try not to treat everybody like a suspect. Yet if evidence is mounting up, do take action! Overall, I hope your plant is not much affected by theft. If it is, please let me know your juicy stories through the comments.

In any case, I hope this article was interesting to you. Now **go out and organize your industry!**

44.6 AllAboutLean is #1

Figure 341: First Place Ribbon (Image Ruby.W. under the CC-BY-SA 2.0 license)

Quick side note: The people from BTOES Insights did a survey among their readers to find the best Operational Excellence Blog. Over 100 blogs were suggested, and guess who made it into the top ten? AllAboutLean.com! While it does not say so on their site, they told me by email that my "*blog was most popular when we asked the community. [...] your blog came in at #1*!"

There you have it, **you are reading the best blog on the web on operational excellence 🙂 …** based on a survey by one website with an unknown sample size of responses, limited number of blogs examined, terms and conditions may apply, take it with a grain of salt – but I am just thrilled about it! Keep on reading!

45 Line Layout Strategies – Part 1: The Big Picture

Christoph Roser, November 08, 2016, Original at https://www.allaboutlean.com/line-layout-strategies-part-1-the-big-picture/

Figure 342: Ford assembly line 1913 (Image unknown author in public domain)

In flow shops, you have a production line of some sort. This may be an assembly line or a manufacturing line; this may be automatic or manual. In lean, you often hear about the famous U-line.

While this is a great solution, it may not fit all problems. Depending on the surrounding conditions, a different line layout may be beneficial. This post is the first in a series on line layout. In this post I would like to discuss what you should consider when designing a new line layout. The next post will look at actual line layout options.

45.1 The Big Picture

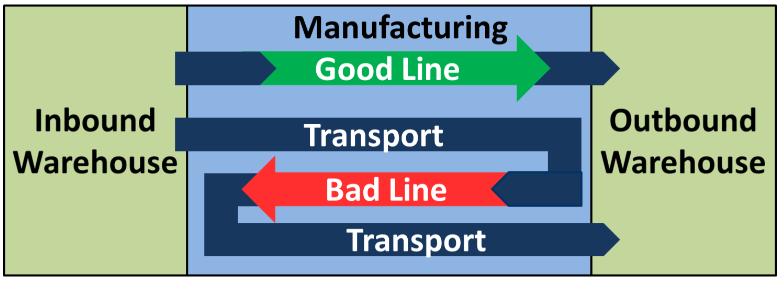


Figure 343: Good and bad line directions with separate inbound and outbound warehouses (Image Roser)

The first thing you would have to consider is the big picture. What is the overall material flow in your plant? In other words, where is your inbound warehouse, and where is your outbound warehouse? Take for example the image shown. The inbound warehouse is on the left, and the outbound is on the right. A good line design would follow the overall material flow and go from the left to the right. A bad line design would go in the opposite direction, requiring you to transport all material through the plant twice. And, as you surely know, transportation is one of the [seven types of waste (muda)](#) that should be reduced or eliminated.

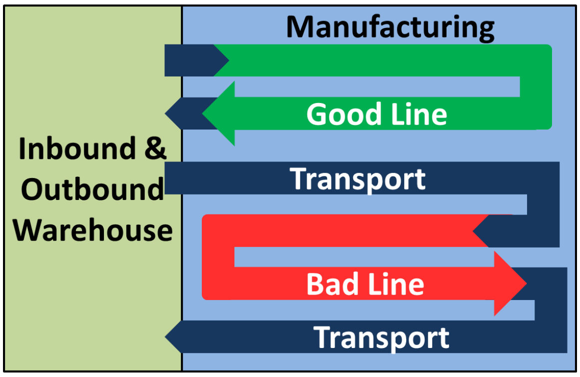


Figure 344: Good and bad line directions with a single warehouse (Image Roser)

This is similar for systems where the inbound and outbound warehouse is combined. In this case, a "loop" starting and ending near the warehouse would be best. A loop in the opposite direction would be worst, since again you would have to transport the material through the entire plant twice.

Similar applies if your line supplies or receives material not from the warehouse but from another production location. It would be good if the line starts closer to the source and ends closer to the drain of the material flow.

While this sounds obvious, you would be surprised how many plants forget this simple big picture when designing a line or even a complete plant. Naturally, for existing plants it may not always be possible to get a perfect material flow due to the historic development of the plant over time. But at least try not to make it worse.

45.2 The Surrounding Conditions

Before you go into more detail of the line layout, there are a few things that you need to consider beforehand for a good line design.

How Much Material Has to Go to (or from) the Line?

Figure 345: How to get to the line? (Image Katarzyna Kobiljak in public domain)

Obviously, some material has to go in on one side and come out on the other side. However, how much material has to be provided at the different steps in the line? For an assembly line, this may be a lot. For a manufacturing line where, for example, a part is milled, drilled, stamped, and cut, this may be next to nothing. Depending on the amount and especially the size of the material, you may have to consider how to supply the material. Does it come from the sides or only one side? Can it be delivered overhead or from the floor above, or is there even an underground conveyor or delivery system? Can it be handled by hand, or do you need a crane or other mechanical lifting device? Do you need forklift access to the processes? Do you need milk run stops and space for small supermarkets?

Is It an Automated Line, or Are There Operators Working?

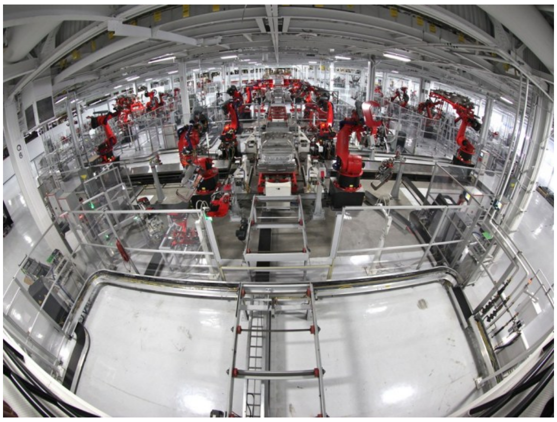


Figure 346: Automated line (Image Steve Jurvetson under the CC-BY 2.0 license)

Naturally, if there are operators you would need space for them. Additionally, operators may be able to work on multiple machines. You may have heard of the famous U-line (more below), where the U-shaped line allows an operator inside the U to handle multiple machines with less walking distance. At the same time you don't want to deliver material where operators are working, but rather from the other side if possible. If you don't have operators, then this is not a constraint. If you don't even have materials, you have to consider only maintenance access.

45.2.1 Is there Shared Equipment?

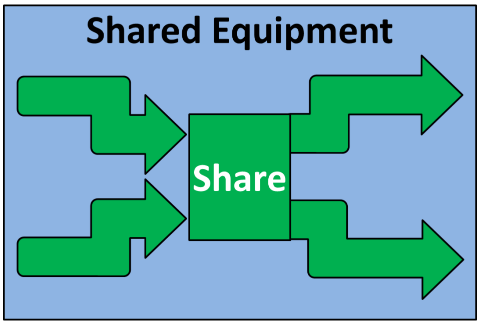


Figure 347: Shared Equipment (Image Roser)

If your line (or lines) have to share one or more processes, it may be a bit more complicated. The lines have to merge at the shared process and then split up again.

Naturally, there are many more factors that influence the line design, like number of variants, customer takt, etc. Additionally, physical constraints like support columns or exit doors also influence your final design. For this post, however, we only look at the layout and leave the details to other posts.

45.2.2 What Are the Conditions of Your Shop Floor?

Figure 348: Picture your plant here in two years …. (Image Andrew Filer under the CC-BY-SA 2.0 license)

If you have a greenfield location where you build a new plant, you are in luck. You can design the line any way you want and then just build the building around it.

In most cases, however, you do not have this luxury, but have to fit your line in the building you already have. In this case many other considerations come into play. Where do you have space? Are there certain processes or locations that cannot be moved? Such *Process Monuments* may be a large stamping press where you have not only the press but also infrastructure underneath the shop floor. Moving such a press may be prohibitively expensive.

Figure 349: Will it fit? (Image Mstyslav Chernov under the CC-BY-SA 3.0 license)

What is your overhead space? Will your machines actually fit in? What is the carrying capacity of the floor space? Some heavier equipment may exceed the carrying capacity of some more delicate shop floors. One example I have heard was a company delivering a heavy machine using an even heavier mobile crane when they learned that there was a parking garage underneath. The driver went white as chalk and immediately drove back out very, very slowly. Luckily the floor did not collapse.

Where are your support pillars for the roof? These are the bane of any line layout designer, especially if they are not shown correctly in the technical drawings of the plant! A smaller issue is often access to pneumatic lines or certain gas lines.

45.3 Conclusion

Overall, there are a lot of things to consider when designing a new production line. The points above are just to get you started. In my next post I will look at actual line layouts. This includes I-shaped lines, S-shaped lines, L-shaped lines, and or course the famous U-shaped line – although while the U shape is good, it is not a perfect solution for everything. So stay tuned. In the meantime, go out and **organize your industry!**

46 Line Layout Strategies – Part 2: I-, U-, S-, and L-Lines

Christoph Roser, November 15, 2016, Original at
https://www.allaboutlean.com/line-layout-i-s-u-l-lines/

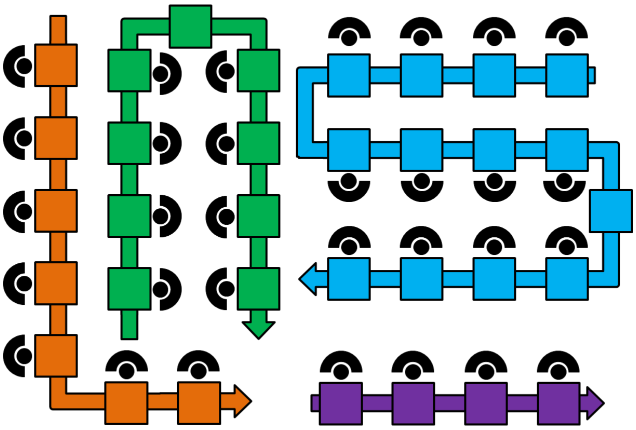


Figure 350: Different Line Layout Options (Image Roser)

The layout of a line can make quite a difference in the performance of your line. The U-line is most famous, although in my view while good it may not be the right thing for all situations. There is also the I-line, the S-line, and the U-line. In my last post I described some general thoughts on line design and took a look at the big picture. In this post I want to look at and compare actual line layouts, in particularly the I, U, S, and L layout. Let me give you an overview of the different options.

46.1 I-Line

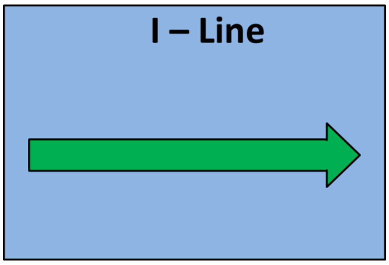


Figure 351: The I line (Image Roser)

The simplest line is the I-line, a straight line. This is common for very short lines or for automated lines. It is also used for processes that cannot have bends in the line for technical reasons (e.g., the float glass process for producing flat glass, where the 100-meter-long piece of glass naturally can't go around corners until you cut it into smaller pieces, or rolling mills or paper plants where the sheet metal or paper strips also cannot go around corners very easily).

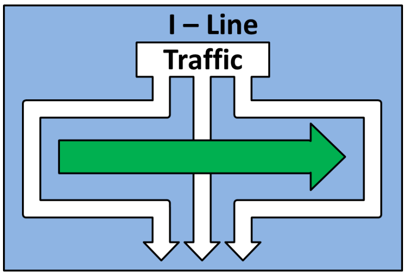


Figure 352: Traffic flowing through and around an I line (Image Roser)

The advantage is easy access from both sides for both material and operators. On the other hand, if this type of line is too long, it may reach the limits of the building you have. Additionally, a long I-Line may act as a barrier, and both material and operators always have to go around the line unless you incorporate a sort of bridge or other crossing.

Finally, due to the length of the line, managing and supervising the line involves more waste for the supervisor and possibly also the operators due to walking distances. An operator may be able to tend to his own process and maybe the two adjacent processes, but everything beyond that may involve too much walking.

46.2 U-Line

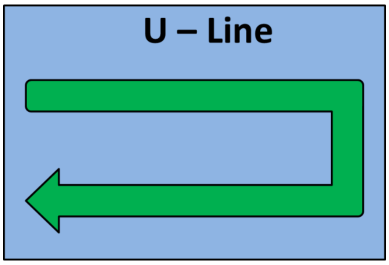


Figure 353: The U line (Image Roser)

The U-line is actually quite famous in lean manufacturing. Often it is praised as the best possible line layout. This U-shaped line is indeed quite nifty, but it is not a universal solution for anything.

The U-line is used mostly for manual manufacturing lines. A U-line is less ideal for fully or mostly automated lines. The main benefit exists if multiple operators are within the "U" of the line. All the operators are within the "U," while the material is supplied from outside of the "U." This of course requires devices and tools to bring the material across the line from the outside to the inside. Slides and chutes are often used to bring material over the line, and roller conveyors for material from underneath of the line. Often, a separate operator (usually called a "point-of-use provider") is in charge of refilling these devices from the outside using material provided by logistics. Overall, refilling material in an U-line is not as easy as with an I-line, but often other benefits make this effort worthwhile.

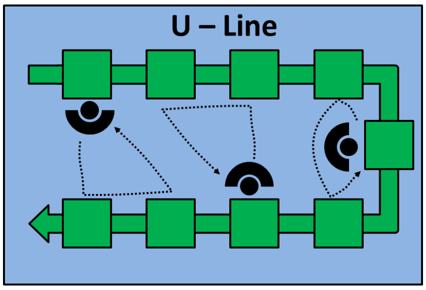


Figure 354: Workers in an U line (Image Roser)

The advantage of the U-line is the ability of workers to tend multiple processes within the line. Since not only the adjacent workstations but also the workstation "on the other side" are close by, the worker can manage multiple work stations. Therefore this type of line is well suited for multi-machine handling.

An additional benefit is that a worker can tend to both the beginning and the end of a line. If the line has a breakdown or problem, the worker can tend to the section in trouble and can temporarily neglect the other end of the line. Overall, breakdowns and other problems may be fixed faster than in other lines.

This is, for example, popular with Chaku-chaku lines. Chaku-chaku (ちゃくちゃくライン, 着々ライン) is Japanese for "arriving," but also represents the sound of the process. In this line, the operator loads the machines and starts the process before moving to the next machine(s). The machine works independently and ejects the part afterward before the worker loops back to the machine. Automating ejection from a machine is much easier than placing a part in a machine, hence this Chaku-chaku line is often a good compromise between automation and manual labor.

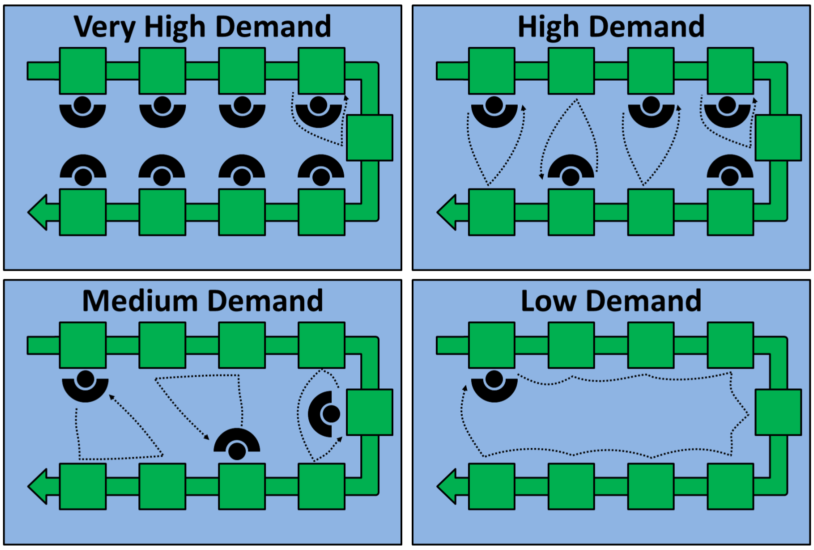


Figure 355: Flexibility by adjusting workers in an U line (Image Roser)

Since an operator can tend to multiple machines without excessive walking distances, this type of line is well suited to be scaled up and down by adding or removing workers. If demand is very high, you put a worker at every workstation and the total output goes up. If demand is lower, you reduce more and more workers from the line, until at the end only a single worker handles all the processes, producing only a few parts. Of course you would have to ensure that the machines are fast enough, and that the workers in the different settings all have similar workloads to avoid waiting times of operators.

46.3 S-Line

Figure 356: The S line (Image Roser)

The S-line is often used for particularly long lines, as for example automotive assembly lines. These lines can easily be thousands of meters long. Putting them in a straight line would not only require a very long building but would also put quite a strain on intra-logistics material transport.

An S-shaped line can fit much easier in a manufacturing plant, and the logistics are also much easier to handle. Of course, you would need to create crossings and access points where forklifts and milk runs can drive in and out of the line without having to go all the way around. Since the spaces between the loops of the line need to be wide enough for forklifts and milk runs, operators usually tend only to the stations on their side and do not cross to the other side, although this may also be possible for lines requiring less material to be delivered from the sides.

Often, these lines are created using multiple I-line segments arranged in an overall S-shape, with buffers at the turns of the material flow. The image shows, for example, the line layout of the Toyota Motomachi plant, where multiple I-segments are arranged in different loops, plus an engine production line merging with the main line during chassis assembly. The otherwise perfect S shape is broken by the Chassis 2 assembly on the left side, which was probably necessary to merge the engine assembly line with the main line. This may have been more difficult in the middle of the "S," hence the Chassis 2 line was moved to the side of the system. For more on the Motomachi assembly line and how it changed over time, check my post Evolution of Toyota Assembly Line Layout – A Visit to the Motomachi Plant.

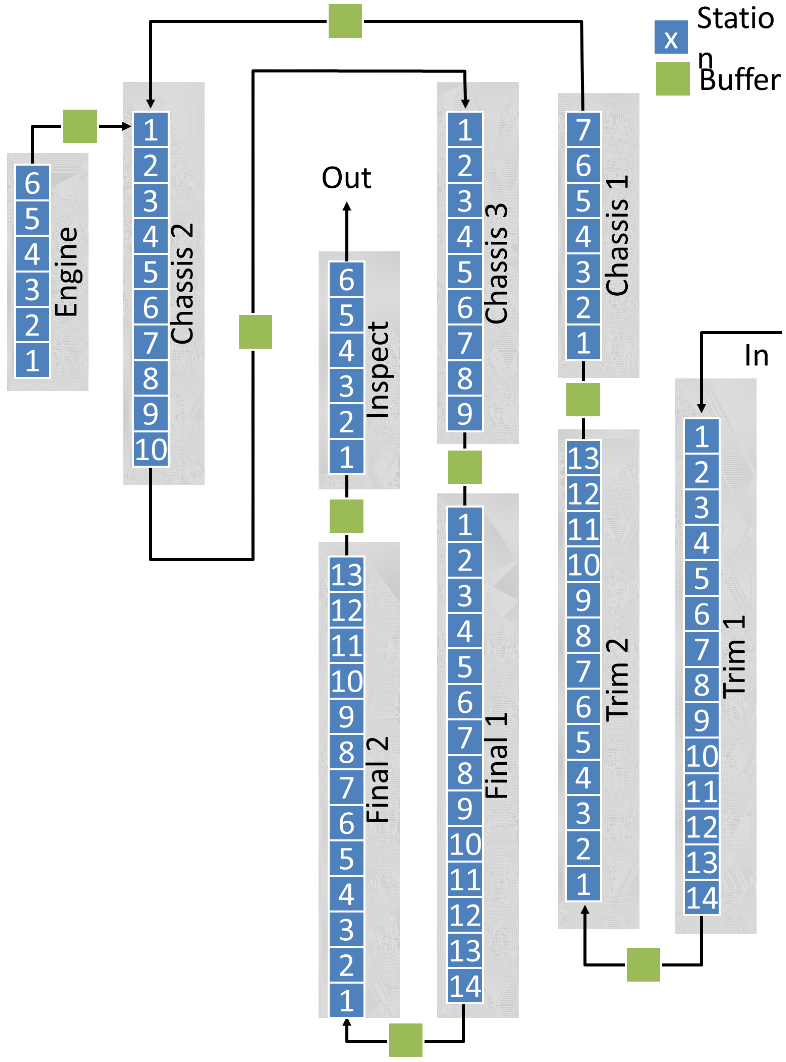


Figure 357: Toyota Motomachi plant (Image Roser)

46.4 L-Line

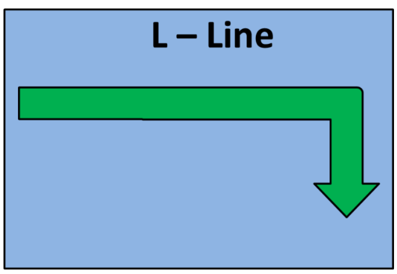


Figure 358: The L line (Image Roser)

The L-line is usually not part of a grand design. Most L-lines are forced to be L-shaped by the available space in the plant (or by sloppy line design). They may also be useful if the inbound and outbound warehouse are at an right angle to each other. In the image shown, imagine the inbound warehouse to the left, and the outbound warehouse at the bottom, and the L suddenly makes sense.

They have similar advantages and disadvantages to the I-line, except they have an additional corner to go around. They are hence not that common.

46.5 Conclusions

And there you have it. These are the most common line layouts for normal flow lines. These will serve you for most purposes. Of course there are always more possibilities. For example, once I had to design the line layout of a distribution center, where packages are added to a circular line at one spot, and they go around the circle until they are picked off for a particular destination.

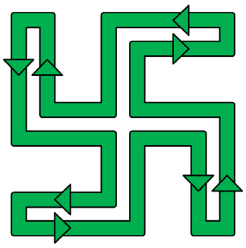


Figure 359: Line layout fail… (Image Roser)

I spent quite some time on that design, and got a good solution. Ease of access, lots of space for the operators, efficient use of floor space, quite nice actually. I was just about to present this line layout proposal to management when I took a last look at it and **… it turned out to be a swastika shape! With me being German – and working in a city that was destroyed and then occupied by the Nazis during World War II. That's when I decided that maybe I should NOT leave a 30-meter swastika behind on the shop floor as the result of my work.**

The Nazis ruined an otherwise perfectly good line layout option. The point I am getting to is that there are always more possibilities besides the I, U, S, or L. You have to do what is best for your situation. You could also use a cell, or maybe even use a job shop (although flow shops are usually better). In my next post I will present a few options for merging of production lines. Now **go out, don't build 30-meter big swastikas, and organize your industry!**

47 Line Layout Strategies – Part 3: Merging

Christoph Roser, November 22, 2016, Original at https://www.allaboutlean.com/line-layout-strategies-part-3-merging/

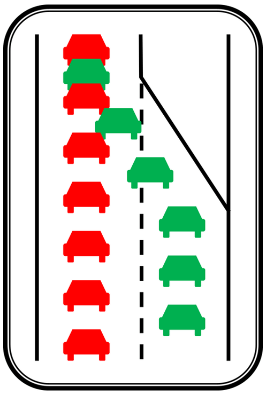


Figure 360: Zipper Principle (Image Roser)

In my last two posts (here 1 and here 2) I discussed line layouts, including the famous U-line. In the last post of this small series, I would like to wrap up the line layout discussions, looking at merging material flows and other things.

47.1 Merging Material Flows

Figure 361: Assembly lines are the prime example for merging material flows (Image unknown author in public domain)

The above line layouts are normal straight-line layouts. However, there may also be merging of manufacturing lines. Less commonly there may even be manufacturing lines that split up temporarily or permanently to make different products (often in chemical processes, where for example you break down crude oil into its components). Here, too, you have different possibilities, although the limitations and advantages are not as significant as with the main line layout.

The general advantage of having a sub-assembly or secondary manufacturing line merge with the main line directly is that there is no warehouse speed needed in between. If the output of the secondary lines matches the demand of the main line, you can establish a good material flow with little inventory. Overall it will be a very lean system, allowing one-piece flow and smaller lot sizes between the sub-assemblies and the main line. For some good examples, see my post Toyota's and Denso's Relentless Quest for Lot Size One, where they even managed to put an aluminum foundry in the overall assembly system, having the required output and also the needed flexibility to provide parts just on time (or Just in Time – JIT).

47.1.1 Comb-Line

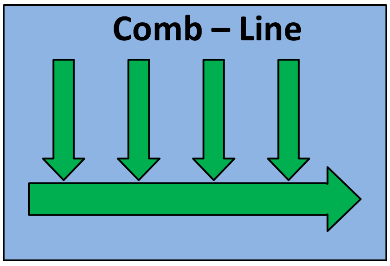


Figure 362: A comb style merging line (Image Roser)

Merging different sub-assemblies or sub-manufacturing lines into one main line may be done using a comb-style design. All secondary lines merge from one side of the line. I have seen this, for example, with manual assembly lines, where the operators of the main line stand on the same side as the sub-assembly lines. Besides a smooth material flow, this also created a close-knit group, and occasional problems caused by the sub-assembly line were resolved quickly. Due to the close interaction, all involved operators had a steep learning curve to reduce problems.

The other side of the comb-line may be used to bring additional material to the main line, as it is easily accessible for fork lifts and milk runs from that side.

47.1.2 Spine-Line

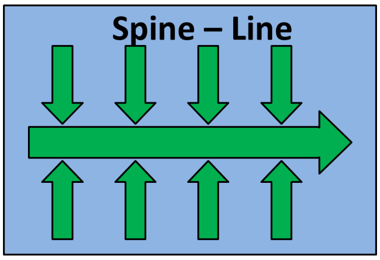


Figure 363: A spine style merging line (Image Roser)

The spine-line, sometimes also called fishbone-line, has sub-assemblies coming from both sides. I have seen this at bigger assembly lines, where operators were working on both sides of the main line. It has similar advantages as the comb-line, except that it may be more difficult to bring larger materials to the line using forklifts or milk runs, as both sides are occupied by sub-assemblies. Still, also a possibility.

47.2 Segmenting a Value Stream

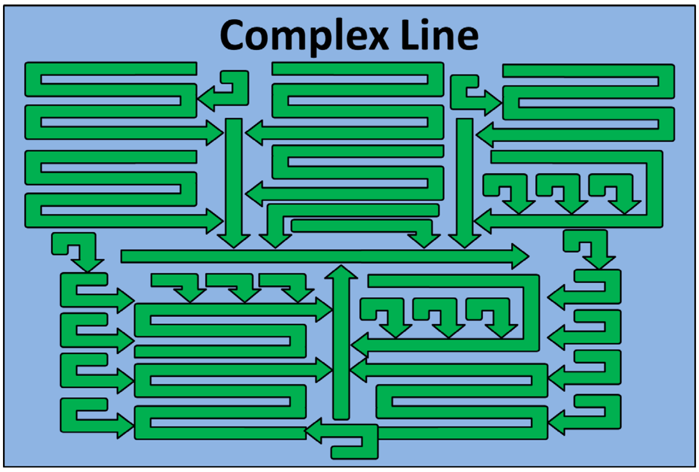


Figure 364: Probably too much… (Image Roser)

A value stream is usually a system with many, many branches. For designing a good system, it is necessary to be aware of these branches. Please note that here I talk only about how to determine segments, not if they should be decoupled using inventory and supermarkets, or if they should be attached using one-piece flow. Below are a number of suggestions and considerations that may play a factor for creating different segments of the line.

- **Merging parts**: This is of course the biggest reason. Whenever two parts merge, then you have a merge in the value stream. Hence, two material flows come together. Again, how you manage this is not yet the question, but at this stage only the realization that they do.
- **Vastly different production techniques**: For example, having a foundry within the assembly line is quite difficult. For a good example, see Toyota's and Denso's Relentless Quest for Lot Size One, mentioned above.
- **Negative technical influences**: Sometimes, one process may negatively influence another process. For example, if you have a 5,000-ton stamping press next to a high-precision milling operation, the high-precision milling won't be that high precision anymore. (The stamping press doesn't mind though).
- **The "*My Turf*" factor**: Often, production is in different plants, maybe within the same company, maybe with external suppliers. In this case turf wars can play a factor. Few plant managers are willing to give away part of the production, since production means employees, revenue, and, after all, power. Depending on how important this is to you, and on your level of influence, you can fight it or you can accept it. As usual, you can't fight everybody, and you should avoid fights that you would lose.

47.3 Segments: Decoupling vs. One-Piece Flow

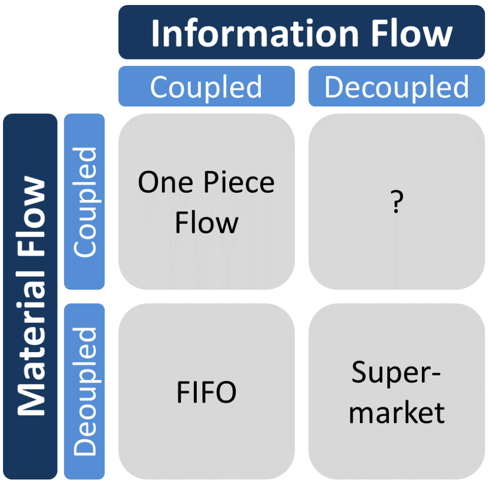


Figure 365: Coupled Decoupled Matrix (Image Roser)

Larger assembly systems may quickly become too complex to have all on one single line. While it would be nice to have a one-piece flow between every part of the value stream, it may be too much to handle in many systems. Even Toyota has buffers between segments of their value stream. Overall, it usually makes sense to break the entire value stream down into smaller systems.

Above we looked at where we could have segments. Now we want to look at where and how we decouple the segments. You can decouple the material flow, and can also decouple the information flow. You have the following options:

- **No decoupling:** This would be one-piece flow. The segment produces a part exactly when the subsequent segment needs it. This is often quite efficient, but it is also the most difficult to implement.

- **Decouple material but not information flow:** The prime example here is FiFo lines. There is a buffer inventory between the segments to cover fluctuations in speed, but the segments are still part of the same information loop. A common example is seat manufacturing for automotive. There is a buffer, but the decision to manufacture a car is automatically also a decision to manufacture the matching seat, and the seat has to be ready in time when the car needs it.
- **Decouple material and information flow:** The prime examples here are supermarkets. Only if the subsequent segment uses a part does the preceding segment start to reproduce. Unfortunately, supermarkets work only for mass production, but not very well for individual made-to-order parts. For made-to-order parts, this decoupling of both material and information flow is usually not preferred, as it takes too long to produce the product. Ideally, you make components for the product simultaneously, which would require a coupled information flow. If you start producing only when you need it, then your overall lead time may become unfeasibly large.
- **Decouple information flow but not material flow**: I don’t think this is even possible. This would mean that the part has to be ready just when you need it, but you don’t tell the preceding segment when you need it. I just added this here for completeness sake. Ignore it.

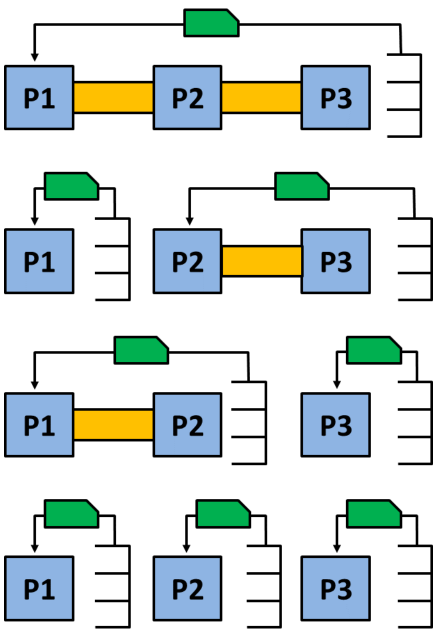


Figure 366: Kanban Loop options for three Processes (Image Roser)

So, when and where should you decouple and break it down into different value streams? You would have to find a compromise. Of course, no decoupling can be most efficient, but it is also most difficult to manage (and if you don’t manage it well, the efficiency can also be much worse than other systems). The exact answer depends on your system. For some very related posts that may give you suggestions, see [Ten Rules When to Use a FIFO, When a Supermarket – Introduction](#) and [Ten Rules When to Use a FIFO, When a Supermarket – The Rules](#). Also very related are [The Three Fundamental Ways to Decouple Fluctuations](#), [Determining the Size of Your FiFo Lane – The FiFo Formula](#), and [The FiFo Calculator – Determining the Size of your Buffers](#).

47.4 Ride the Learning Curve

Figure 367: Big Wave Surfing (Image Shalom Jacobovitz under the CC-BY-SA 2.0 license)

In many companies, I see the expectation that it has to be perfect from the beginning. **No, it doesn't!** Toyota is well known for its strive for perfection. But this applies to products, which it usually produces in large quantities. A production line is usually unique. Hence, Toyota aims to have a line that is good but allows further optimization. After the line is up and running, Toyota works on improving and fine-tuning the system. For a good example on how the line changes over time, look at The Evolution of Toyota Assembly Line Layout – A Visit to the Motomachi Plant.

While this optimization is necessary, it is unfortunately not glamorous. In the West, you can make a career by building lots of lines. Improving the lines is, however, something that is not really noticed very much. If you do your job right, nothing (bad) really happens. Hence, you can't even shine through firefighting, since you prevented the problems from happening in the first place. Overall, this line optimization happens, in my opinion, way too little in the West. If you can, do ride the learning curve and optimize your system!

Anyway, this concludes my series of articles on line layouts. I hope this was interesting for you. Now, **go out, optimize your line, and organize your industry!**

48 Interview on the David Pakman Show on the Future of Manufacturing

Christoph Roser, November 29, 2016, Original at https://www.allaboutlean.com/interview-on-the-david-pakman-show-on-the-future-of-manufacturing/

Figure 368: David Pakman Show Logo (Image David Pakman Show for editorial use)

Recently I had the exciting opportunity to be interviewed on the David Pakman Show on American TV, where I talked about the future of manufacturing, especially in America. Our subjects of discussion ranged from "*bringing jobs back,*" to the presidential election, to the carbon tax and many more current issues. Here's the full video and also the transcript:

The Video by the David Pakman Show is available on YouTube as "Neither Candidate Is Telling You the Truth About 'Manufacturing Jobs'" at https://youtu.be/VPT188kAIt4

48.1 Transcript of the Interview

48.1.1 Jobs Won't Come Back from Overseas

Figure 369: David Pakman (Image Dpakman91 under the CC-BY-SA 3.0 license)

David: I'm joined today by Chris Roser, who is a professor of production management, Toyota and McKinsey alumni, and interested in the past, present, and future of manufacturing. He writes on his blog AllAboutLean.com, and he just published a book called Faster, Better, Cheaper on the history of manufacturing. So Chris, I want to jump right in because there's so much to talk about. First, let's talk a little bit about your field in the context of the presidential election that we have here in the US. We've heard, to varying degrees from Hillary Clinton and Donald Trump, claims about bringing jobs back— manufacturing jobs from other countries, including China and Mexico. Of course, Donald Trump having sent some of these jobs to those countries to begin with, but we'll ignore that for the time being. My critique has been that many of these jobs no longer exist due to technology and neither candidate is really talking about that. How big of an issue is technology and automation in the field of manufacturing right now?

Chris: It's a very big issue. The work will come back, but not the jobs. Eventually when we have the automation and the robots to do all the work automated, then of course East Asia and other far-off countries have known a labor cost advantage, so you can manufacture in America too, but it won't be with people. It will be mostly with robots.

48.1.2 Automation of Design and Engineering?

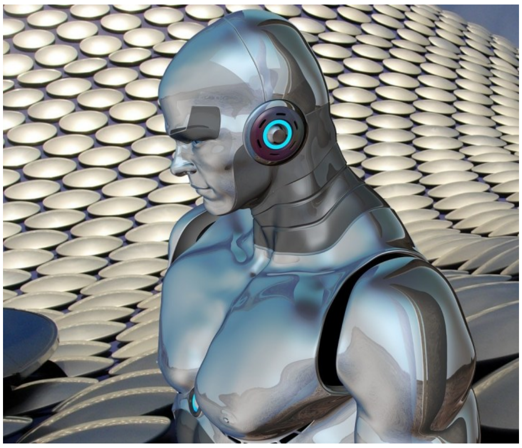


Figure 370: Modern Man with Background (Image DrSJS and Mcginnly in public domain)

David: And very often when we think about manufacturing and automation, people's minds go to factories with robots instead of people, but there's a sort of further question that I want to explore with you, which is: What about the pre-manufacturing portion, which is the engineering part, right? I think for many people it's harder to imagine that the engineering part will be automated, but is that also in the future?

Chris: I believe yes. Of course, at some point, we're talking about opinions, not facts, because it's the future, but I believe in the future it will also be possible to automate more complex and cognitive demanding tasks like engineering. To me, the human brain is a collection of neurons and signals, and it's nothing that cannot be simulated or modeled with a computer if the computer will be powerful enough. Right now, it's not yet, but in the coming decades, I believe it will. About when exactly, people have different opinions. Some researchers say twenty years, others say one hundred years, and some say never, but I believe at one point the computer will be able to do pretty much everything better than we do.

48.1.3 Least Automatable Jobs?

Figure 371: Interview Pakman – Roser Screenshot (Image David Pakman with permission)

David: There are some tools online that have started to pop up which say enter your job and we'll tell you how likely it is to be automated or replaced by a machine or a robot or AI in the future. Within the broader areas of manufacturing, what are the least automatable jobs in your estimation?

Chris: The least automatable jobs are probably the jobs where the customer puts value on interaction with humans. If the customer pays not for product but for something to talk to a human being, that's a job which will probably remain non-automated for longer. And of course, right now many jobs which we have with talking with human beings, they can be automated and already are, like call centers and stuff like that. They're already heavily automated, but if you go, for example, to a psychologist or something, I'm not sure if a computer would give the same feeling as a machine. But then, maybe I'm wrong.

48.1.4 Sustainable Manufacturing

Figure 372: Green Idea (Image vege with permission)

David: Can we expect significant changes to more environmentally conscious or sustainable manufacturing anytime soon? And I'd also just want to broadly ask you what would that even mean to have more sustainable manufacturing, particularly when we think about the Industrial Revolution being at the sort of center of human-caused climate change on the planet. What would it even mean to move towards environmentally sustainable manufacturing?

Chris: When you say sustainable manufacturing, there are actually three things that need to be sustainable. One is the environment. The second one is relations with people, and the third one is the finances of the company, and in most cases many companies are already squeezed financially. They'll do environmentally what is necessary, and they'll do what will in the long run save money, but few companies are doing it just out of the goodness of our hearts. There are some, but for many companies that trust their cost value analysis to see where to put in money to save the environment, where it is forced to by law, and if they do it voluntarily, they often spend more money on advertising their good deeds than on the good deed itself.

48.1.5 Economics of Sustainability

Figure 373: Green city (Image 9comeback with permission)

David: So if we were to—I'll get into some more specific questions in a second—but if we were to say subsidies aside and sort of government incentives aside, generally speaking in the world of manufacturing, is more sustainable manufacturing more expensive typically?

Chris: That's a good question. It can balance out to plus minus zero. It depends on the exact case. In some cases, when it actually saves money, they've done it long ago. Like car makers, they save every piece of scrap metal and melt it down to recycle it because it just makes sense money-wise, so in that respect, sustainability is already good business sense and most people wouldn't really call it ecologically friendly because it's just done anyway because it saves money. But other things that cost more money are things which companies are more hesitant with, and I believe it’s a task of politicians and the customers and the population channel to put a pressure to motivate those companies to become more environmentally friendly.

48.1.6 Incentives for Green Production

Figure 374: Hand with Money on Green (Image saiyood with permission)

David: Right, because very often when we think in the US, I think the carbon tax is sort of an example where people say the only way to really incentivize more environmentally friendly behavior is to artificially make it more expensive to be environmentally unfriendly, so to speak. Now what the critics of that idea say is that you’re not considering the cost of the negative externalities of the environmentally unfriendly actions, and I’m wondering, is this even something that we can really fine-tune and do specifically from a financial standpoint? Can we really measure the negative externalities of manufacturing in an objective way, or will there always be disagreement about exactly what the financial value there is?

Chris: It’s difficult to measure financial value and the cost, and also, whenever you put an external influence or external matching on it, companies also try to avoid it or try to find a way out of it, and I’m not even talking about Volkswagen *Dieselgate* as a particular case. But imagine you’re a company and you’re into logging and you’re seeding new forests. You would’ve done this anyway, but nowadays you probably make a little bit money on the side by selling it as a new tree, as carbon friendly. Even so, it may not grow that many additional trees, but only it looks better for the company that buys the carbon rights from the trees that one company is planting.

48.1.7 More Jobs through Automation?

Figure 375: Robots and Jobs (Image nmcandre with permission)

David: Interesting. The last thing I want to touch on a little bit: I’ve read a few articles and they’re admittedly not backed by the most precise and extensive sort of data, but there have been a few articles I’ve read which suggest that for the US specifically, the move towards automation and robotics and artificial intelligence may actually be good in the sense that, and you sort of alluded to this at the beginning when you said when it’s the machines doing the work, it’s no longer drastically cheaper to have the machines do the work overseas than in the United States, and there’s a possibility—and I have no idea whether the numbers actually bear this out. There’s a possibility that if you move all of the work back to machines in the US rather than people in Asia and other parts of the world, that you might actually bring some ancillary jobs back to the United States. The maintenance of the machines, for example. Maybe some more of the engineering would be brought in-house, or some more money would be freed up for engineering and creative jobs because the machines are now doing the work. Is there anything to that idea, or is it really sort of unreasonable?

Chris: It's really hard to get solid and reliable data about those kinds of things. Most models are little bit more of a wild guess than an estimate, but I believe in the medium term, it will increase the participation of the workers or it will provide more jobs for exactly the people you mentioned—for the people who maintain, install, and build the robots. There will be more jobs for some in the medium term, and of course in the long run, in maybe fifty or one hundred years, they may get automated too. But it's in the medium-term that I think will bring jobs back to America which otherwise would have never come back.

48.1.8 Closure

Figure 376: Interview Pakman – Roser Screenshot (Image David Pakman with permission)

David: Absolutely fascinating. I will remind you the book is [Faster, Better, Cheaper](). We've been speaking with the book's author, Chris Roser, who is a professor of production management. Thanks so much for talking to us about this.

Chris: Thanks, David.

48.2 Comments

Wow, my first TV Interview 🙂. It was quite exciting, and I liked the conversation. The response with comments on YouTube was also good. I especially liked Timothy O'Brien's comment: "*Outstanding conversation! Please have him back for more I'm amazed at how many comments it has generated*." Well, I wouldn't mind …

Another comment was on my accent: "*I can't pin down his accent. Alabama or Ireland?*" For all of you to know, it is Swabian-German 🙂.

In any case, I have to work on my camera angle. Surely there must be some tricks to make me look lean and sexy. In any case, **go out and organize your industry!**

49 Kanban Card Design

Christoph Roser, December 06, 2016, Original at https://www.allaboutlean.com/kanban-card-design/

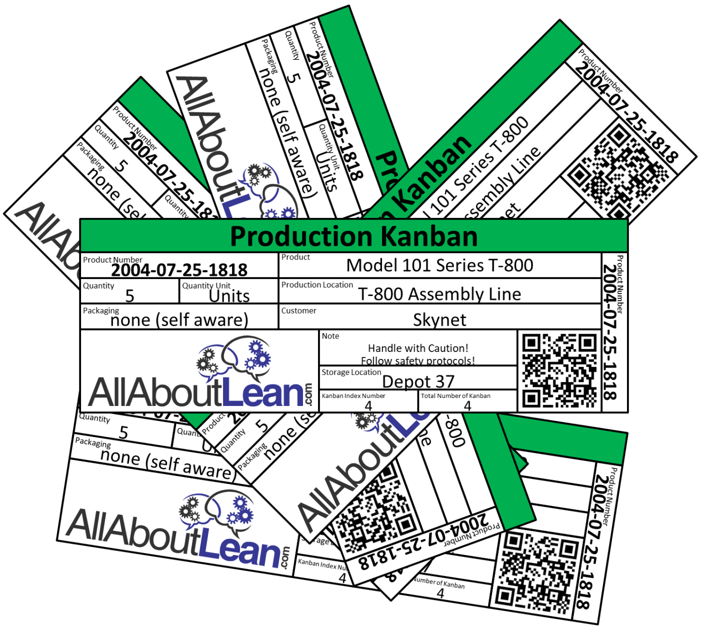


Figure 377: Pile of Kanban Cards (Image Roser)

A kanban is, in its basics, information to reproduce or reorder parts. Hence, in its most basic form it has to say "*make me this part*" or "*bring me this part.*" While such very simple kanban systems are possible, usually it helps to include other information on the kanban card. In this post I want to talk about the design details of a kanban card, especially what kind of information we should include on the card. Please note that the items on the list below are suggestions. Which ones you actually include depend on the system you want to establish.

49.1 Physical (or Digital) Form of the Kanban

A kanban can have many different forms, including paper cards, paper in a protective folder, digital, a box or container, a piece of metal, or pretty much anything that goes with it. I usually prefer containers or metal pieces since they are less likely to get lost and are often easier to implement and visualize than an digital ERP system kanban. For details on different physical kanban types, see The Problem of Losing Kanban – Different Kanban Types.

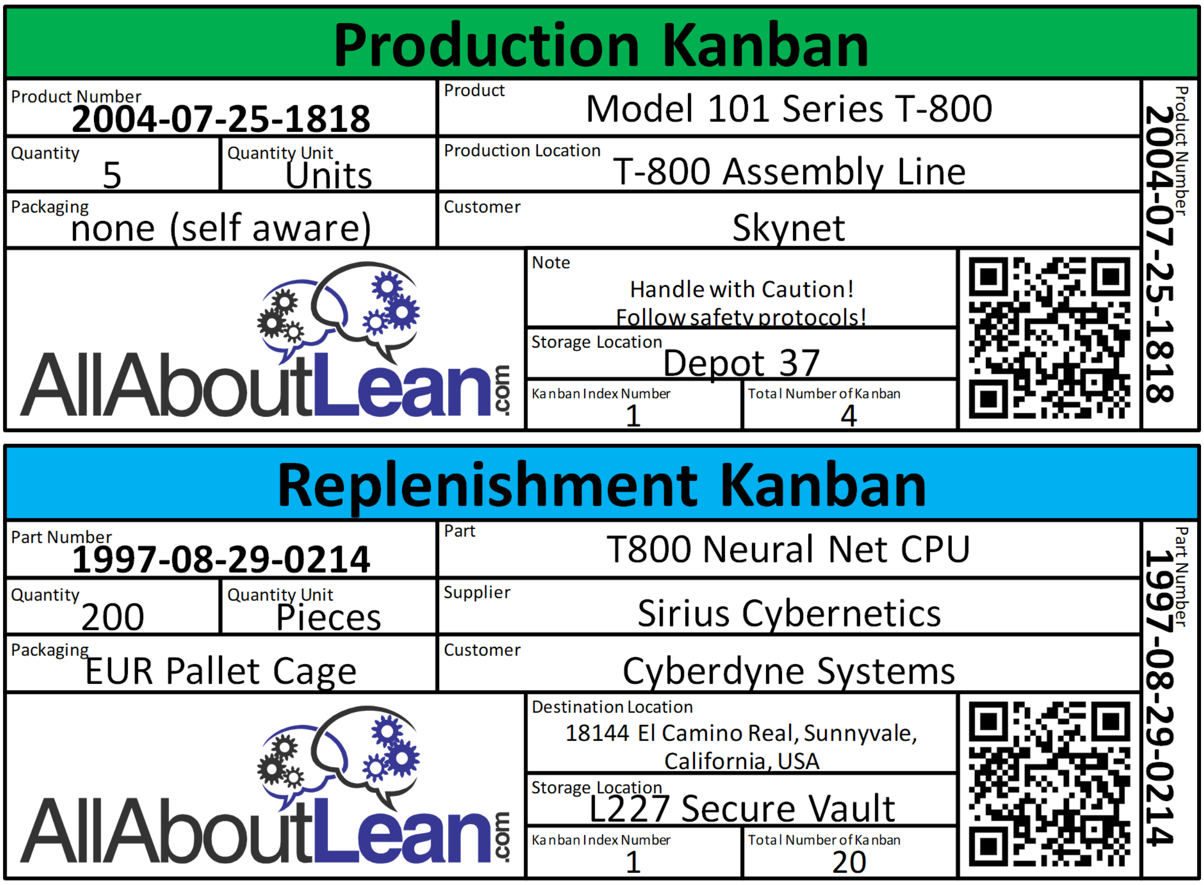


Figure 378: Example kanban card with (selected) Information (Image Roser)

Also, for simple system you may consider a triangle kanban, i.e. a special type of Kanban system with only one kanban. The triangle kanban is used if a lower limit on inventory is reached. In this case, the triangle kanban indicates reproduction of a fixed quantity of parts. The remaining inventory after the triangle kanban is large enough to cover the replenishment time. Named after its originally triangular shape at Toyota (since it was cut from scrap metal, which did not yield good rectangular shapes).

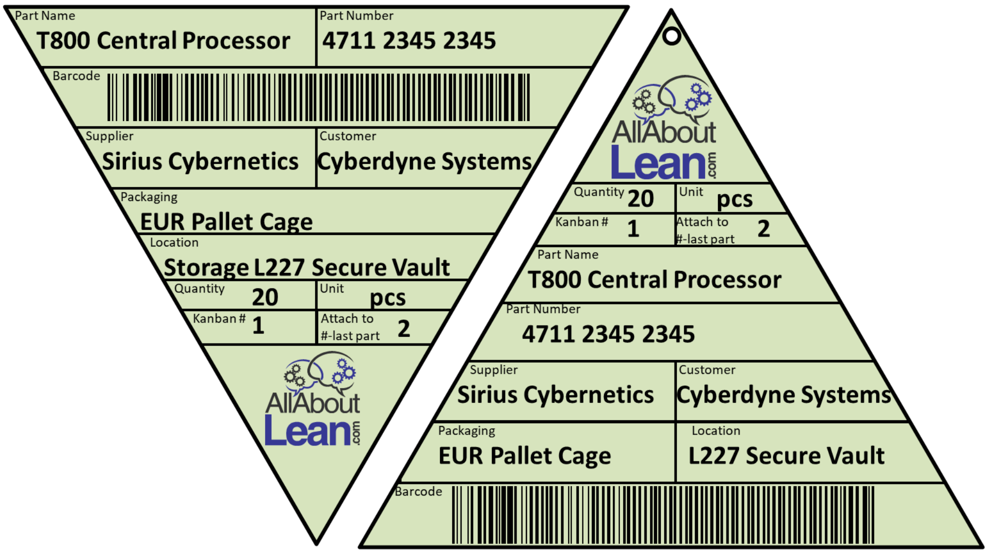


Figure 379: Upside-Down and Normal triangle Kanban. I prefer the one on the right, since it is easier to hang them up. (Image Roser)

49.2 Part-Related Information

Figure 380: The worker and his part (Image auremar with permission)

Now we have to think about what kind of information we include with our kanban. A kanban card stands for one or more parts. Hence, first and foremost, you need information related to the part. In all of the examples below, I assume you have a physical sheet (a card or a label on a box). For digital kanbans, the required data is similar, but now you have to link it in your ERP system.

Part Number: Probably the most relevant information is the part number. In a proper modern manufacturing system, every part type has its unique part number, usually an alphanumeric string. It could look like, for example, *T2232-55675-A2322*. The computer can identify the part using this number. On a side note, Toyota also sometimes uses additional shorter 3 digit codes that are valid only within a certain part of the value stream. These three digits are easier to remember, and help users to identify the part within their own working area (Thanks to Damien for the info).

Part Name: Humans usually don't know all the part numbers (although many of the people working with these numbers often know quite a lot of them). In any case, it helps to write out in plain English what the part is.

Quantity: Finally, you should write down the quantity of parts this kanban card stands for. A kanban card can represent exactly one part. However, if you have a lot of parts of this type in the system, it may make sense to use one card for a box or container with multiple parts. A kanban card may stand, for example, for a box of twenty parts. If you represent multiple parts with one kanban card, I strongly recommend getting a container or box that fits this number of parts. This way it is easier to keep track of the parts if you take them out of the container one by one. If you have smaller packaging units in a larger pack (e.g. boxes on a pallet), you can also include this information, e.g. 20 packs of 5 pieces each (Suggestion from Rob – Thanks Rob!).

Unit: This is related to the quantity. If your kanban card for screws says a quantity of twenty, is this twenty screws, or twenty packs with fifty screws each, or twenty kilograms of screws? Often, this may be obvious, but it is usually good practice to include the unit.

Picture: This is not very common, but you could include a picture of the part on the kanban card. This may be helpful for humans to know what they're looking for.

Important: While you can also put a lot of technical details about the product on the card, think carefully if a kanban is really the right place to add the information (Suggestion from Rob – Thanks Rob!).

49.3 Material Flow-Related Information

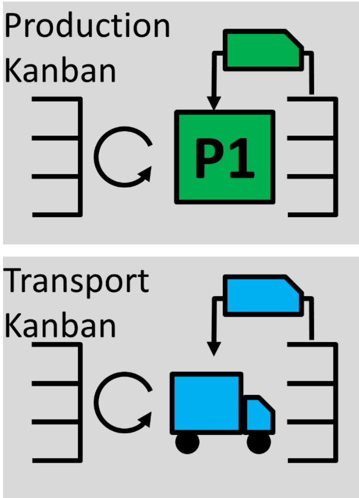


Figure 381: Production Kanban and Transport Kanban (Image Roser)

Type of Kanban: There are different types of kanban. Most often you distinguish between a *production kanban* and a *transport kanban (withdrawal kanban)*. A production kanban issues the reproduction of a new part. A transport kanban merely orders another part from a preceding supermarket or general inventory. It helps to write on the kanban if it is a production kanban or a transport kanban so you don't mix them up and accidentally produce a part instead of delivering it. You may even think about using different colors to distinguish the two types. Also, depending on the type, the following information may differ.

Figure 382: Packaging option: cage pallet (Image Elmar Zenner under the CC-BY-SA 4.0 license)

Packaging: A kanban card can also include packaging information. Is it a pallet, a pallet cage box, a cardboard box, a standard size industry plastic box, etc.? This helps to know how to ship the goods.

Source: Where does the material come from. For a transport kanban, this may be the warehouse or inventory where the material is taken out. For a production kanban, this may be the production line that reproduces this part. This information can also be set up in different levels. You could indicate the source as it is known to the workers (e.g., "*housing line*" or "*inbound warehouse*"). You could also use the ERP numbering system for the inventories or systems (e.g., "*L23-5*" or "*I225/4*"). For loops between plants you could add not only the line or inventory, but also, if necessary, the plant or warehouse (e.g., "*Detroit East*" or "*Kentucky II*"), which again could also be added using the ERP code for these locations.

Destination: Similarly, where does the material go. Since it is a kanban, the destination should be a supermarket. Again, you should write on the card where the material goes, often both in human-readable form and in ERP code, possibly also including the plant location.

49.4 Information Flow-Related Information

After the part and material flow-related information, we now look at the information flow.

Index Number: First of all, it is really helpful to number your kanban. If you have twenty kanban for one part type, you should number them from one to twenty. This really helps if you want to check for lost kanbans (e.g., if all kanban cards but #13 are repeatedly passing through the supermarket as part of their loop, then it is possible that kanban card #13 got lost and needs to be replaced).

Total Number of Kanban: How many kanban are in the loop for this part number. This may be helpful information for anyone checking or trying to understand the system. On the other hand, in a kanban system it is often good practice to experiment by adding and removing kanban to improve the number of kanban. In this case, you would have to either exchange all kanban in the loop or have a wrong total number of kanban (or you could just skip this information altogether).

Kanban Loop: You may have a name and/or number for the kanban loop to uniquely identify the kanban loop where the card belongs. This is not always used but may be helpful depending on your situation.

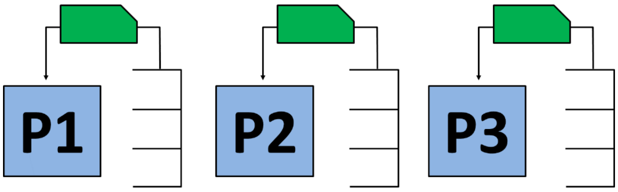


Figure 383: Which loop did the kanban belong to again? (Image Roser)

Lead Time: Some cards include additional data like lead time or replenishment time. Personally, I find this less helpful, as the lead time can change quite a bit over time, and I wouldn't need this on a kanban card. Still, some people like it that way. You decide if it is helpful for you or not.

Contact Person/Department: The kanban card may also include a contact name of the person or department that issued the cards and is responsible for the upkeep of the kanbans (not necessarily the machines).

Order Date and Due Date: This is possible for kanban cards that are printed from an ERP system, where the paper printout is thrown away and reprinted whenever the "kanban" leaves the supermarket. In this case you can include the additional information for the order date (time) and the due date (time) for this cycle of the kanban card through the kanban loop. However, this information is cumbersome if you reuse the kanban cards. (On the other hand, this information is helpful if it is a closely related CONWIP card for made-to-order goods).

49.5 Digital Readability

The kanban card can be read by humans, but nowadays it is often useful to have it in a machine-readable form.

Figure 384: 2D "QR Code" (Image Roser)

1D/2D Bar-code: A bar-code in either the classical bar code form or a 2D code that can store more information. In this case a simple handheld laser scanner will make it much easier to transfer information from the card into your ERP system.

RFID: Another option is to include a RFID chip (radio frequency identification). Rather than with a laser scanner, this works through radio communication. While this also works if the code is dirty or not in the line of sight, this approach has other issues (e.g., with shielding by metal parts).

49.6 Other Information

Figure 385: Brain with Gears (Image Roser)

Company Logo: Often, kanban cards include a logo or name of the company. Strictly speaking this is not necessary, but it is something companies like to do.

49.7 Good Practice for Kanban Card Design

There are a few things to keep in mind when adding data to the kanban card.

Priorities: Which information do you really need? You have limited space, so use it for the information that is necessary and don't overload the kanban card. Some information on the card is more important than others. For example, the part name, part number, and bar code are probably the most important information. Mixing these up will lead to lots of problems downstream. On the other hand, the index number of the kanban, for example, is infrequently needed.

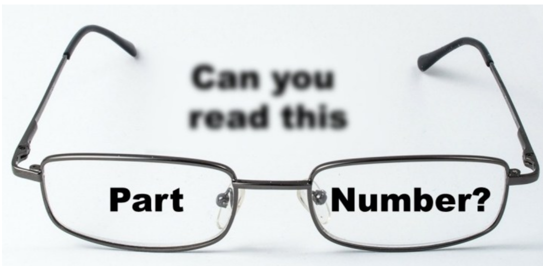


Figure 386: Can you read this Part Number? (Image Siberfuchs in public domain)

Readability: Print the important information using a larger font. Keep in mind that not all of your employees may have 20/20 vision. At least the critical information should be easy to read.

Labels: This should be obvious, but do label the fields or boxes. If you have a box with the number "20," it helps to know if this is the quantity, the packaging type, or the ERP code for the source.

Colors: You may be able to do the kanban cards in different colors. This may help your people. You could, for example, distinguish production and transport kanbans by color. You could also distinguish high runners from exotic parts, indicate source or destination, or use color to create priorities (see this series of posts for more on priorities).

Clarity: Do avoid choices or options for the operators. For example, if a transport kanban could get parts either from "*Warehouse A*" or "*Warehouse B,*" it will lead to confusion and waste. The same goes for "If … then …" kind of information. Instructions like "*If Warehouse A has more parts than Warehouse B, use Warehouse A*" is a sign of a ill-designed kanban system that leads to waste. Luckily, those kinds of thing seem to be very rare (or I just did not yet go to these places).

49.8 Very Simple Kanban

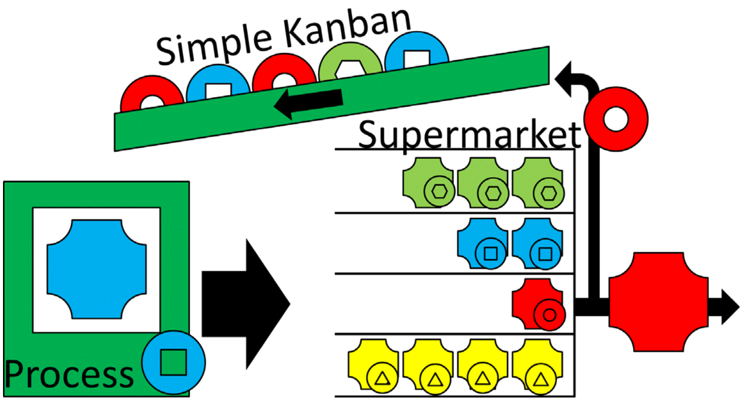


Figure 387: Simple washers as kanban (Image Roser)

Depending on the complexity of the products in the kanban loop, you may not need all this information. Toyota sometimes uses simply color coded washers or balls to inform the preceding process on what to produce. As shown in the image, a red washer with a round hole would mean a red part, a blue washer with a square hole would mean a blue part. If the information is clear for the supplying process, then these systems also work.

49.9 Simplest Kanban

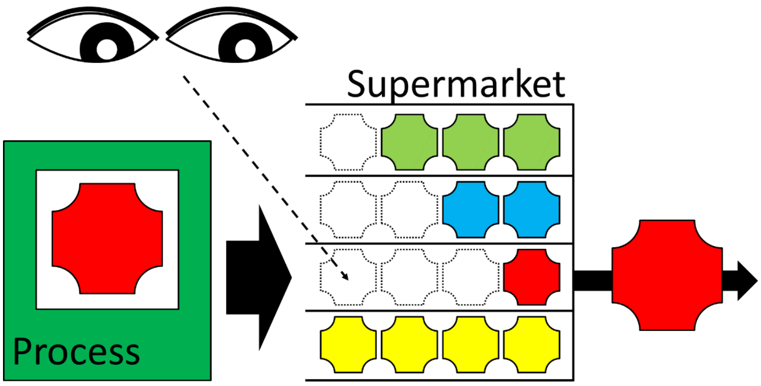


Figure 388: Even simpler looking at empty spaces as kanban (Image Roser)

The absolutely simplest kanban is of course no kanban at all. If the supplying process and the supermarket are right next to each other and the product variety is small, the worker can simply be instructed to always fill up the supermarket, starting with the part that has the most gaps (in the image this would be the red part). It is still a pull system, even though it has no kanban anymore.

Overall, the actual design of the kanban is not quite as easy, and a few things can be considered. Please do take the time to think about this when designing kanban cards. Now, go out, print some kanban cards, create a pull system, and **organize your industry!**

50 How to Ramp Up a Kanban System – Part 1: Preparation

Christoph Roser, December 13, 2016, Original at https://www.allaboutlean.com/kanban-ramp-up-1/

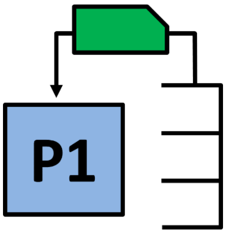


Figure 389: Simple Kanban Loop (Image Roser)

Designing a kanban system on paper is much easier than implementing it on the shop floor. In many of my previous posts I discussed the design of a kanban system in detail. In these two posts I will discuss the steps needed to actually put the system on the ground. This first post is the preparation, and my next post will be the actual switch to the new kanban system.

50.1 Planning Preparation

Figure 390: A man drawing blueprints (Image Tiko Aramyan with permission)

Before you implement, you need a few things. This includes, for example:

- A value stream design of the new system
- The number of kanban you want to use for each part type (either by calculation or – my preference – by estimation)
- The physical type of the kanban
- The data that goes on the kanban
- Coordination with and support from the people actually using the kanban system

50.2 Safety Stock and Timing

Depending on the extent of your changes, you may disrupt production. If something goes wrong, you may also need more time than expected. One possibility is to build up some buffer stock before the implementation to avoid stock-outs.

Figure 391: You don't want to run out of ice cream … (Image Tan Kian Khoon with permission)

On the other hand, the more inventory you have, the more inventory is in your way for the actual implementation of the supermarket. You may have to store the goods elsewhere to have the space to install a supermarket and make other changes if needed. A good compromise is to plan the change for a seasonal period of low demand when you don't need much material anyway. For example, if you produce ice cream, don't tinker with the system during the hottest days of the summer!

50.3 The Supermarket

For your kanban system to work, you need a supermarket. See my posts for [Theory and Practice of Supermarkets – Part 1](#) and [Part 2](#) for details. The supermarket has to be set up depending on the type and quantity of containers that go in there. Ideally, the supermarket should be able to hold all the products for all the kanban cards in circulation. If you are really short on space, you may be able to get away with less space for some high runners, but then you need a backup plan for where to put the material if the supermarket is full.

If the container size allows it, then supermarkets are well suited for rolling lanes. You add the material on one side and it rolls or slides down to the other end. This way it is very easy to create a first-in, first-out system for a supermarket.

Figure 392: Supermarket in construction with rolling tracks for pallets (Image praethip with permission)

In any case, you would have to get an actual supermarket. There are lots of details that are necessary. Does it fit the material? Does it fit in the space? Do you need electrical connection? Is the storage rated for the weight? Are the emergency doors still accessible? The list is endless, and the questions above are only examples of what you may have to keep in mind. If you have the equipment for the supermarket already on hand, you have to install it. Otherwise you have to first order the equipment and then install it. Of course, it is easiest if the equipment is already there and you can re-use the already installed equipment.

50.4 The Kanban Cards

You need kanban cards. Even with a digital system, this usually includes a printer with printed cards attached to the material. Simply print the cards and if necessary insert them in the kanban cover, attach them to the kanban box, or otherwise prepare them. For details on the design of the kanban card, see my post on [Kanban Card Design](#).

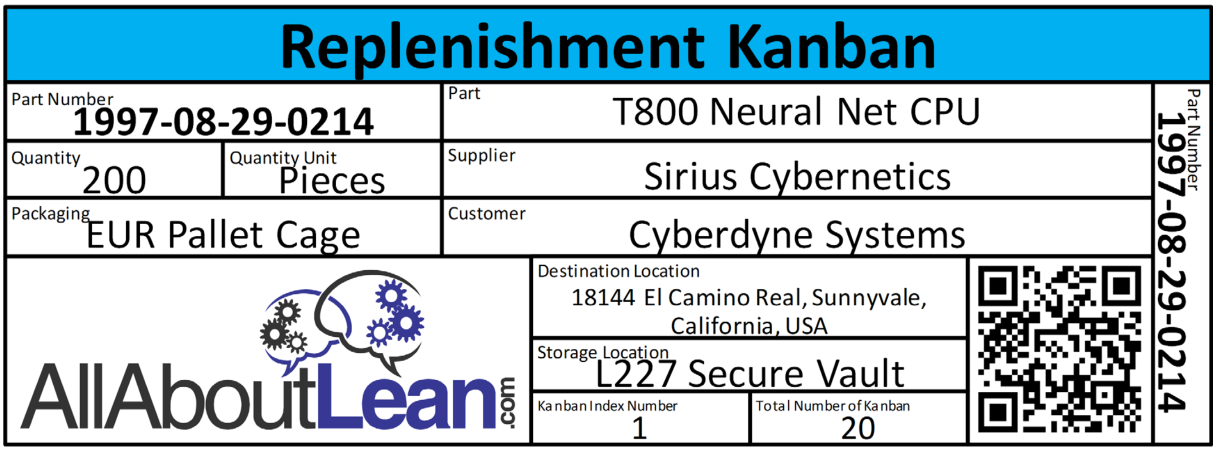


Figure 393: Kanban card (Image Roser)

Pro Tip: Print a few more cards and put them in your drawer. If for some reason you estimated too few kanban for your system, you can simply pull some more cards out of the drawer and bring them into circulation. You also may need them for the ramp-up if you have more material than kanban cards (see next post). Of course, ideally it should be the other way round: your estimate was too large, and over time you reduce kanban cards from the system. More on that below.

50.5 The Flow of the Kanban Cards

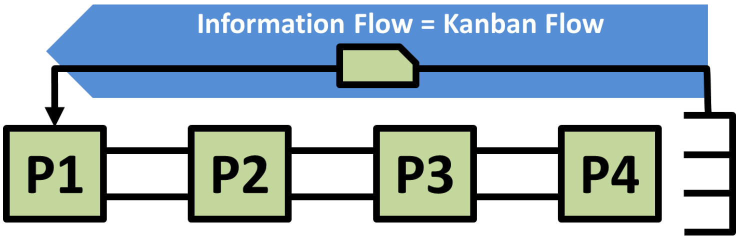


Figure 394: Information Flow Arrow (Image Roser)

When parts are taken out of the supermarket, the kanban card has to go back to the source to get more parts. Walk the way the kanban cards would go back to the source. Don't add any cards yet; we will do that later. Ask yourself the following questions:

Figure 395: Kanban mail box? (Image alexlmx with permission)

- Who would bring the kanban cards back?
- How often would this happen?
- Where would the kanban cards be stored at the supermarket in the meantime until the kanbans are picked up to be brought back? (Sort of a mail box for kanban cards.)
- Where would the kanban cards be dropped off?
- If you create lot sizes of more than one kanban card of the same part type: Where? How? Who does it?
- How do you organize the waiting of the kanban for processing? It should be a first-in, first-out system, with the kanban card waiting for production the longest (first in line) should be

processed first (unless you have a more complex prioritization system in mind — then see my series of posts on prioritization for details).

50.6 The Flow of the Material with the Kanban Cards

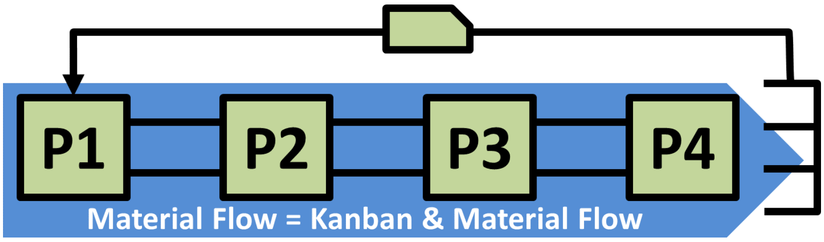


Figure 396: Material Flow Arrow (Image Roser)

Now walk the way from the start of the production or transport back to the supermarket. Again, we don't add any kanban cards yet but merely see how the card would move along the line. The kanban should stay with the part at all times. Is this possible? Of course, if for example the part goes through a tempering oven at 1000°C, the paper kanban card won't make it. Same for coating processes where the kanban is attached to the part.

- Where would you have to remove the kanban? By whom?
- Where would the kanban be put temporarily?
- When is the kanban attached to the part again? By whom?

You see, there are tons of little details to take care of. I highly recommend doing this together with the workers who will handle the kanban cards, both for the information and the material flow.

Okay, now we are ready and prepared to do the actual switch of the kanban system. This will be described in more detail in my next post. In the meantime, stay tuned, and **go out and organize your industry!**

P.S.: These two posts are based on a question by Felix.

51 How to Ramp Up a Kanban System – Part 2: The Switch

Christoph Roser, December 20, 2016, Original at https://www.allaboutlean.com/kanban-ramp-up-2/

Figure 397: On Air (Image mipan with permission)

In my last post I described how to prepare for the implementation of a kanban system. This post goes into more detail on the actual change to the new kanban system. You surely know that every part should have a kanban. But what do you do if you have more kanban than parts? What do you do if you have more parts than kanbans? Find the answers below.

51.1 The Switch

Figure 398: End Theory Start Practice (Image Roser)

After sorting out all of these details, you may be ready to switch and add the kanban cards to the system. Go through the system and attach the correct kanban card to every part in the system, including the parts in the supermarket. This is easier if you do it **against the material flow, starting from the supermarket.** This way the material comes toward you, and you are less likely to miss a part.

You have to attach the kanban cards to the material. When you do that, there are two possibilities. The easier one is to have more kanban cards than material (or equal numbers). However, if you have more material than kanban cards, it becomes a bit more tricky.

51.1.1 More Kanban than Material (or Equal)

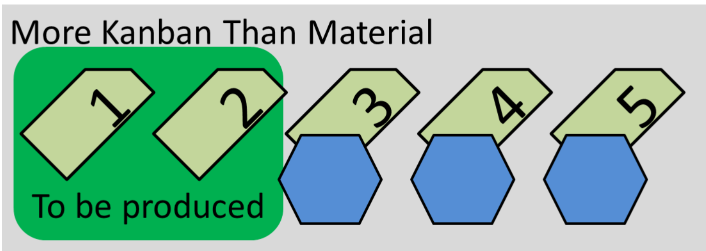


Figure 399: More Kanban than Material (Image Roser)

If you have kanban cards left over, put them in the stack of kanban cards at the source of the material so that the cards get processed. The sequence of the cards should be mixed, ideally not randomly mixed but with a sequence that ensures you don't run out of parts. This is very similar to the pattern of the one-piece-flow leveling.

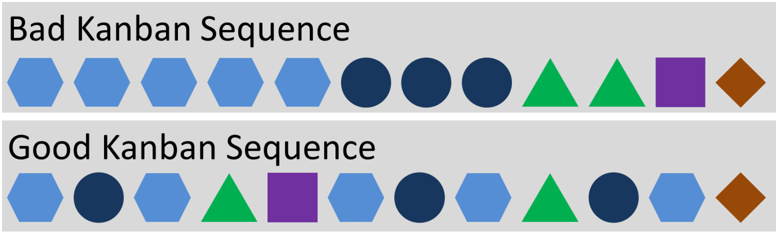


Figure 400: Kanban Sequence Mix Example (Image Roser)

Of course, if it is a completely new system without any existing material yet, all kanban are mixed according to this pattern. You can (optionally) create a temporary priority that any kanban coming from the supermarket has priority over the kanban from the initial mix that still are not yet produced. This way your production follows demand even closer. But again, this is optional.

51.1.2 More Material than Kanban

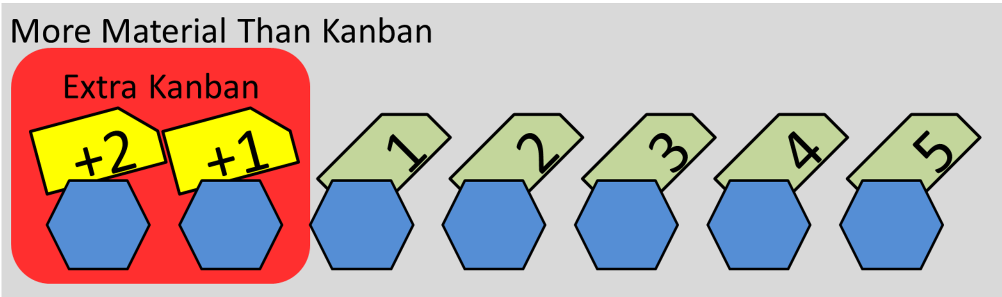


Figure 401: More Material than Kanban (Image Roser)

On the other hand, if you have more material than kanban, you have a bit more work. You have more material than your system should have. Yet, in a kanban system, all material must have a kanban associated with it. Hence, you need more (temporary) kanban cards. Attach a card to every piece of material, even if it exceeds your initially planned number of kanban.

Now that all material is "kanbanized," you have to reduce material. Whenever the customer orders a part, you get a kanban card without material. These you now can reduce until you have the desired inventory levels/number of kanban. However, this reduction has to be gradually over time. If you take away all cards that are coming from the supermarket, your workers may be idle and have nothing to do.

Now you could think, *Well, I just shut down the line until I have my number of kanban.* Unfortunately, this may not be good either. In all likelihood you have multiple part types on the line. In this case, in all likelihood you have too much material only for a few part types. If you now shut down the line, you risk running out of stock of the other part types which you did not have too much material for. It is probably best to gradually reduce the number of kanban over time rather than reduce all of them as soon as possible. This is part of the debugging and adjusting process below.

51.2 Training of the Workers


Figure 402: Training in the use of the new standard (Image ndoeljindoel with permission)

All workers who have to use the new kanban system need to be trained in its use. Don't forget the night shift. At the beginning, you probably should spend quite some time at the line to verify proper use of the kanbans.

A common mistake is in the case of no kanbans at the process. In this case, the process should stop. Workers are usually hesitant to stop and may work on parts without kanbans. This is overproduction! Don't do it. Rather, if they run out of parts, they should come to a supervisor or manager. Depending on the situation, they may be temporarily assigned to another workplace until kanbans become available again. But: **No production without kanban!**

51.3 Debugging

Figure 403: Get 'em all! (Image natbasil with permission)

Wonderful. Your system is up and running and the kanbans are circulating. This means you are probably more than halfway done. The second half of debugging, adjusting, and verifying is unfortunately all too often forgotten.

Just because the system is running does not mean that it runs smoothly. There is still much more work to debug the bugs, fix the kinks, and overcome smaller hurdles. This will make the difference between a mediocre system and a good one – but it will take quite some time and effort. Talk with the operators and foremen frequently, and see where they have problems. Mentally sort the complaints into those due to the workers not being used to a new system (nobody likes change anyway) and those that are actual problems. Try to help them with the latter ones.

Overall, this debugging process will also help you with the "check" and "act" of the PDCA sequence. If you do this debugging, you will learn if the system actually works and if it is (hopefully) better than what you had before. **Don't take it for granted that just because you changed something, it must be better than before!**

51.4 Kanban System Maintenance

Figure 404: Maintenance (Image ArtemSam with permission)

Another thing to do is maintenance of the kanban system. This is mostly two parts:

Is it the right number of kanban? If everything runs super, maybe you can remove a kanban and become even leaner. If you have some stock-outs, maybe you should add some kanban (or improve the system so it works with the same number of kanban but less stock-outs. Better, but more difficult).

Are kanban missing? Kanban do occasionally get lost. Check every now and then to see if there is still the number of kanban cards in the system that you want to have.

I wrote about this a bit more in detail on a previous post How Many Kanbans? – Estimation Approach and Maintenance.

Additionally, there is of course continuous improvement. Never stop getting better. **Now go out, get better, and organize your industry!**

P.S.: These two posts are based on a question by Felix.

52 Dealing with Uncertainty

Christoph Roser, December 27, 2016, Original at https://www.allaboutlean.com/dealing-with-uncertainty/

Figure 405: Uncertainty (Image Chris Titze with permission)

A lot of decisions in lean manufacturing have uncertainty. How many products will I sell (and what is my customer takt)? Which layout is more efficient? Should I believe expert A or expert B? Uncertainty is a part of life in manufacturing. In fact, the higher up you go in the hierarchy, the more you have to deal with uncertainty. And often these are not just simple "A or B" type of questions, but highly complex and interacting decisions like "What should our new line look like?" Here are some suggestions on how to deal with uncertainty. Please note that they will not answer all of your questions but will help you make better decisions.

52.1 The Wrong Way

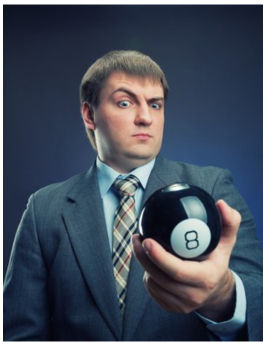


Figure 406: I know all the answers… (Image Nomad_Soul with permission)

In industry, I often encounter managers who seem to have an answer for any question. No matter what you want to know, they can tell you what you should do.

Those managers scare me!

Nobody knows all the answers! They just tell you the first thing that pops into their minds. Unfortunately, this is rarely the best and many times not even a good solution. Equally unfortunately, their answers often look good to their bosses and may help them to get promoted.

Please do not get this "instant answer" confused with conviction. Once a decision has been made, the manager should give his people a feeling of certainty and conviction. A commander-in-chief usually should not show his own doubts to his people. But he should have doubts and question his own decisions. **Most of all, the manager should not just make up answers on the spot!** Here are some suggestions on how to do it better.

52.2 Break Problems into Smaller Problems

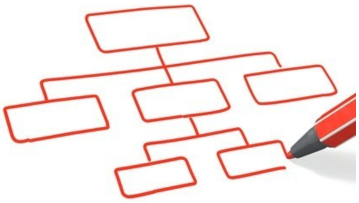


Figure 407: Tree Diagram (Image bluedesign with permission)

One approach is to break a big problem into multiple smaller problems. The initial big problem may have lots of uncertainty. If you break it into smaller sub-problems, there will be less uncertainty. Sure, there are still things you don't know, but others you will know. A mix of sub-problems with varying uncertainty will generally give a better result than looking only at the big problem with lots of uncertainty.

Take for example the problem of designing a new line. It will be much easier to break this into sub-problems. To answer the question of how the line should look, you answer many sub-questions like "*What is my customer takt?*" "*What is the OEE?*" "*What are my cycle times?*" and so on. Even though all of these questions have some uncertainty, overall the result will be much better than creating a line without these details.

You can break down problems into smaller sub-problems. You can also give these problems a hierarchy or sequence. First you decide if you want a flow shop or a job shop, and then you go to the next decisions based on your previous decisions (see also the *alternate scenarios* below).

52.3 Get Good (Enough) Data

Figure 408: Analyze Data (Image peshkov with permission)

Sometimes, uncertainty can be answered by getting and analyzing data. Yet obtaining and analyzing this data takes effort and – more importantly – time. Hence, you have to make a trade-off.

In my experience, Western managers often fall short when obtaining and analyzing data. Take for example sales prediction. In the West, many mathematical models are available to predict future sales data based on past sales. Unfortunately, while mathematically beautiful, they are often not very good. In fact, the most complex models seem to give the worst results.

Toyota, on the other hand, spends a lot of time talking to past, current, and future customers. Much more, in fact, than Western car makers. Hence, the sales predictions at Toyota are often of a very high quality compared to other companies.

52.4 Use the Wisdom of Groups

Figure 409: Lots of Wisdom. (Image Kurhan with permission)

Correctly managed, groups can be more intelligent than individuals. Together, a group has more knowledge and experience than an individual. Hence accessing the knowledge of the group can create better results.

Figure 410: Man on the Moon (Image NASA in public domain)

There is a famous NASA exercise, "Ranking Survival Objects for the Moon," that demonstrates this point. Assume you are stranded on the moon and have a list of 15 possible items that you can take along (from oxygen tanks to a compass to matches). What would be the ranking in priority of the different items. In this exercise, groups consistently perform better than individuals.

Hence, involving multiple people in the decision making often gives better results. You could either interview or talk with different people to get their view and help form your opinion. Alternatively, you could have a group workshop or exercise to access this wisdom of the crowd. Please note that the smoothest talker is not always the most knowledgeable person.

52.5 Make Different Scenarios

Figure 411: Many different options … (Image alphaspirit with permission)

It can also help to make different alternative scenarios. Sometimes it is difficult to decide between two or more options. In this case it can help make a scenario for the different options.

For example, if you have not yet decided if it will be a flow line or a job shop, make a draft of both and compare them. Do not make a completely designed flow shop or job shop, but merely an estimation of how it could look. This should be enough to compare multiple ideas.

I have seen this multiple scenario problem solving very often in Japan, and I also use it myself. I like this method so much that I wrote a full blog post on it: "Japanese Multidimensional Problem Solving."

52.6 Delegate

Figure 412: You decide … (Image DDRockstar with permission)

In many companies I have seen, it is common to leave the problem for the next level in the hierarchy. Many managers also feel empowered by making decisions and want to make the decisions.

Unfortunately, all too often managers have to make too many decisions while lacking both time and knowledge to make good choices. There is even the common effect of Decision Fatigue for the deteriorating quality of decisions made by an individual, after a long session of decision making. The more decisions a person makes, the worse these decisions become.

Often, it would be much better if the manager hands the decision making back down to the next level in the hierarchy. These people generally know many more details and also can pay more attention to the particular decision. Hence, whenever someone asks you to make a decision, think first if you are the right person to make this decision or if it would be better if you let your people make the decision.

52.7 Summary

Making decisions without all the information is tough. Yet in industry this cannot be avoided. In fact, the pay grade tends to reflect the level of uncertainty in decision making. A CEO needs to make decisions with much less certainty about the outcome than an operator on the shop floor. Yet the decisions have to be made. Now, **go out, make some decisions – or even better, have them made by your people – and organize your industry!**

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Figure 413: 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.

Prof. Dr. Christoph Roser is an expert for lean production; Toyota, McKinsey, and Bosch Alumni, and professor for Production Management at the Karlsruhe University of Applied Sciences. He is interested in everything related to lean manufacturing, bottleneck detection and management, as well as historic developments of manufacturing. His first book is "Faster, Better, Cheaper" on the history of manufacturing.

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