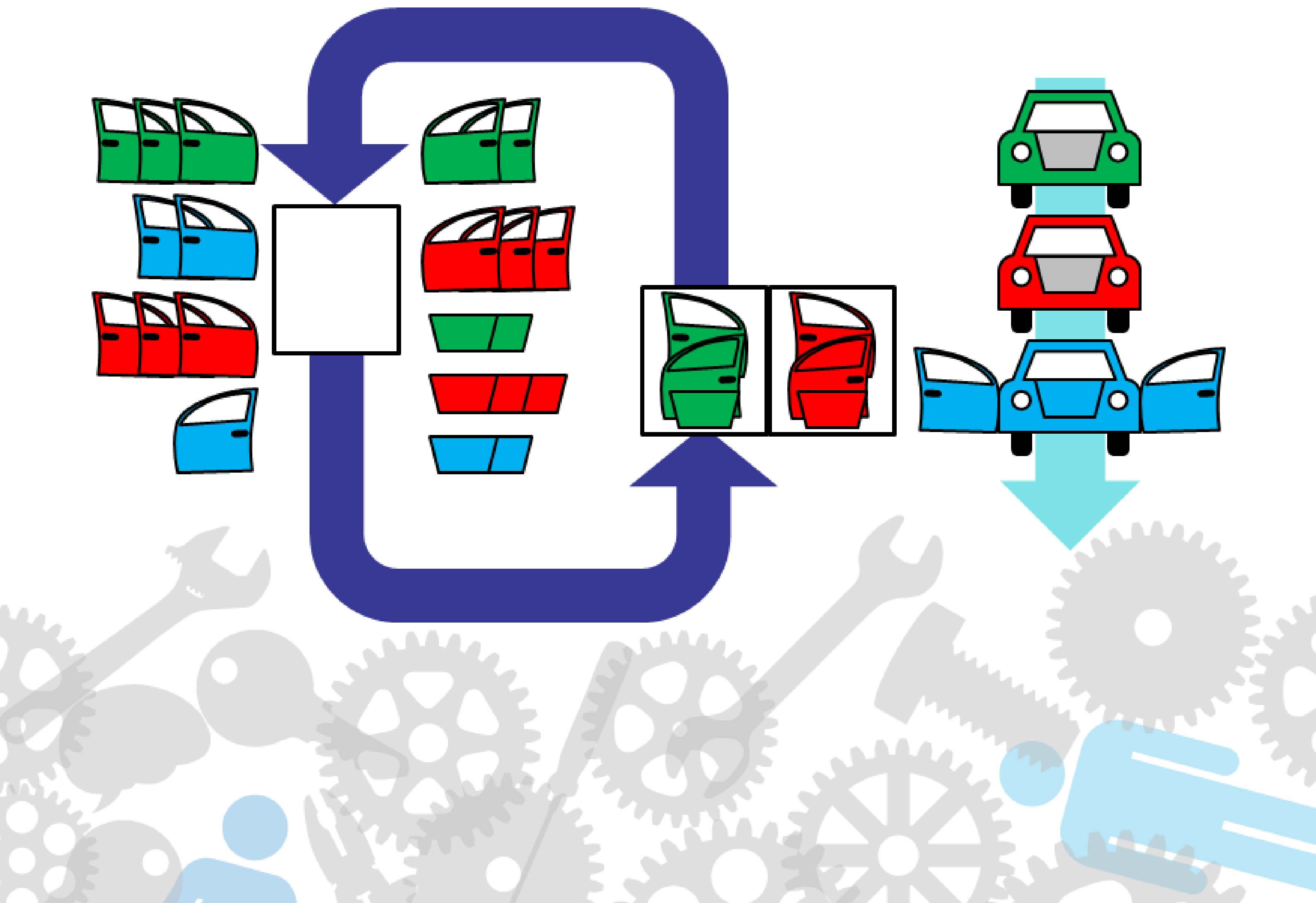
Collected Blog Posts of AllAboutLean.com

2018

Christoph Roser



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Christoph Roser

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Other Books by Christoph Roser

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

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

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

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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.

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1 The Dark Side of Japanese Working Society

Christoph Roser, January 02, 2018, Original at https://www.allaboutlean.com/dark-side-of-japan/

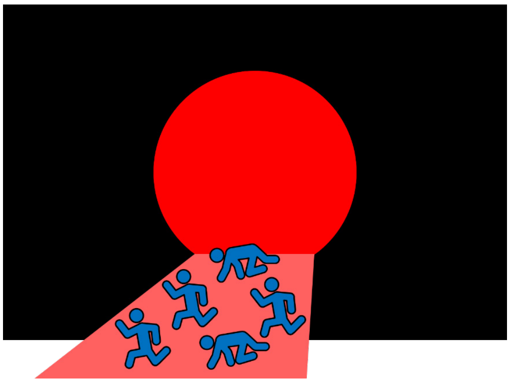


Figure 1: The dark side of Japan… (Image Roser)

The Japanese work ethic is pretty amazing, and their work standards are among the best of the world. In previous posts I have often written very favorably on these standards. Yet, not all is right in the Japanese working world. In fact, a lot is wrong and troublesome, and this superior work performance comes at a significant cost of work-life balance.

1.1 Introduction

Figure 2: Pointing and calling. (Image Roser)

A lot of my previous posts deal with the excellent aspects of Japanese monozukuri (e.g., Japanese Standard Pointing and Calling, The Japanese Supermarket Checkout, Toyota's and Denso's Relentless Quest for Lot Size One, Japanese Multidimensional Problem Solving, or even Lean in the Japanese Public Toilet). Many of these are role models for the rest of the world.

Yet, as in all societies, not everything is perfect. Japan has a huge problem with an aging society, having the highest proportion of elderly citizens in the world. Japan also has the highest debt in the world, with public debt exceeding 200% of their GDP (poor Greece has only 180%). However, in this post I will focus on the work-life balance, which is also among the worst in the First World.

1.2 Pressure to Fit In

Figure 3: Hello Lizzy, how are ya doing? (Image Agência Brasil – EBC under the CC-BY-SA 3.0 Brazil license)

One difficult part of Japanese society is the pressure to fit in. These social norms are much more detailed than in pretty much any other country. The Japanese give many interactions the rigid formality of a visit by the queen.

Figure 4: Japan business card hand over procedure. (Image aijiro with permission)

A simple example. A process like exchanging a business card (名刺 *meishi*) requires the knowledge of many different rules unless you want to look like a buffoon. I have listed the rules (as far as I know them) at the bottom of this post if you are curious.

Mix up any of these rules, and you look uncultivated and amateurish. And this is only a very small example of rigid Japanese social norms. Even Japanese who have lived abroad for a few years often have difficulty fitting back in. For example, one Japanese female I know who works for a Japanese company abroad needed one week merely to figure out what to wear to the office when visiting the Japanese head office. Even with a standard business suit, there are many variations that can make you the oddball-out. Another one who returned from decades abroad now finds it extremely difficult to live in Japan.

Figure 5: A tea ceremony with a starbucks cup … how I feel in Japan. (Image Adriano under the CC-BY-SA 3.0 license and Engin_Akyurt in public domain)

Japan sometimes feels like one big tea ceremony, where everything has to be in perfect conformity with the rules. As a foreigner you never really notice this pressure. If you don't have a Japanese face or don't speak Japanese, then you are already outside of the system, no matter what. Nobody expects a foreigner to know any of the rules, hence foreigners have a lot of liberty. In the big tea ceremony of Japan, foreigners are the Starbucks soy latte, and are exempt from (almost) all the rules. Just don't litter, and keep the soap out of the public bathtub.

Yet, for Japanese this pressure is unforgiving, like a straitjacket on everything you do. There is almost no escape, especially when entering working life. The peer pressure is enormous. Many Japanese who go abroad never want to return home due to the restrictive society and very stressful work life. In Japan there is also the social phenomenon of *hikkikomori* (ひきこもり or 引き籠り), or extreme social withdrawal, where a person just doesn't leave their room for months, having their parents care for them instead. Supposedly there are 700,000 people with this problem in Japan, some staying indoors for twenty years, simply because they can't deal with the pressure of Japanese society.

1.3 Working Hours

Figure 6: A typical Japanese office. (Image Danny Choo under the CC-BY-SA 2.0 license)

The second big impact is the often grueling working hours. Officially, Japan has a forty-hour work week, but 22% of the workforce works fifty hours or more per week (US 11%, Spain 6%), and some workers put in even more hours. One-hundred-hour work weeks do exist (including Saturdays and even some Sundays), and that does not even count the commute, which on average takes forty minutes one way, but 2 hours is also not exceptional (the US average is 25 minutes). It also does not include the frequent and almost mandatory drinking parties (飲み会 *nomikai*) after work. Fortunately, at least the last aspect is changing, and many younger employees decline to join, or request overtime pay if it is mandatory.

Figure 7: Rush hour in Tokyo (Image Chris 73 under the CC-BY-SA 3.0 license)

After World War II, the US occupational government started to establish US-style workers unions in Japan. However, these unions were soon taken over by the communist party. This was around 1950, when McCarthy and his McCarthyism communist witch-hunt was in full swing, and communist unions in Japan were absolutely not what the US wanted. Hence they changed the laws to take away power from the unions in Japan. Nowadays, unions in Japan have no power. Each company has their own union, which consists mostly of the managers or supervisors of the company. Unsurprisingly, they do not do much to improve the lot for the common employees. Japan never went through the labor problems to reduce work weeks, and its working hours are often quite long.

Japanese also have comparatively few vacation days, and use them even less. The average Japanese uses only seven of the eighteen vacation days every year. Seventeen percent of the workers take no holidays at all. The society sees taking holidays as abandoning the company, and how dare you take more than three days vacation in one row! There are many workers in Japan who would have accumulated hundreds of vacation days – except that they are usually voided above a certain number. Another example: A Japanese expat in Germany profusely apologized to his German colleagues for taking holiday, which resulted in hilarious laughter from the Germans, because there is nothing to apologize about.

1.4 Work-Life Balance

The rigidity and the long hours make for an often miserable work-life balance. A Japanese adult working life consists mostly of work interrupted by brief sleep. You rarely have time to talk to your spouse, no time to play with your children, no time or energy for hobbies, and no time to relax. Japanese workers are always in a rush, and to me it seems they often don't really have a life. Of course, this does not apply to all Japanese, and some managed to find work that combines well with having a life, but many Japanese, especially office workers, are stuck in this rat race.

There are anecdotal stories of children asking their mom what that strange man is doing sleeping in their home … it was their dad, who the children see so rarely that they have forgotten him. I also have met many 40isch year old men and women that want to get married and have children, but don't have time for dating. Hence, especially for the women it may never happen.

1.5 Effects

Figure 8: Sad Japanese worker. (Image oka with permission)

The effects make Japan a rather unhappy place to work if you are a corporate employee. Long hours, no free time, often little freedom. On the world happiness index 2016, Japan ranks 51st out of 155 countries, but far behind other wealthy nations (#1: Norway, USA #14, Germany #16).

Death from overwork and work-related stress is so common that there is even a Japanese word for it: *Karoshi* (過労死). The death is usually through a heart attack, stroke, or suicide. As an example, a twenty-four-year-old female employee killed herself after having depression most likely caused by the 105 hours of overtime in the preceding month. In the fiscal year ending March 2016, there were 93 cases of death from overwork confirmed by the health ministry, although the police reports attribute 2,159 deaths to work-related stress.

Work is so present in Japan that many don't even know what to do if they have some time off. Many retired people keep on working since they don't know what else to do. Divorce rates increase since the spouses never learned to live together or talk with each other.

I find this sad, as Japan would have all the ingredients for a happy society: peace, stability, economic prosperity, health, etc. However, the long working hours and the internal constraints of society make it a pretty miserable work life. Yet, the long work hours would not really be needed, since productivity does not suffer if you reduce work hours to a (for Westerners) more normal level. Relaxed and well-rested workers are much more productive. I can tell you from my own experience that working long hours reduces productivity enormously. Yet, the long work hours in the office in Japan are often spent at the water cooler or reading the newspaper.

1.6 Government Activities

The government recognizes these problems, to some extent, and tries to work against them. There are laws limiting overtime to 45 hours per month and 360 per year, but they are only slowly being enforced. The average overtime is also only slowly coming down. Relatives of deceased workers also now find it easier to file for damages due to death from overwork.

Figure 9: Premium Friday logo. (Image 経済産業省 in public domain)

The government also tries to change society to shorter work hours. In February 2017 they introduced a "Premium Friday," where workers can go home after 15:00 on the last Friday every month (for reference, in Germany we just call this Friday, as almost nobody works on Friday after 15:00).

Figure 10: Premium Friday logo in Japanese (Image 経済産業省 in public domain)

Yet, this initiative did not work well. Many people simply did not know what to do with their free time (since they haven't really had any before), and hence some bosses told everybody that they need to go to the *nomikai* drinking party at 15:00 rather than 20:00 or 22:00. In any case, "Premium Friday" is now pretty much ignored.

Overall, Japanese society blocks itself from happiness, and the government's actions change it only slowly. Of course, not everybody in Japan is depressed. There is also lots of happiness. However, overall the workplace makes it a bit more difficult to be happy than most other countries.

I hope that your workplace is happier, and you work to live rather than live to work. Now, go out, enjoy your life, maybe even go home early today and have some fun, and then come back the next day relaxed and energized to organize your industry!

1.7 Appendix: Japanese Business Card Etiquette for Beginners

- When to give another person your business card: At the beginning of the first meeting, but initiated by the higher rank. It becomes more complicated if you are a bigger group with different ranks. Yet there are also exceptions where the lower rank offers it first to show humility.
- How to give it: With two hands, each hand holding a corner on the longer side. Do not cover logos or text with your fingers. There is a slightly different protocol if you receive a card at the same time.
- Which side to face up: Japanese character side in the correct orientation so the other can read it, unless it is a foreigner, in which case the Latin letter side is facing up.
- What to say: Standard phrase giving your name and company, standard phrase thanking for the card.
- Body posture and movement: Of course you bow while doing it, opening up the completely new social norm of bowing (angle, duration, etc., depending on the social status).
- What to do next: The card is put in front of you on the table for the duration of the meeting, and treated with uttermost care.
- Where to store the card: The only acceptable place to store the card after the meeting is the business card holder. Never put it in your wallet, or – omygosh – sit on it in your wallet.
- Absolute no-no's: Never ever write on the card of the other person. You may as well write on his face. Do not bend the card. In fact, always treat it with uttermost respect.

2 Heroes, Firefighting, and Corporate Culture

Christoph Roser, January 09, 2018, Original at https://www.allaboutlean.com/on-firefighting/

Figure 11: Hero with a cape (Image rudall30 with permission)

Heroes save the day. Heroes turn around the disaster and rescue the puppy from the burning building. Heroes are admired, and everybody wants to be one. Everybody wants a hero when they need one.

But what about the people who prevent the need of a hero? What about the people that make sure the disaster never happens? What kind of people do you really need in your company?

2.1 Firefighting

Figure 12: Firefighters (Image skeeze in public domain)

Firefighters are the prototype of the modern-day hero. While most of their tasks are low risk, every now and then they run toward danger while everybody else is running away. During the 9/11 attacks, of the 2,977 victims, 412 were emergency workers, of which 343 were firefighters.

Statistically speaking, however, firefighting is reasonably safe. The fatality rate of 6.1 is roughly identical to the average for male workers of 5.8, measured in deaths per 100,000 full-time workers a year (Source: Bureau of Labor Statistics, 2016 data for USA). You are much more likely to die as a logger (135.9), fisherman (86.0), aircraft pilot (55.5), or even taxi driver (13.0).

When the average person interacts with a firefighter, it is often in a time of dire need, and the firefighter is there to help. In contrast, if the police come running for you, it may not always be what you want.

2.2 "Firefighting" in Industry

Figure 13: Here to save the day… (Image luismolinero with permission)

In industry, firefighting often refers to fixing any kind of problem. “The delivery of parts is delayed? Someone needs to take care of that!” “We have quality problems? Someone fix that issue!” “The machine is broken (again)? Who saves the day?”

Many businesses rely on such firefighters to keep running and solve the many daily problems that pop up. Like real firefighters, they are often valued for their ability to put out fires and keep the system running.

2.3 Fire Safety Inspector

Figure 14: You are in violation of fire safety code 47-11. Exchange the batteries of your smoke detector immediately! (Image Minerva Studio with permission)

Real firefighters save lives, no question about that. Yet, I argue that many, many more lives are saved by preventing the fire in the first place, not to mention other damages avoided.

There are a myriad of actions, technologies, and standards to keep fires and other problems from happening in the first place. Most consumers are not even aware of these, but a lot of effort goes into making buildings more fireproof. Similar efforts go into building so that in the case of a fire, it is contained and occupants are warned and evacuated.

Figure 15: Luckily a rarity nowadays (Image Natalie_Oxford under the CC-BY 4.0 license)

Nowadays, it is luckily rare that a fire turns into a major disaster, as for example the Grenfell Tower fire in London 2017, in which 71 people died. But in history it was common that entire towns burned down due to a small fire. Major parts of London, for example, burned down in 1130, 1132, 1135, 1212, 1220, and 1227. During these 100 years, there was a major fire every 15 years.

Modern safety is in large part due to the improvement and enforcement of safety standards. It is said that these are “*written in blood,*” as they usually get updated after someone dies. The Grenfell Tower fire went from being a minor refrigerator fire to a major blaze of the entire complex probably due to highly flammable exterior panels. Hence, building codes are currently updated accordingly to prevent this from happening again. This also happens in other industries, for example in aviation, rail, and road traffic. Many standards are there to make things safer.

Figure 16: US Airways Flight 1549 (Image Greg L under the CC-BY 2.0 license)

Yet, most of us do not consider fire safety inspectors as heroes. In fact, those enforcers of standards often come across as nagging and annoying, making it harder for us to do actual work. Take for example the movie "*Sully*" with Tom Hanks, about the emergency ditching of US Airways Flight 1549 in the Hudson River. A large part was about the work of the National Transportation Safety Board. However, for dramatic purposes they portrayed the NTSB as prosecuting, harsh, cold, and antagonistic – very different from the actual events.

In any case, safety inspectors are not very high on our list of people we admire. Yet, while they usually do not risk their lives, their actions probably save more people than firefighters do.

2.4 Prevent "Industry" Fires

Figure 17: Electric candles prevent fires (Image PXHere in public domain)

In industry, it is the same as in firefighting or aviation. Your focus should be on preventing the accident rather than fixing it afterward. A problem that never happened is much better and more profitable than a problem that was fixed using firefighting.

Yet, careers are made by firefighting. Like with real fires, the firefighter gets the glory, and the fire inspector is a nagging annoyance. No wonder that firefighting is often more popular in industry than preventing fires.

Fires will happen, and you do need people to put them out. Yet, often these "heroes" are the ones that ignore standards. They fly by the seat of their pants, make quick gut-based decisions, and hence make many mistakes and worsen the system. In some industries they are called firefighters; others name them cowboys or capes. The effect is the same: chaos! See for example the two excellent quotes below from healthcare at Virginia Madison before they became lean (full source at the bottom):

"We used to heavily reinforce the value of the person who could kind of swoop in and save the day, the one who did the exceptional things. [...] No one followed standard work and the **cowboys** *did great things in health care, but they were probably some of the most dangerous people, too, because they weren't following standards. They were multitasking, they were doing everything that led to bigger errors." (pg 123)*

*"Many people in health care are in leadership positions because they are able to do amazing things that save the day. [...] We call them '***capes***.' They're the ones who come in during a crisis and make a decision that saves the day. That has been our system in health care—to rely on people who do it all and they keep the system together; people who can manage in a crisis. But we don't want a crisis. We want systems and standard work to prevent a crisis. If there's a crisis, most often it's a failure of leadership." (pg 159)*

2.5 Fueling the Fire for Glory

Figure 18: Burning for glory… (Image Осадчая Екатерина under the CC-BY-SA 4.0 license)

It gets even worse. Sometimes to achieve glory, the firefighters/cowboys/capes are the ones intentionally lighting the fire. In actual firefighting this is called firefighter arson.

In industry, too, there is anecdotal evidence of similar behaviors. I know of one story where a female supervisor was the only one able to fix a frequently malfunctioning machine and was heavily praised for it. Yet, at one point, someone did an analysis and found that this machine never broke down when this supervisor was on vacation or on a business trip, but frequently broke when she was present. She left the company shortly before the analysis.

2.6 What Kind of People Do You Need?

Now, ask yourself what kind of people you need in your company. Compare this to what kind of behavior you actually give positive feedback on. What kind of behavior gets a promotion or a raise in your company? It is easy to value firefighting, because it is very visible, whereas the prevention is much harder to see.

When I am in a burning building, I definitely want a firefighter and will be very glad if one shows up. Yet, my preference would be that the building doesn't catch fire in the first place. You definitely need firefighters. The focus, however, should be on fire prevention! Now, **go out, recognize and praise someone for preventing fires in the first place, and organize your industry!**

2.7 Source of the Quotes

Transforming Health Care: Virginia Mason Medical Center's Pursuit of the Perfect Patient Experience, Taylor & Francis Inc, ISBN 978-1563273759

3 Training within Industry – TWI – Oldies but Goldies

Christoph Roser, January 16, 2018, Original at
https://www.allaboutlean.com/training-within-industry/

Figure 19: We Can Do It! (Image J. Howard Miller in public domain)

Training within Industry – or TWI for short – was a US program during World War II. It significantly improved industrial production and helped the Allies to win the war. While the ideas date to the 1940s, they are still very relevant. In my view, they are pure gold if you have to manage a shop floor. It is to me the best overarching system for training and managing workers, and it significantly influenced Toyota.

While technology has changed a lot since 1945, people have not. The methods of TWI still work, and can really help you to improve. Even better, the original US government documents from 1945 are all in public domain. Let me introduce you to TWI. This is the first in a series of five posts on TWI.

3.1 History

Figure 20: Do The Job He Left Behind (Image Office of War Information in public domain)

TWI has it origins (very loosely) in World War I, when Charles R. Allen developed his four-point method of Preparation, Presentation, Application, and Testing to train shipyard workers. He published it in his book "The Instructor, the Man and the Job; a Hand Book for Instructors of Industrial and Vocational Subjects" (1919).

In preparation for joining the World War II, the US established the TWI Services as part of the **War Manpower Commission** in the summer of 1940. The problem was that the US needed to rapidly increase its industrial output. After all, it was the primary supplier of equipment to the allied forces Great Britain, France, and even the Soviet Union. At the same time, the industrial manpower was abroad fighting the war. Initially, the TWI Services was planned only for a short time, and the manpower was mostly borrowed from industry for a symbolic $1 per year (the "*Dollar a Year*" men).

Women stepped up to provide the labor, but they had no experience in industrial work like welding, milling, and drilling. Hence, TWI developed the main four modules based on Allen:

- **JI: Job Instructions**: Teach supervisors and experienced workers on how to train new workers.
- **JR: Job Relations**: Teach supervisors on how to deal with workers and possible conflicts, using facts, with the goal to find the best solution for everyone involved.
- **JM: Job Methods**: Teach how how workers can improve their work.
- **Program Development**: Overarching course on how to spot, analyze, and improve production problems.

Figure 21: I'M proud of you, folks! (Image John Whitcomb in public domain)

There are a few more modules in existence, mostly developed after the war by successor institutions of TWI. These are Union Job Relations; JS: Job Safety; PS: Problem Solving; DL: Discussion Leading; and Job Economic Training. Out of these, Job Safety is the most successful one.

In any case, these four main modules of TWI were a smashing success, with over 1.7 million people trained. TWI was an crucial tool in stepping up industrial output for the war.

However, after the war ended, most of the men came back, took their old jobs, and the women went back to their kitchens. The TWI Services was shut down by the US government on September 28, 1945. With this, the TWI effort became much smaller. From the 16,551 plants that had people trained, a few hundred pledged money to keep the program alive. TWI conferences were held until 1952 (and since restarted again). The key people of TWI founded the TWI Foundation and the TWI Inc, but without the government backing it had much less influence in the US. They were, however, more successful abroad, especially in Japan. TWI significantly influenced Toyota, and old TWI manuals popped up as training materials at Toyota when they established their NUMMI joint venture with GM in the US.

The graph below shows the mentioning of TWI in books during the last century. The war peak between 1940 and 1945 is clearly visible, after that there is a gradual decline to the present.

Figure 22: Training within Industry Ngram Viewer (Image Roser)

Out of the programs, Job Instructions was the most popular one with around 1 million people certified. Job Relations came second with 490,000 certifications, followed by Job Methods with 244,000. Union Job Relations had only 8,800, and Program Development only 1,800.

3.2 Why TWI?


Figure 23: Here's your new welder… (Image gstockstudio with permission)

Nowadays, TWI is often known in industry, but lacks … well … sex appeal. Management's focus usually goes to more glitzy and modern (looking) programs.

But this misses out on a great program. TWI managed to boil its methods down to a few key points for each of the modules, which they printed on small cards the size of a playing card. Hence, it is not a complicated method, but rather straightforward.

TWI considers five important skills that every supervisor should have, or what they call **the five needs of a supervisor**. These are all improved by using them in practice, but a theoretical training can give a head start. These five skills are also usually the starting point for each of the different modules.

- **Knowledge of the Work**: This may relate to machines, tools, materials, operations, processes, or technical skills.
- **Knowledge of Responsibilities**: This may be policies, regulations, interdepartmental relationships, agreements, rules, schedules, and – very important – safety rules.
- **Skill in Improving Methods**: To utilize machines, manpower, and material more effectively. Nowadays we would say to reduce waste (muda).
- **Skill in Instructing**: To have a well-trained and effective workforce.
- **Skill in Leading**: Improve your ability to work with people to get the most out of the people you have.

Three of the modules directly address one skill each. Job Methods is about improving methods. Job Instructions is about instructing. And Job Relations is all about leadership. TWI assumes that the knowledge of work and responsibilities is taught by the workplace, as it is difficult to generalize these topics.

3.3 Some Limitations

The TWI approach is very good at what it does, but its focus is on teaching and leading the worker as well as helping him to improve his job. It is not so much focused on the bigger picture of management. But if you use it for what it is intended to do, it works well.

The Job Instructions program is in my view still very good and very useful for training most working tasks. The Job Relations is also pretty solid and good material, although it has potential to include more improvement into the daily leadership tasks. Job Methods has, in my view, the most shortcomings, as it involves the workers very little, both for idea generation and implementation. It could also use some touch-ups to embed the improvements as part of the bigger picture of the plant goals. The original TWI people actually wanted to do this, but management decided that it was good enough. This is also the program that got the most updates after 1945.

In the next few posts I will go through the main modules in more detail. I try to summarize these modules, but most of the text comes directly from the original documents of the War Manpower Commission. Again, these documents are still extremely useful for managing (on) a shop floor. Stay tuned, and **go out and organize your industry!**

P.S.: Many thanks to TWI Guru Mark Warren for checking the text.

4 JI: Training within Industry – Job Instructions

Christoph Roser, January 23, 2018, Original at https://www.allaboutlean.com/twi-job-instructions/

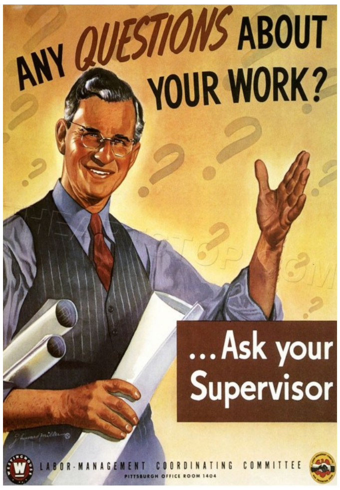


Figure 24: Any Questions about your Work? (Image J. Howard Miller in public domain)

Arguably the most successful module of Training within Industry is Job Instructions, or JI for short. JI has a precise focus on one topic: how to train your workers. The method is very simple and basic but works well.

Of course, there are some limitations. The process works well with pretty much any type of work, but it is best done one-on-one, as it was intended. It is not well suited for classroom teaching of larger groups; the trainer does need to invest time and attention to every individual student. But overall a very useful method. This is the second in a series of five posts on TWI.

4.1 The Fundamentals

Let me start with the fundamental rules. These rules were printed on a small card so the instructor could have them with him all the time. While original cards are hard to find, modern reprints are common. A picture of an original card is shown here

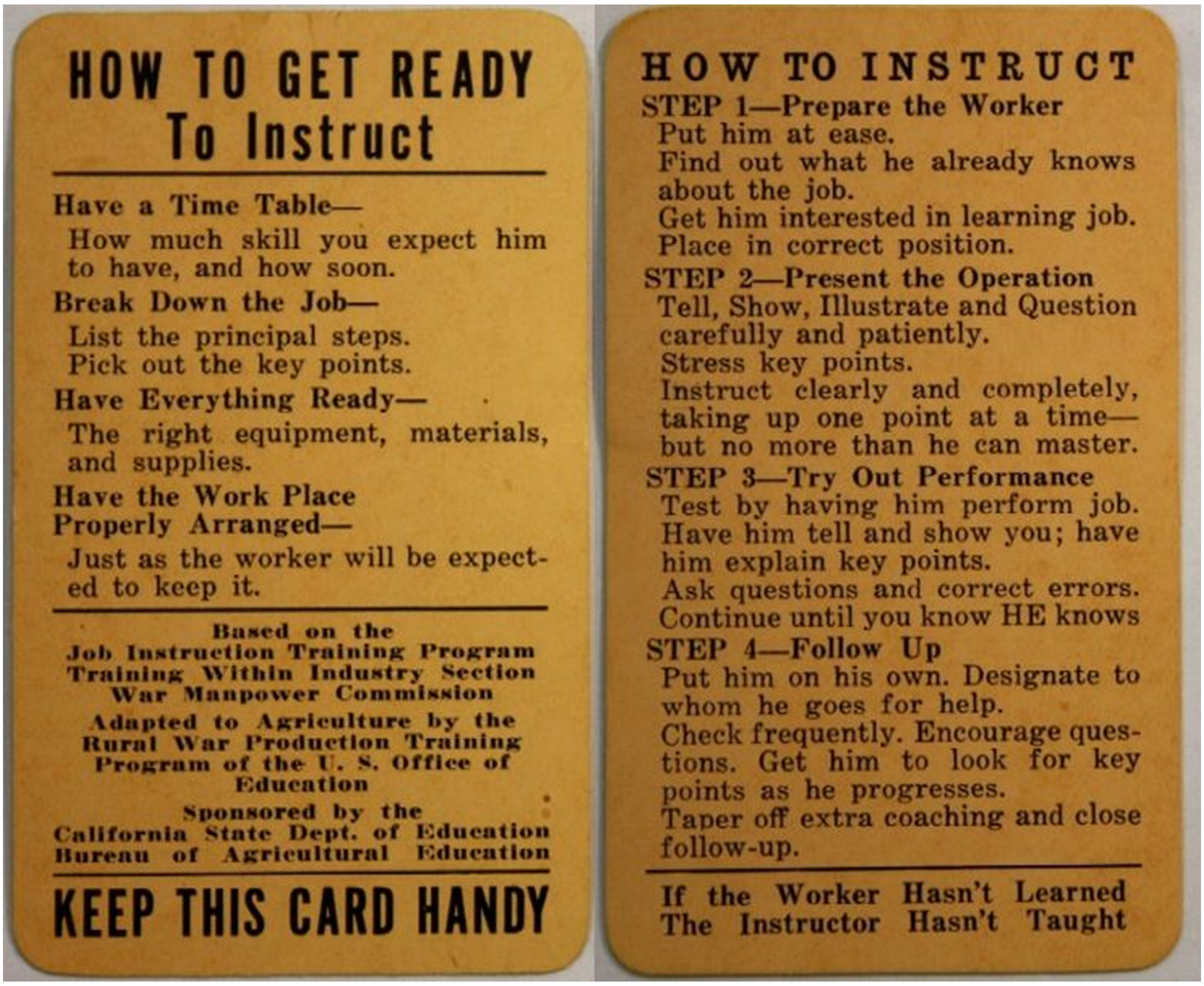


Figure 25: Job Instructions Card (Image War Manpower Comission in public domain)

I have written the text below as an introduction. But further below I will go into more details.

4.2 How to Get Ready to Instruct

- **Have a Time Table**: How much skills you expect him to have, by what date?
- **Break Down the Job**: List important steps, pick out key points (safety is always a key point).
- **Have everything ready**: The right equipment, material, and supply.
- **Have the Workplace Properly Arranged**: Just as the worker will be expected to keep it.

4.3 How to Instruct

Step 1: Prepare the Worker:

- Put him at ease.
- State the job and find out what he already knows about it.
- Get him interested in learning job.
- Place in correct position (so the learner can see the instructor).

Step 2: Present the Operation

- Tell, show, and illustrate one IMPORTANT STEP at a time.
- Stress each KEY POINT.
- Instruct clearly, completely, and patiently, but no more than he can master.

Step 3: Try Out Performance

- Have him do the job, correct errors.

- Have him explain each KEY POINT to you as he does the job again.
- Make sure he understands.
- Continue until YOU know he knows it.

Step 4: Follow Up

- Put him on his own. Designate to whom he goes for help.
- Check frequently. Encourage questions.
- Taper off extra coaching and close follow up.

4.4 Example Instructions

Figure 26: Work so they can fight! (Image Packer in public domain)

The TWI Job Instructions Session Outline and Reference Material uses as an example, the fire underwriters knot. This knot was used in electrical wiring to prevent the wires from being pulled out of the housing, which could start a fire, hence "fire underwriter knot." Nowadays there are much better solutions available, and the knot is not really used anymore. Yet, it serves as a good example for the training.

4.5 How to Get Ready to Instruct

So lets get ready to instruct. First, we need to **Have a Time Table**. Which of your people do you want to train in what by when? Below is the original example from 1945. It is a simple skills matrix about which worker can do what, with two workers who will get trained in drilling and taper turning by a certain date.

Bill Smith Machining Dept. 2/1/44	DRILL	BORE	REAM	FACE	TAPER-TURN	BUFF + BURNISH		
White	✓	✓	✓	✓	✓	✓		
Nolan	✓	✓	✓	✓	2/25	✓		
Black	✓	✓	✓	✓	✓	✓		Mar. 1 Induction
Jones		✓	✓			✓		
Green	✓	✓				✓		
Brown	✓	✓	✓			✓		
Riley	2/20					✓		

Figure 27: Job Instructions Timetable Example (Image War Manpower Comission in public domain)

Second, we need to **Break Down the Job**. Below is an image and the corresponding steps of making the fire underwriters knot. The numbers in the list match the numbers in the image.

Please note that for your job, the steps should be not every little thing you do, but the main steps needed to do the job.

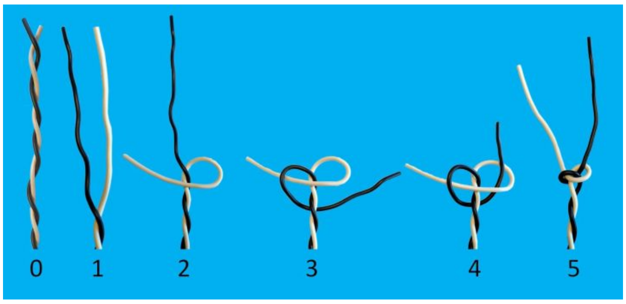
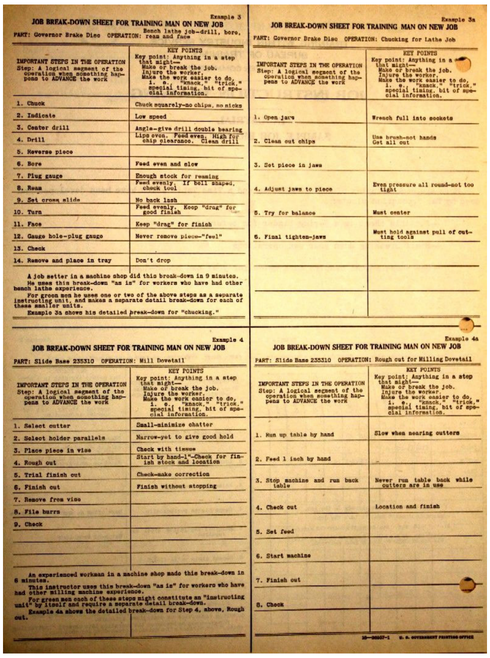


Figure 28: How to tie the Fire Underwriter Knot (Image Roser)

- **Untwist and straighten ends**. The key points is that you need about six inches of untwisted wire.
- **Make the right hand loop**. The key point is that the wire crosses in front of the main strand.
- **Make the left hand loop.** The key points are that the wire must be pulled toward you, so it goes over the first wire and then passes below the main strand.
- **The end of the second wire goes now through the loop of the first wire.** (No key points here.)
- **Pull the knot tight**. The key point is to make the ends even.

Their Job Breakdown form had only two columns, "**Important Steps in the Operation**" and "**Key Points.**" Nowadays there is a third column explaining "**why**" these steps and points are necessary (with credits to the University of Chicago, School of Business around 1967-68). Below are the original (two-column) examples with the original job and the improved job.



Example 3

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Governor Brake Disc OPERATION: Bench lathe job-drill, bore, ream and face

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	KEY POINTS Key point: Anything in a step that might— Make or break the job. Injure the worker. Make the work easier to do, i. e., "knack," "trick," special timing, bit of special information.
1. Chuck	Chuck squarely-no chips, no nicks
2. Indicate	Low speed
3. Center drill	Angle-give drill double bearing
4. Drill	Lips even. Feed even. High for chip clearance. Clean drill
5. Reverse piece	
6. Bore	Feed even and slow
7. Plug gauge	Enough stock for reaming
8. Ream	Feed evenly. If bell shaped, check tool
9. Set cross slide	No back lash
10. Turn	Feed evenly. Keep "drag" for good finish
11. Face	Keep "drag" for finish
12. Gauge hole-plug gauge	Never remove piece-"feel"
13. Check	
14. Remove and place in tray	Don't drop

A job setter in a machine shop did this break-down in 9 minutes.
He uses this break-down "as is" for workers who have had other bench lathe experience.
For green men he uses one or two of the above steps as a separate instructing unit, and makes a separate detail break-down for each of these smaller units.
Example 3a shows his detailed break-down for "chucking."

Example 3a

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Governor Brake Disc OPERATION: Chucking for Lathe Job

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	KEY POINTS Key point: Anything in a step that might— Make or break the job. Injure the worker. Make the work easier to do, i. e., "knack," "trick," special timing, bit of special information.
1. Open jaws	Wrench full into sockets
2. Clean out chips	Use brush-not hands Get all out
3. Set piece in jaws	
4. Adjust jaws to piece	Even pressure all round-not too tight
5. Try for balance	Must center
6. Final tighten-jaws	Must hold against pull of cutting tools

Example 4

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Slide Base 235310 OPERATION: Mill Dovetail

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

An experienced workman in a machine shop made this break-down in 6 minutes.
This instructor uses this break-down "as is" for workers who have had other milling machine experience.
For green men each of these steps might constitute an "instructing unit" by itself and require a separate detail break-down.
Example 4a shows the detailed break-down for Step 4, above, Rough out.

Example 4a

JOB BREAK-DOWN SHEET FOR TRAINING MAN ON NEW JOB

PART: Slide Base 235310 OPERATION: Rough cut for Milling Dovetail

IMPORTANT STEPS IN THE OPERATION Step: A logical segment of the operation when something happens to ADVANCE the work	KEY POINTS Key point: Anything in a step that might— Make or break the job. Injure the worker. Make the work easier to do, i. e., "knack," "trick," special timing, bit of special information.
1. Run up table by hand	Slow when nearing cutters
2. Feed 1 inch by hand	
3. Stop machine and run back table	Never run table back while cutters are in use
4. Check cut	Location and finish
5. Set feed	
6. Start machine	
7. Finish cut	
8. Check	

U. S. GOVERNMENT PRINTING OFFICE

Figure 29: Job Instructions Job Breakdown Sheet Examples 3-4 (Image War Manpower Comission in public domain)

Please note that the above list is not yet the method of instruction; we are still in the preparation phase. Before training a worker, we now need to **Have Everything Ready** and **Have the Workplace Properly Arranged**.

4.6 How to Instruct

For **Step 1: Prepare the Worker**, we need to get the worker comfortable and interested in the job. We also would need to find out what he knows already about the tasks.

For **Step 2: Present the Operation**, we show the process to him. We explain the main steps and also the key points. Often, this is done twice so the worker can remember it easier. In the first repetition, you merely state the main steps while doing it; in the second repetition, you also state the key points along with the main steps.

Now in **Step 3: Try out Performance**, the worker can finally try it out himself. The worker also does the job multiple times. The first time the worker states the main steps. In the second repetition, he also states the key points. Both come from the preparation list above. Repeat this until the worker knows can do and recite all main steps and key points. Naturally you should correct the worker as needed, and also answer his questions. Continue until YOU know he knows it.

In the final **Step 4: Follow Up**, you check up on the worker's progress, let him know who to ask if there are questions, and repeat this until the worker is comfortable and stable in his new tasks.

4.7 Extensions and Variations

Figure 30: Feeling at ease already, chap? (Image Allan Warren under the CC-BY-SA 3.0 license)

The Job Instructions Session Outline and Reference Material has much more info on the process. It is basically a step-by-step training guide with five sessions of two hours each. Most of it is still very valid today, with a few exceptions.

One exception is that they recommend the trainer to smoke a pipe or cigarette so the participants feel at ease – please don't do this. Some things HAVE changed since 1945.

For example, the key points of the example above were mostly about the position of the wire. But key points could also be on the feeling of the part or tool, the sound they make, the temperature, special motions or information, and especially safety critical points.

For **longer tasks**, they recommend breaking the task down into manageable steps and teaching each of them separately. For **loud or noisy workplaces**, they recommend showing extra care and going to a quieter area for talking if needed. Luckily, many plants nowadays are able to keep the noise down so it is possible to hear each other.

There are different methods of conveying information, namely showing, telling, illustrating using a diagram, and answering questions. The "illustrating" may not be used every time, but it may be an useful addition to the other three if needed.

They also state repeatedly that **If the student hasn't learned, the teacher hasn't taught.** Again, this is a very simple but, in my view, effective method of teaching individuals new skills. The Job Instructions Session Outline and Reference Material is available on multiple locations on the internet, and easy to find with Google. Now, **go out, teach your people some new tricks, and organize your industry!**

P.S.: Many thanks to TWI Guru Mark Warren for checking the text. He also wrote a series of articles that merges the Trainer's Guide materials with the Sessions Outline, available online for free.

4.8 Sources

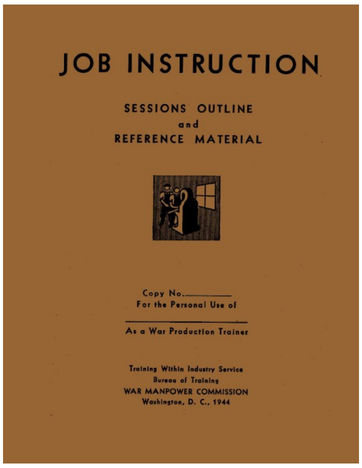


Figure 31: Cover of Job Instructions Session Outline and Reference Material. (Image War Manpower Comission in public domain)

War Manpower Commission. 1944. "Job Instructions Sessions Outline and Reference Material." War Manpower Commission.

Please note that there is also an updated version available, with updated language and an additional "why" column to the job breakdown sheet by the TWI Guru Mark Warren. It is also much better print than the worn out original typewriter pages:

Mark Warren 2014: "Job Instruction Sessions Outline – 2nd edition."

Mark Warren: "Job Instructions: 10 hour session outline", available online & free at Medium.com.

5 JR: Training within Industry – Job Relations

Christoph Roser, January 30, 2018, Original at https://www.allaboutlean.com/twi-job-relations/

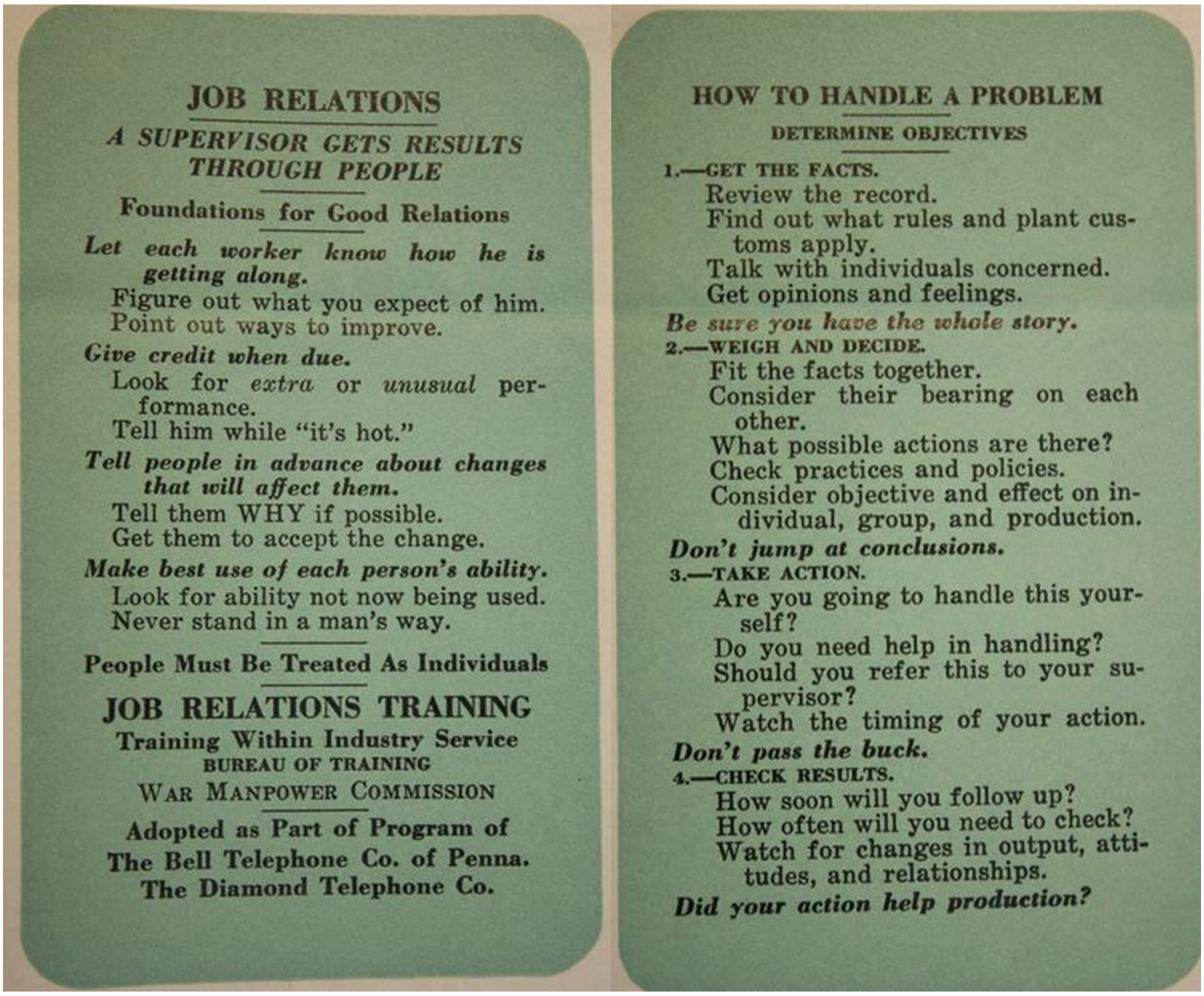
Figure 32: Free Labor will Win (Image Office of War Information in public domain)

Job Relations (JR) is one of the modules of the original Training within Industry (TWI) program. It was actually developed at Harvard using case studies, and for its time was groundbreaking in its idea that leadership can be learned! Like most TWI modules, it is sensible and useful. As with most TWI programs, it is focused on the front lines of the shop floor, and designed for first-line and second-line supervisors. The module is about good shop floor leadership.

While the program dates from World War II, it has lost none of its relevance, and can still help modern-day shop floor managers in becoming better leaders. The steps are not rocket science, but good common sense, and described with a clarity and brevity unusual for a management book. Below is a summary, mostly condensed from the "Job Relations 10 Hour Sessions Outline and Reference Material." This is the third in a series of five posts on TWI.

5.1 The Fundamentals

Again, let me start with the fundamentals. These were printed on small cards, and represent the basic steps of good management. One of the cards is shown below. Most important is the first line: **A supervisor gets results through people!** The steps handle two issues: first, how to establish good relations with your people (proactive), and second, how to handle disputes (reactive). Here are the basic rules of job relations:



JOB RELATIONS

A SUPERVISOR GETS RESULTS THROUGH PEOPLE

Foundations for Good Relations

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

People Must Be Treated As Individuals

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

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

HOW TO HANDLE A PROBLEM

DETERMINE OBJECTIVES

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

Figure 33: Job Relations Card (Image War Manpower Comission in public domain)

5.2 Foundations for Good Relations

- **Let each employee know how he is getting along**: Find out and tell him what you expect. Point out ways to improve.
- **Give credit when due**: Recognize extra or unusual performance. Tell him while it's fresh.
- **Tell an employee in advance about changes that will affect him**: Tell him WHY if possible. Get him to accept the change.
- **Make best use of each person's ability**: Look for ability not now being used. Never stand in an employee's way.

People must be treated as individuals!

5.3 How to Handle a Problem

Determine Objectives

- **Step 1: Get the facts**: Review the record. What policies, rules, regulations apply? Talk with individuals concerned and get opinions and feelings. Be sure you have the whole story.
- **Step 2: Weigh and Decide**: Fit the facts together and consider their bearing on each other. What possible actions are there? Check each action against objectives, weighing effect on individual, group, and production. Select the best action.
- **Step 3. Take Action**: Should I handle this myself? Who can help in handling? Should I refer this to my supervisor? Consider prompt time and place. Explain and get acceptance. Don't pass the buck!

- **Step 4: Check Results**: How soon and how often will I check? Watch for changes in output, attitudes, and relationships.

Did my action help production? Were objectives accomplished?

5.4 On Leadership…

Figure 34: Labor and Management Poster (Image US Government in public domain)

Leadership is tough. There are often many conflicting objectives, insufficient data to know things for sure, and lots of employees and other stakeholders wanting different things from you – or even challenging your leadership. The challenge of leadership is getting all of these at least somewhat aligned. The TWI manual states the following as the demands on a good leader, but here I took the liberty to add a part that I believe is very important (in italics):

> *Good Leaders get the people in the department to do **what** he wants done, **when** it should be done, and the **way** he wants it done, because **they** want to do it, and also gets them to **improve** what they are doing!*

Below is the chart that TWI used to show these relationships.

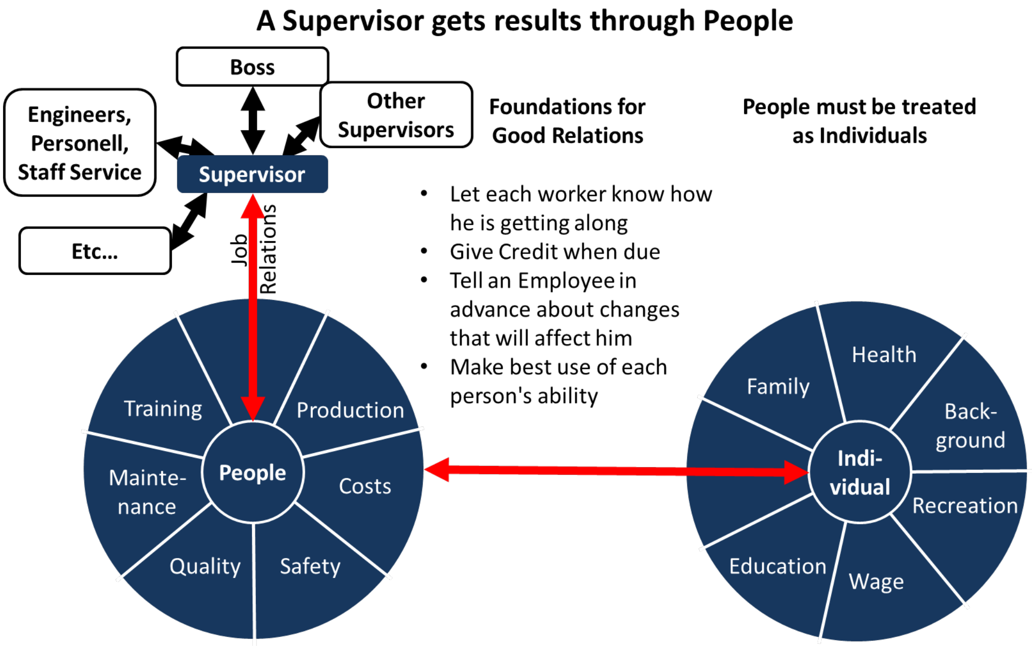


Figure 35: A supervisor gets results through people! (Image Roser)

5.5 Common Pitfalls

Figure 36: We can't win with Blueprints! (Image Office for Emergency Management in public domain)

There are a few common pitfalls in understanding men, where the supervisor (or others) judge prematurely. The Job Relations manual lists the following:

- The **"Die Casting" habit**: We try to sort a person in a certain category in our minds, and have difficulty adjusting that if the behavior or facts change.
- The **"Just Like" habit**: This is similar to the "die casting habit," but instead of a category we compare him to another person who he is "*just like.*"
- The **"Go, No-Go" habit**: Quickly sorting a person into one of two categories like can/cannot do, useful/not, good/bad.
- The **"Formula" habit**: Dealing with a type of person (see the above habits) in a stereotypical manner. While this can be useful, excessive use should be avoided.
- The **"Standardization" habit**: Treating people like a standard commodity (he is a welder), and ignoring special abilities and interests (he is good at optimizing the welding settings). Often these particularities will make a worker especially useful.

5.6 Understanding Your People

Figure 37: Together We Win! (Image War Production Board in public domain)

The manual looks at certain aspects in understanding a worker. Please note that issues with most of these points below could be also a failure of management rather than the worker. In fact, it may be more likely to be a management shortcoming than a worker failure.

- **To what degree is he doing a good job?** Please note that this may also be a shortcoming on the training by the supervisors.
- Does he fail to understand the instructions? This could also be a training issue.
- Does his attention wander from the job?
- **Is he interested in his job?** Understanding the reason for his job and recognition are two important points here.
- How does he respond to recognition?
- **Does he stand on his own feet?** If not, give him more confidence.
- **Does he seem ill adapted to the job?** If he is a misfit, it may again be a training issue. Also, being unskilled in one job doesn't mean that he is unskilled for everything.
- Does he get along well with the other people in the department?

Figure 38: Join us in a Victory Job! (Image Australian Government in public domain)

The manual showed a couple of examples. Interestingly enough, one of the examples was about promoting a woman to supervisor, which would be the first female supervisor in the plant. The woman was selected only because no qualified man was available.

Luckily, this is one of the things that have changed since 1945, and female management is no longer an issue, although still far from 50% of the managers on the shop floor.

5.7 Summary

The points above are fundamentals and basics of good leadership, both for good times as well as during disputes. Nothing fancy here, but solid good leadership basics will often go a long way. I found these notes rather helpful, although I would put a bigger focus on improvement. TWI does this with the *Job Methods*, but I would have liked to see a bit more of *kaizen* already in the job relations. But, apart from that it, is a pretty useful standard approach.

Will it solve each and every problem? Probably not, but it will definitely help with many issues arising on the shop floor. Management will continue to be difficult, and you won't be able to make everybody happy, but it has to be done. Doing it well is a major step toward a good factory. Now, **go out, look at your people – and I mean really look and understand them, go through the Job Relations card, and organize your industry!**

P.S.: Many thanks to TWI Guru Mark Warren for checking the text.

5.8 Sources

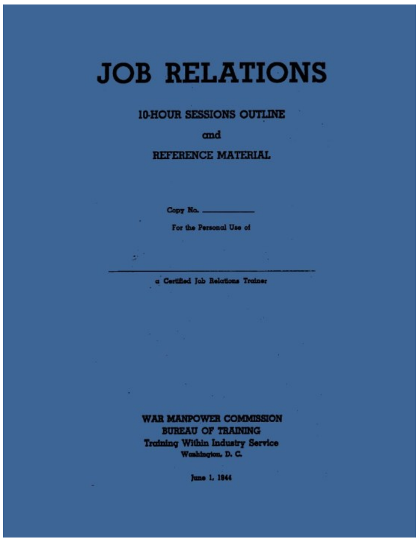


Figure 39: Cover of the Job Relations Manual (Image War Manpower Comission in public domain)

War Manpower Commission. 1944. "Job Relations 10 Hour Sessions Outline and Reference Material." War Manpower Commission.

6 JM: Training within Industry – Job Methods

Christoph Roser, February 06, 2018, Original at https://www.allaboutlean.com/twi-job-methods/

Figure 40: Still More Production (Image Office for Emergency Management in public domain)

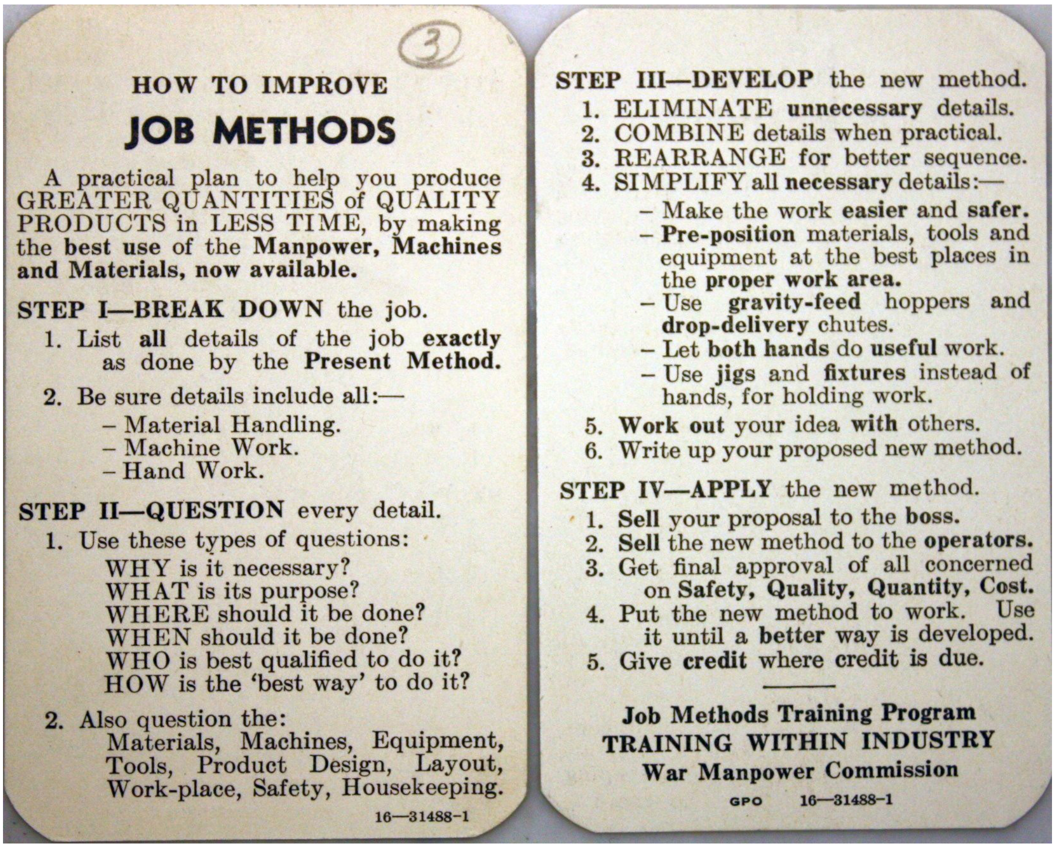
Job Methods is the TWI module focusing on improving the workplace. The method is a basic four-step process focused on optimizing mechanical work. The underlying approach is good. The documents from 1945, however, put the improvement squarely on the shoulders of the supervisor.

My belief is that the workers should be involved much earlier and that the decision of what to improve would also benefit from more attention. But the basic method is still sound. The TWI people also saw this problem, but their management told them that it is "good enough." Hence this module saw a lot of improvements after 1945. Yet, it was the smallest of the three main programs. Let me show you the TWI Job Methods in more details. This is the fourth in a series of five posts on TWI.

6.1 The Fundamentals

Here is the text from the standard Job Methods card from 1945. I left this text pretty much unchanged, although I believe there are some potentials for improvement.

This is a practical plan to help you produce **Greater Quantities** of **Quality Products** in **less time**, by making the best use of the manpower, machines, and materials now available.



HOW TO IMPROVE

JOB METHODS

A practical plan to help you produce GREATER QUANTITIES of QUALITY PRODUCTS in LESS TIME, by making the **best use** of the **Manpower, Machines and Materials, now available.**

STEP I—BREAK DOWN the job.

1. List **all** details of the job **exactly** as done by the **Present Method.**
2. Be sure details include all:—
   - Material Handling.
   - Machine Work.
   - Hand Work.

STEP II—QUESTION every detail.

1. Use these types of questions:
   WHY is it necessary?
   WHAT is its purpose?
   WHERE should it be done?
   WHEN should it be done?
   WHO is best qualified to do it?
   HOW is the 'best way' to do it?
2. Also question the:
   Materials, Machines, Equipment, Tools, Product Design, Layout, Work-place, Safety, Housekeeping.

16—31488-1

STEP III—DEVELOP the new method.

1. ELIMINATE **unnecessary** details.
2. COMBINE details when practical.
3. REARRANGE for better sequence.
4. SIMPLIFY all **necessary** details:—
   - Make the work **easier** and **safer.**
   - **Pre-position** materials, tools and equipment at the best places in the **proper work area.**
   - Use **gravity-feed** hoppers and **drop-delivery** chutes.
   - Let **both hands** do **useful** work.
   - Use **jigs** and **fixtures** instead of hands, for holding work.
5. **Work out** your idea **with** others.
6. Write up your proposed new method.

STEP IV—APPLY the new method.

1. **Sell** your proposal to the **boss.**
2. **Sell** the new method to the **operators.**
3. Get final approval of all concerned on **Safety, Quality, Quantity, Cost.**
4. Put the new method to work. Use it until a **better** way is developed.
5. Give **credit** where credit is due.

Job Methods Training Program
TRAINING WITHIN INDUSTRY
War Manpower Commission

GPO 16—31488-1

Figure 41: Job Methods Card (Image War Manpower Comission in public domain)

- **Step 1: Break down the job**: List all details of the job exactly as done by the present method. Be sure to include all material handling, machine work, and hand work.
- **Step 2: Question every detail**: Use these types of questions: **Why** is it necessary, **what** is its purpose, **where** should it be done, **when** should it be done, **who** is best qualified to do it, and **how** is the best way to do it? Also question the materials, machines, equipment, tools, products, design, layout, work-place, safety, and housekeeping.
- **Step 3: Develop the new method**: **Eliminate** unnecessary details, **combine** details when practical, **rearrange** for better sequence, **simplify** all necessary details. Make the work easier and safer. Pre-position materials, tools, and equipment at the best place in the proper work area. Use gravity-feed hoppers and delivery chutes. Let both hands do useful work. Use jigs and fixtures instead of hands for holding work. Work out your idea with others. Write up your proposed new method.
- **Step 4: Apply the new method**: Sell your proposal to the boss. Sell the new methods to the operators. Get final approval of all concerned on safety, quality, quantity, and cost. Put the new method to work. Use it until a better way is developed. Give credit where credit is due.

6.2 Spotlight on Step 1: Job Breakdown

Figure 42: We're depending on you – Produce to Win! (Image Office for Emergency Management in public domain)

The job breakdown is the important first step of the improvement process (besides deciding on the problem in the first place – see below). The other TWI module on Job Instructions already had a step "**Break Down the Job**: List important steps, pick out key points." However, in Job Instructions, you focus only on the key points, with a lot of minor steps in between being implied. For the job methods, you would need to look deeper at the different steps.

For example, when attaching a screw to a gizmo, the job instructions may only say to attach the screw to the gizmo. The Job Methods, however, would also have to list where to get the nuts and other details to get a full picture. Nowadays you can also use, for example, video to help you with the job breakdown (make sure to get the permissions of the workers and the unions), or measure times (again it may be better to involve unions and workers on this) for a more quantifiable improvement estimate.

Below is the original World War II training example job breakdown sheet. This is the first page of two pages with a total of thirty steps to rivet two plates together. The improved process is another similar page.

JOB METHODS BREAKDOWN SHEET

Operation Inspect, Assemble, Rivet, Stamp and Pack Product Radio Shields Department Riveting and Packing

Your name Bill Brown Operator's name Jim Jones Date June 14, 1944

List of All Details for PRESENT ~~PROPOSED~~ Method Every single thing that is done—Every inspection—Every delay	NOTES Reminders—Tolerances—Distance—Time Used—Etc.	IDEAS Write them down—Don't trust your memory
1. Walk to box of copper sheets.	Placed 6 feet from bench by handler.	
2. Pick up 15 to 20 copper sheets.		
3. Walk to bench.		
4. Inspect and lay out 12 sheets.	Scratches and dents. Scrap in bins.	
5. Walk to box and replace extra sheets.		
6. Walk to box of brass sheets.	Placed 3 feet from copper box by handler.	
7. Pick up 15 to 20 brass sheets.		
8. Walk to bench.		
9. Inspect and lay out 12 brass sheets.	One on top of each copper sheet.	
10. Walk to box and replace extra sheets.		
11. Walk to bench.		
12. Stack 12 sets near riveter.		
13. Pick up one set with right hand.		
14. Line up sheets and position in riveter.	Line-up tolerance .005".	
15. Rivet top left corner.		

(OVER) 16—40147-1

Figure 43: Job Methods Breakdown Sheet Example (Image War Manpower Commission in public domain)

6.3 Suggested Improvements over 1945

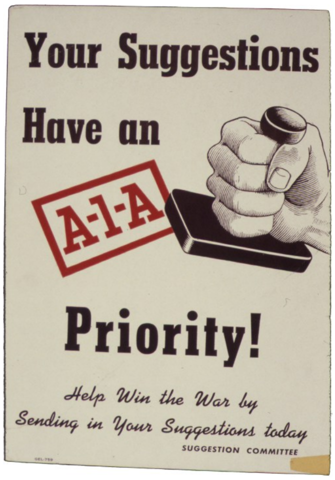


Figure 44: Your Suggestions have an A-1-A Priority! (Image Office for Emergency Management in public domain)

The original text dates from 1945. Since then, the workplace has evolved somewhat, and there are some improvements that I would suggest to the original text from 1945. Primarily **the workers are involved only at a very late stage**. Above, they are involved in Step 4 where the idea is merely "*worked out with others*" pretty late in the process, rather than having the workers involved from the beginning. Only in the last step is the worker explicitly mentioned and pretty much merely has to agree to the idea the supervisor had. I would involve the workers much earlier in the decision making. This also helps with the acceptance problems that often arise.

A second objection is that **the whole process starts with the supervisor**. The worker is never asked for improvements, and has no place in suggesting improvements. They certainly did this (based on the dozens of different wartime posters telling workers to suggest ideas), but I would like to see this in the description. What is the method for the worker to suggest an improvement.

Figure 45: Another Break for the Axis. (Image Office for Emergency Management in public domain)

The **decision on which problem or which process to improve is also not codified**. It is pretty much whatever the supervisor fancies. However, I believe there are two ways to initiate improvements. One is to do whatever a person thinks is an issue. This is what they do above, and it is perfectly fine for small issues and quick and easy improvements. However, as a second way to originate improvements, I would also look at the master plan or the overarching goals of the plant. If the biggest issue is quality, then I wold analyze where the defects come from and focus improvements on where the plant hurts most. But here I am probably unfair to TWI, as their focus is the first line of leadership, whereas the big picture would involve middle and upper management.

Nowadays, it should be also easier to **measure times and quantify the improvement**. While this may not always be necessary, it can help to estimate the improvement benefit and to sell the ideas to others.

6.4 Overcome Objections to Change

Figure 46: Yes Sir We're gonna lift that line! (Image Office for Emergency Management in public domain)

There are two major reasons why people may object a change. The first is **resistance to new ideas**. The people know the current method well and can work with it. If they did it for a long time, it probably feels natural to them. Any new method or standard does not feel natural, but is something new. It also has the risk that the new method may actually be worse than the current one (and quite a few workers have been burned that way). Hence, many prefer the familiar to the unfamiliar and potentially worse.

The second is **resentment of criticism**. If the new one is better, then the old one is worse, and people may see it as a personal criticism that what they did before or even implemented before is wrong. They may also see it as criticism why they did not improve it already earlier.

Both cases are not easy to handle. It may be difficult to convince everybody, but you should start with the informal leaders of the group, often also called the alpha males. It also helps significantly if the people were involved in the creation of the new standard, and any questions and objectives were discussed in the group before.

6.5 Summary

Overall, the Job Methods of TWI are useful, but they do have a few shortcomings in the modern world. In my view, the Job instructions and Job Relations are still very useful, but the Job Methods would need an overhaul (and probably someone has already done that). Yet, looking at them can give you a good structure and guideline for improvements. So I hope this post gave you some inspiration for your improvement process. Now, **go out, improve a process together with your people, and organize your industry!**

P.S.: Many thanks to TWI Guru Mark Warren for checking the text.

6.6 Source

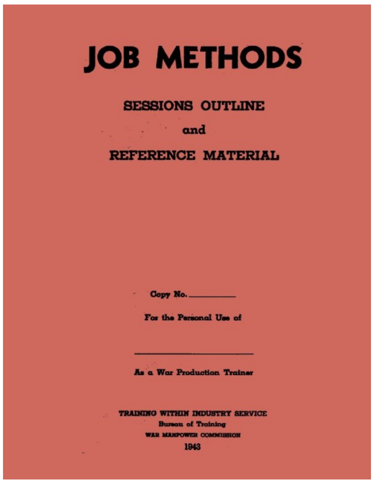


Figure 47: Job Methods Manual Cover (Image War Manpower Commission in public domain)

War Manpower Commission. 1943. "Job Methods Sessions Outline and Reference Material." War Manpower Commission.

Mark Warren also created an updated and revised Job Methods sheet in A3 format, and gave me permission to host it here. Many thanks, Mark!

7 More on TWI Programs

Christoph Roser, February 13, 2018, Original at https://www.allaboutlean.com/more-on-twi/

Figure 48: America's Answer – Production! (Image Jean Carlu in public domain)

The TWI Program during World War II was very successful. Besides the Job Instructions, Job Methods, and Job Relations, a few other modules were developed, some of them internally. After the war, different institutions took over what the US government abandoned in December 1945. These follow-up institutions were the TWI Foundation and the TWI Inc. in the US; but it was also continued by the British TWI Service and the New Zealand TWI Service, and it was especially successful in Japan. Altogether, TWI was used in around seventy countries in 1960, although with quite different intensity and much less than when the US government used it through the war. This is the last in a series of five posts on TWI.

7.1 Final TWI Report

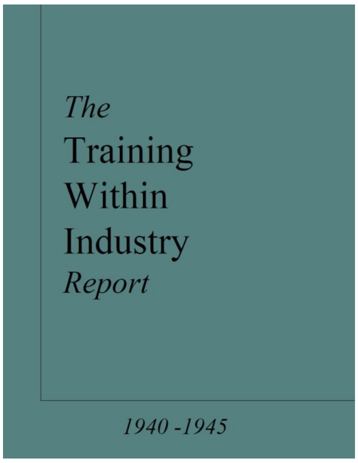


Figure 49: Training within Industry Report Cover (Image War Manpower Commission in public domain)

Before the TWI program shut down, they published a final "*The Training within Industry Report 1940-1945*" (sources below). It tells the story on how TWI was established and developed. It shows how they solved the first major issue of a shortage of 350 lens grinders, reducing the training time from sixty months to less than four months.

It shows how early on they decided on a standardized training package of ten hours (five sessions of two hours each) for ten men for their main modules. They also decided to focus on the supervisors, rather than solving all problems through training. They also have the text of "utter simplicity" of the different cards they handed out. The first main program was Job Instructions, followed by Job Methods and Job Relations, all designed to fill a need in the shop floor.

Overall, it was a smashing success, as "*this is a government war agency that helps instead of hinders.*" Word of mouth helped TWI to spread its wings. Below is the original statistics (TWI report pg. 92) of the percentage of plants reporting improvements over 25% in different areas over time. Pretty much all plants improved significantly due to the TWI program, some even reporting a 500% increase in production output.

	Percentage of Plants Reporting Results of 25 Percent and Over						
	May 1943	Sept. 1943	Feb. 1944	Nov. 1944	April 1945	July 1945	Sept. 1945
Production increased..	37	30	62	76	64	63	86
Training time reduced	48	69	79	92	96	95	100
Manpower saved	11	39	47	73	84	74	88
Scrap loss reduced....	11	11	53	20	61	66	55
Grievances reduced ..	(Not reported)		55	65	96	100	100

Figure 50: Results of the Training within Industry program. (Image War Manpower Comission in public domain)

7.2 Program Development

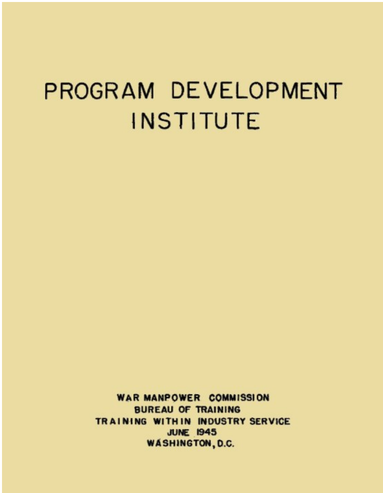


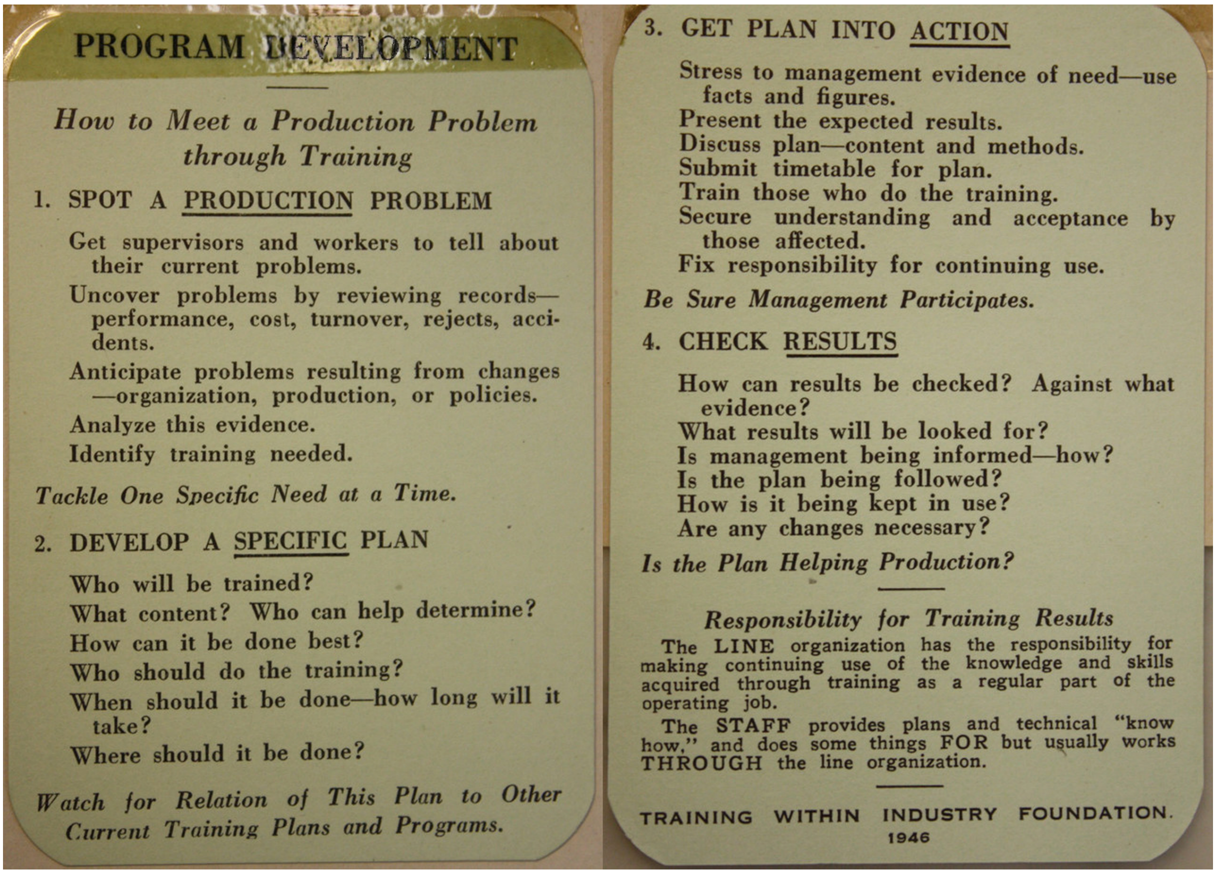
Figure 51: Program Development Institute Cover (Image War Manpower Comission in public domain)

The program development module was also a five-session module, but each session was a whole day rather than two hours as for Job Instructions, Job Methods, and Job Relations. The focus was to identify problems in a plant and improve them through training. They developed a four-step plan, which is very similar to the PDCA (as are actually also Job Instructions, Job Methods,and Job Relations) but with a heavy focus on training.

- **Step 1: Spot a production problem**: Get supervisors and workers to tell about their current problems. Uncover problems by reviewing records: performance, cost, turnover, rejects, accidents. Anticipate problems resulting from changes: organization, production, or policies. Analyze this evidence. Identify training needs. Tackle one specific need at a time!
- **Step 2: Develop a specific plan**: Who will be trained? What content? Who can help determine? How can it be done best? Who should do the training? When should it be done? How long will it take? Where should it be done? Watch for relation of this plan to other current training plans and programs.
- **Step 3: Get plan into action**: Stress to management evidence of need, use facts and figures. Present the expected results. Discuss plan: content and methods. Submit timetable for plan. Train those who do the training. Secure understanding and acceptance by those affected. Fix responsibility for continuing use. Be sure management participates!

- **Step 4: Check Results**: How can results he checked? Against what evidence? What results will be looked for? Is management being informed? How? Is the plan being followed? How is it being kept in use? Are any changes necessary ? Is the plan helping production?

In my view, they missed out on an opportunity to connect the identification of production problems not with training but with actual shop floor improvements. Yet, it was the overarching meta-module. It was also not as successful as the other programs, already in 1945, and only half of the regions participated. The TWI team realized that this program had much more potential and wanted to improve it, but the top brass thought the current program was good enough. The war ended before they completed their upgrade.


PROGRAM DEVELOPMENT

How to Meet a Production Problem through Training

1. SPOT A PRODUCTION PROBLEM

Get supervisors and workers to tell about their current problems.
Uncover problems by reviewing records—performance, cost, turnover, rejects, accidents.
Anticipate problems resulting from changes—organization, production, or policies.
Analyze this evidence.
Identify training needed.

Tackle One Specific Need at a Time.

2. DEVELOP A SPECIFIC PLAN

Who will be trained?
What content? Who can help determine?
How can it be done best?
Who should do the training?
When should it be done—how long will it take?
Where should it be done?

Watch for Relation of This Plan to Other Current Training Plans and Programs.

3. GET PLAN INTO ACTION

Stress to management evidence of need—use facts and figures.
Present the expected results.
Discuss plan—content and methods.
Submit timetable for plan.
Train those who do the training.
Secure understanding and acceptance by those affected.
Fix responsibility for continuing use.

Be Sure Management Participates.

4. CHECK RESULTS

How can results be checked? Against what evidence?
What results will be looked for?
Is management being informed—how?
Is the plan being followed?
How is it being kept in use?
Are any changes necessary?

Is the Plan Helping Production?

Responsibility for Training Results

The LINE organization has the responsibility for making continuing use of the knowledge and skills acquired through training as a regular part of the operating job.
The STAFF provides plans and technical "know how," and does some things FOR but usually works THROUGH the line organization.

TRAINING WITHIN INDUSTRY FOUNDATION.
1946

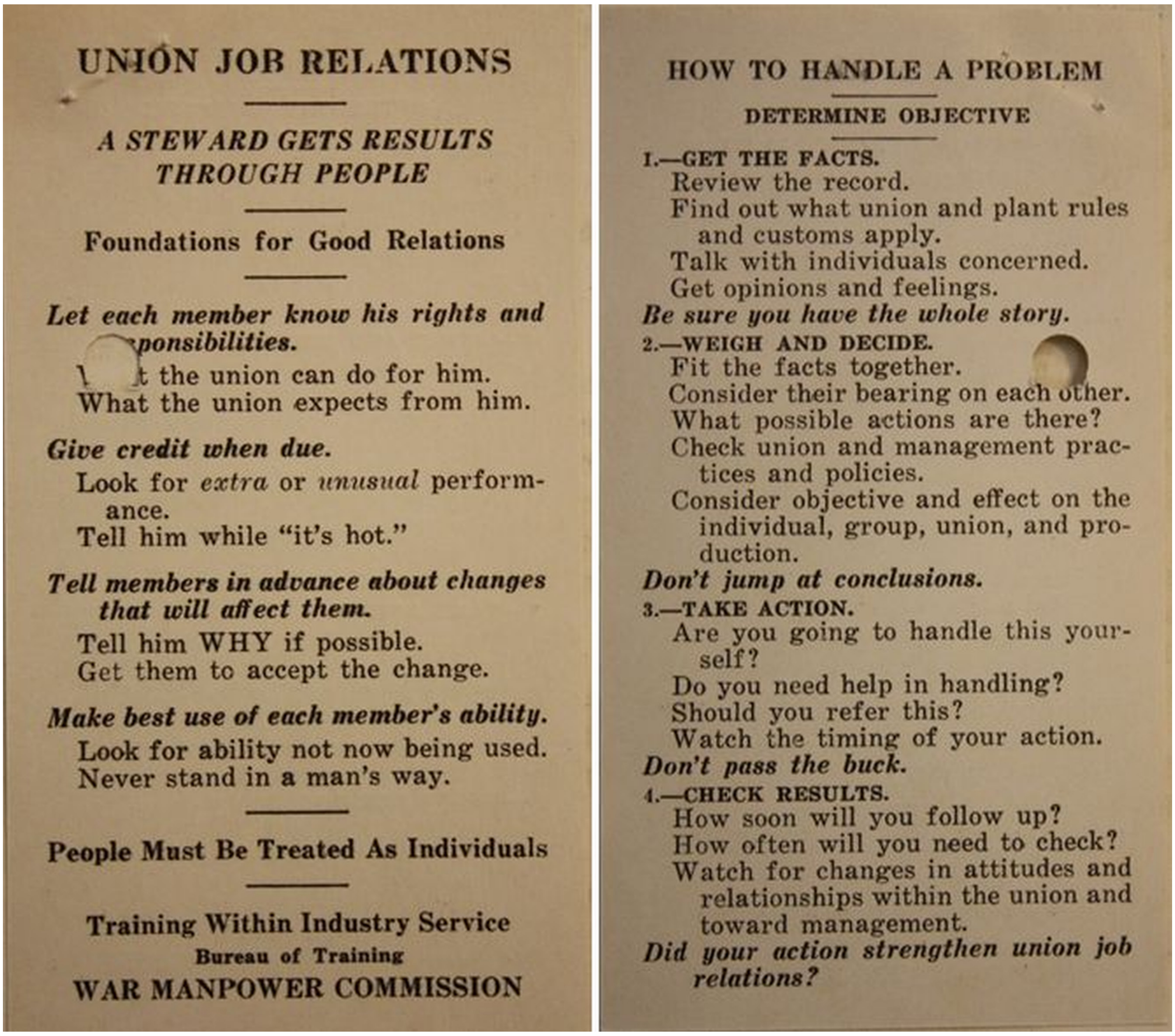
Figure 52: Program Development Card (Image War Manpower Comission in public domain)

7.3 Union Job Relations

Figure 53: Together we can do it! (Image Office for Emergency Management in public domain)

The **Union Job Relations** program was based on the Job Relations program, and was developed together with union representatives. While they had some success, the program was much less popular than the others and available for a much shorter time. The source for the "Union Job Relations 10-Hour Sessions Outline and Reference Material" is given below.

Union Job Relations used a modified Job Relations card. Below is one of the original cards (many thanks to Mark Warren), as well as the text.


UNION JOB RELATIONS

A STEWARD GETS RESULTS THROUGH PEOPLE

Foundations for Good Relations

Let each member know his rights and responsibilities.
What the union can do for him.
What the union expects from him.

Give credit when due.
Look for *extra* or *unusual* performance.
Tell him while "it's hot."

Tell members in advance about changes that will affect them.
Tell him WHY if possible.
Get them to accept the change.

Make best use of each member's ability.
Look for ability not now being used.
Never stand in a man's way.

People Must Be Treated As Individuals

Training Within Industry Service
Bureau of Training
WAR MANPOWER COMMISSION

HOW TO HANDLE A PROBLEM

DETERMINE OBJECTIVE

1.—GET THE FACTS.
Review the record.
Find out what union and plant rules and customs apply.
Talk with individuals concerned.
Get opinions and feelings.
Be sure you have the whole story.

2.—WEIGH AND DECIDE.
Fit the facts together.
Consider their bearing on each other.
What possible actions are there?
Check union and management practices and policies.
Consider objective and effect on the individual, group, union, and production.
Don't jump at conclusions.

3.—TAKE ACTION.
Are you going to handle this yourself?
Do you need help in handling?
Should you refer this?
Watch the timing of your action.
Don't pass the buck.

4.—CHECK RESULTS.
How soon will you follow up?
How often will you need to check?
Watch for changes in attitudes and relationships within the union and toward management.
Did your action strengthen union job relations?

Figure 54: Union Job Relations Card (Image War Manpower Comission in public domain)

7.4 Foundations for Good Relations

- **Let each member know how his rights and responsibilities**: Tell him what the union can do for him. Tell him what the union expects from him.
- **Give credit when due**: Look for extra or unusual performance. Tell him while it's hot.
- **Tell people in advance about changes that will affect them**: Tell them WHY if possible. Get them to accept the change.
- **Make best use of each member's ability**: Look for ability not now being used. Never stand in an man's way.

People must be treated as individuals!

7.5 How to Handle a Problem

Determine Objectives

- **Step 1: Get the facts**: Review the record. Find out what union and plant rules apply. Talk with individuals concerned. Get opinions and feelings. Be sure you have the whole story.
- **Step 2: Weigh and Decide**: Fit the facts together. Consider their bearing on each other. What possible actions are there? Check union and management practices and policies. Consider objective and effect on the individual, group, union, and production. Don't jump at conclusion.
- **Step 3. Take Action**: Are you going to handle this yourself? Do you need help in handling? Should you refer this? Watch the timing of your action. Don't pass the buck!
- **Step 4: Check Results**: How soon will you follow up? How often will you need to check? Watch for changes in attitudes, and relationships within the union and toward management.

Did your action strengthen union job relations?

7.6 Problem Solving

The problem-solving module was developed only after the war, and also only by the successor organizations. Hence there are no public domain documents. In fact, apparently two successor organizations developed different problem-solving programs independently. One is from the TWI Foundation, and the other (better) one from TWI Inc. dating from 1956.

7.7 JS: Job Safety

Figure 55: Protect your Hands! (Image Work Projects Administration in public domain)

Job Safety was a program started after World War II by Canada to … surprise … improve safety on the job. It was later extensively updated by Great Britain before being exported to Japan. Hence, unfortunately it is not in public domain, and therefore I cannot give you the full text. They also have the Job Safety card similar to the other program. The key steps are again similar to PDCA:

- Spot the causes of danger.
- Decide on countermeasures.
- Enforce countermeasures.
- Check results.

On top of that, the card lists the **five hazard spots**, tells you **how to avoid safety hazards**, and goes into both **people considerations** and **environmental considerations**. In my view, the main achievement of this is to raise safety awareness, which is a valid reason on its own.

This rounds up my review of Training within Industry, an old program but with lots of good and solid advice, especially for Job Instructions and Job Relations. **Now, go out, and organize your industry!**

P.S.: Many thanks to TWI Guru Mark Warren for checking the text.

7.8 Sources

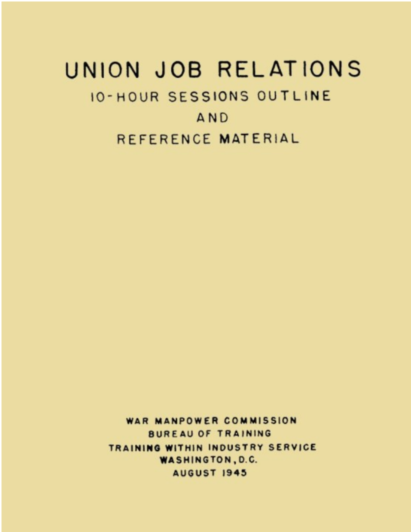


Figure 56: Union Job Relations cover (Image War Manpower Commission in public domain)

Here are the sources for the documents mentioned above.

- War Manpower Commission. 1945. "Program Development Institute." War Manpower Commission.
- War Manpower Commission. 1945. "The Training within Industry Report 1940-1945." War Manpower Commission.
- War Manpower Commission. 1945. "Union Job Relations 10 Hour Sessions Outline and Reference Material." War Manpower Commission.

Please note that there are also updated versions of the report with more than 600 footnotes and 30+ pages on the TWI activities after 1945 by the TWI Guru Mark Warren. It is also a much better print than the worn-out original typewriter pages.

Mark Warren 2010: "The TWI Report", second edition.

8 Continued Evolution of the Toyota Assembly Line

Christoph Roser, February 20, 2018, Original at https://www.allaboutlean.com/toyota-assembly-evolution-2/

Figure 57: Toyota Logo (Image Toyota for editorial use)

Toyota is one of the the most visionary car makers with respect to its manufacturing. They continuously and radically evolve and update their production system. Recently I learned about their new "flexible assembly line." Now, you've probably heard about Toyota's flexible assembly lines producing multiple products on the same line. That is old hat; they've done that for thirty years. Their new flexible assembly line involves a completely different aspect of flexibility, with which Toyota surprised me (again). Let me show you …

8.1 Introduction

Toyota continuously evolves and changes its production system in a way that is more frequent, more radical, and more successful than its competitors.

They already have the ability of doing lot size one on their production line. The ability to produce multiple car models on the same assembly line in any sequence without set-ups was a radical new idea when it started with Toyota in the 1960s, but nowadays it is industry standard, although some major car makers still prefer batch sizes of more than one (e.g., the Honda Sayama plant).

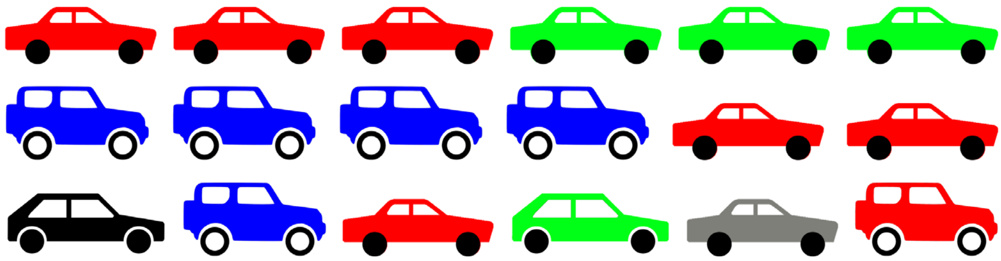


Figure 58: Single-model, mixed-model-batched, and mixed-mode lot-size-one sequences (Image Roser)

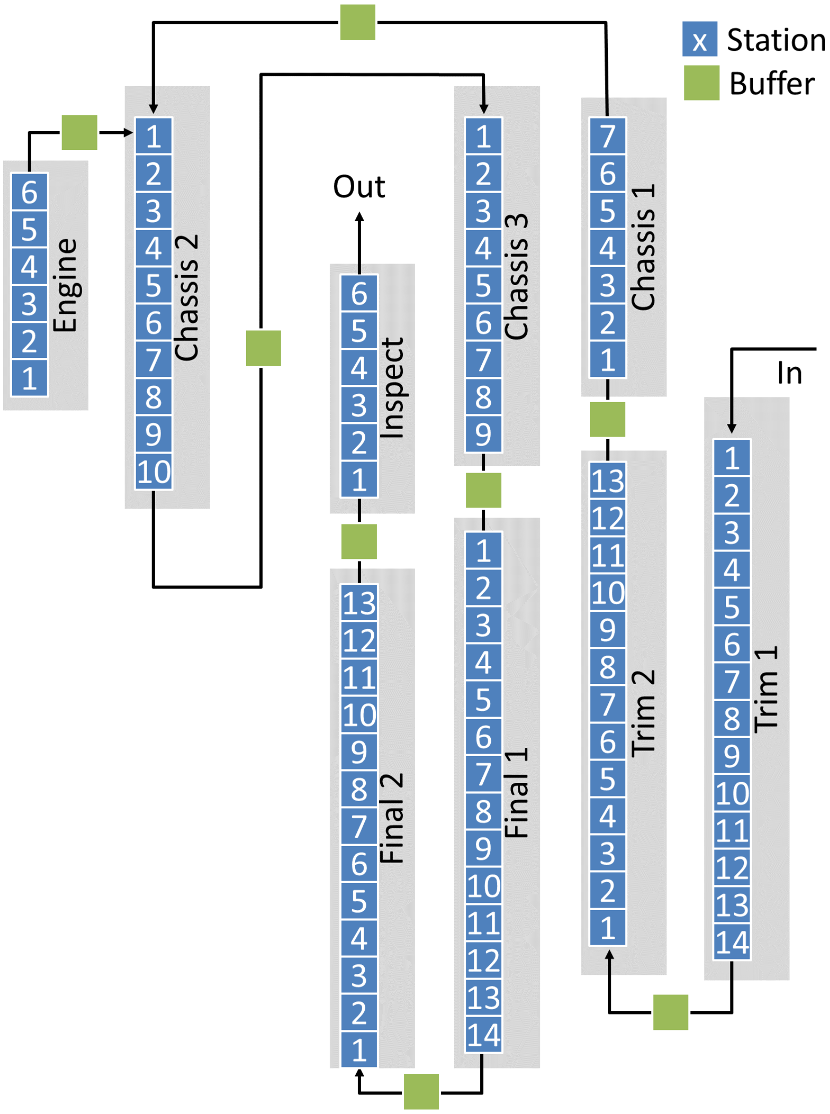


Figure 59: Layout of Toyota Motomachi Plant (Image Roser)

I have previously written on how Toyota split its assembly line layout into smaller segments and how it changed its shift schedule to make the work easier for its workers. I was quite surprised by how radically they push for lot size one, including aluminum casting in lot size one on demand.

Currently they are implementing their Toyota New Global Architecture (TNGA). They realized that they had around one hundred different subplatforms on which to build vehicles, and eight hundred different variants of engines (based on sixteen models, but blooming out into eight hundred variants). Now they are taking major steps to reduce this multitude of products using TNGA.

Their first car based on this TNGA is the 2015 fourth-generation-model Toyota Prius. By 2020, they want to switch half of their models to TNGA. Currently, there are three variants of this platform, GA-L (for "long-mounted engines") and GA-C and GA-K (both transverse-mounted engines). They work together with Mazda, which is considered to have the best platform approach worldwide with their **Skyactiv** approach.

This is all very exciting, but today I want to look at how Toyota is changing its assembly line (again). First of all, it is a bit difficult to find a good name. Toyota calls it a "flexible assembly line" in English (more on that later), but the word *flexible* is heavily overused nowadays and most people think of flexible assembly lines as mixed-model assembly. But before I go into what Toyota does, let me introduce the idea using easier examples.

8.2 Flexibly Configurable Assembly Lines

The basic idea is to have an assembly line that can be moved around, rearranged, and reconfigured on short notice. The idea itself is not new, and I have seen it many times in industry for work cells and chaku-chaku lines. Since the workstations are on wheels, they can simply be unplugged and moved if the product lineup changes, if demand requires an increase or decrease in capacity, or if a new arrangement is simply more efficient. Many of these lines were automotive suppliers. Since car manufacturers like to have a tight grip on their suppliers, sometimes the biggest challenge was to have the customer accept that the line may change without an expensive re-certification of the quality by the customer.

One non-assembly example would be some Japanese supermarket checkouts. As shown below and explained in a previous post, they have one or two workers manning a cashier station. If there is high demand, they have two people for higher throughput; if there is low demand, it is only one. To keep the station at a good size, they have the cashier on wheels.

Figure 60: One and Two Person Cashier on Rollers in Japan (Image Roser)

8.3 Flexibly Configurable Automotive Assembly Lines

Now, it's one thing to roll around a supermarket cash register, but it is a completely different task to do this with an automotive assembly line including all its material flows. Yet, automotive companies in Japan have done it.

Toyota developed what they call a "flexible assembly line" in 2010. However, there is a lot lost in translation from the original Japanese name 伸縮自在な組立ライン (*Shinshuku jizai na kumitate rain*). The first part means not only "flexible," but also "elastic; telescoping; expandable; retractable; extensible." "Expandable" and "extensible" fit the intended meaning much better. It is also part of the TNGA, which not only includes the new platform but also technical improvements and new manufacturing approaches and methods.

Mitsubishi in their Okazaki plant developed a similar concept called Tatami Conveyor (畳コンベア), where all equipment is also placed on the floor. Even overhead body assembly is done using floor-mounted supports.

But let's start with the basics. The image below shows a model from the Toyota Kaikan Exhibition hall, displaying a conventional assembly line. You can clearly see a lot of overhead structure. Not visible but also there are structures in the ground, especially railings, markings for the AGV, and space for turntable gear.

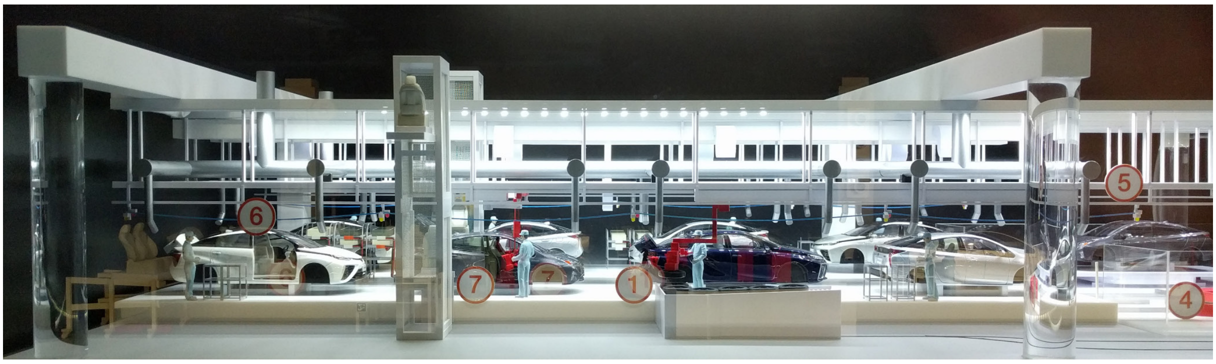


Figure 61: Model of a Line at Toyota before the change to a Flexible Line (Image Roser)

The second picture below shows the new type of line. All of the overhead structures are missing. Also gone are most underground structures. The numbered items are described below the image.

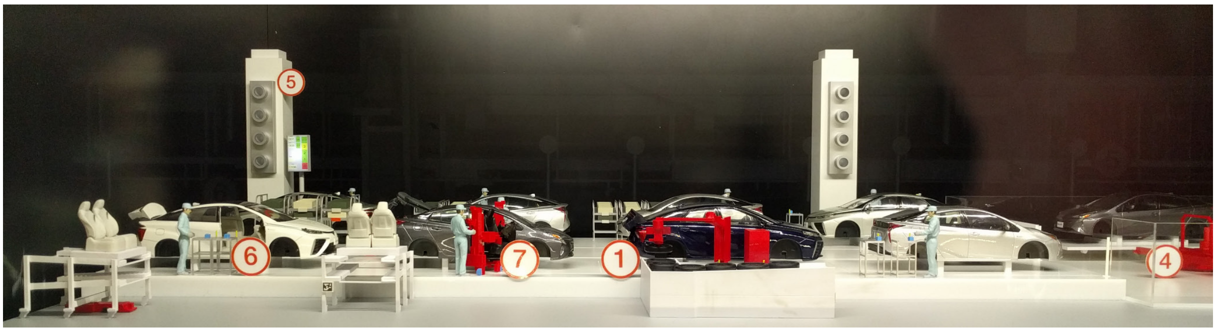


Figure 62: Model of a New Flexible Line at Toyota (Image Roser)

- Collaborative robots working together with humans.
- Tapeless automated guided vehicles. Rather than following markings on the floor, these AGV have a navigation system (not in the picture).
- Solar power is used for some signal lamps and wirelessly connected computers, making the devices easy to move (the number is not visible in this shot, as it is behind the seats on the left).
- Rail-less transport turning equipment. The carts no longer sit on rails but move directly on the floor. Turntables for changing the direction of the car bodies also sit on the floor rather than in an excavated hole.
- Air conditioning towers direct air rather than overhead tubes.
- Call switches (andon lines) are now wireless buttons directly on the carts of the workers.
- All assembly equipment is floor based rather than hanging from overhead. Much of it is on rollers for easy moving.

Toyota already implemented this in its Tsutsumi plant near Nagoya in 2015, and they now want to implement it in all new plants. Below are two still images from a video at the Toyota Kaikan from the Tsutsumi plant. The left shows the assembly line before extension, the right after the extension. The entire change happened over a weekend.

Figure 63: Toyota Flexible Assembly Line Tsutsumi Plant Before and After (Image Toyota with permission)

Additional improvements are a much smaller and more energy-efficient paint shop, and a new type of laser welding that is faster than before (laser screw welding). Injection molding machines are able to change tools so quickly that they sit close to the line and produce parts just as they are needed in any sequence, followed by painting in the desired color. Lot size one is used for injection molded bumpers.

8.4 Why Do They Do It?

The overarching goal of Toyota is to reduce investment in new lines by 40% to make them "simple and slim." The resulting plants should also be 25% smaller. There are also a lot of sub-goals.

- Lines can be extended and reduced easier if the demand goes up or down, or if new features are added or removed (i.e., the work content changes). Of course, they still need the empty space to put the line, however. You may also be wondering why they don't just make a long line and idle some stations if they are not needed. Toyota hates excess inventory, and if these four or so vehicles at these stations are not needed, Toyota would prefer not to have them there. This reduces lead time and also makes for easier communication.
- Overall, the line is easier to change beyond a mere extension. If some stations need to be added in the middle, everything else is just moved a bit.
- It increases reliability. Toyota assembly lines already have a utilization of 95% or more, but occasionally a robot or a machine breaks down. In the old line, this would have stopped the line until the problem is fixed. With the new line, they simply move the robot aside and human workers can take over. While this increases the work, Toyota has such manpower available, and the line keeps running.
- The reduced overhead structure allows a better use of natural light, reducing the electricity consumption.
- Heating, cooling, and general energy consumption is reduced, reducing the carbon footprint too.
- The new lines are cheaper than the old ones.

8.5 Does It Work?

Toyota claims that these lines are significantly cheaper than the previous ones. Now, such claims are easy to make. Most improvement projects claim success even though the actual benefit does not always come true. In this case, however, it seems to work.

Figure 64: Toyota Camry 2017 (Image Tokumeigakarinoaoshima under the CC-BY-SA 4.0 license)

Tsutsumi in Japan and **Georgetown** in Kentucky both produce Camrys. Japan has a labor cost very similar to the USA (hourly compensation costs 2012 Japan 35.34 USD, USA 35.67 USD). The South in the USA is about 10% cheaper than the average, which was one of the reasons why Toyota moved there. Overall, labor cost in Kentucky is probably around 10% less than in Japan. A Camry produced in Tsutsumi and shipped to the United States has the disadvantage of the increased labor cost and the shipping cost compared to Georgetown. It should be a no-brainer that Camrys for the US market should be produced in Georgetown.

Not so. Toyota issued an advanced warning to the Georgetown plant that despite their labor and shipping advantage, Tsutsumi can deliver Camrys cheaper to the United States than Georgetown can make them in the United States. Georgetown will have to improve its costs to stay competitive.

In sum, Toyota has changed the game again. This is what probably amazes me the most about Toyota, that they are able to constantly challenge the status quo, question conventional wisdom, and have a good sense of the right direction. I hope you are also able to see such things for your own area of responsibility. Maybe my blog can even help you a bit with this. **Now, go out, challenge the status quo, question conventional wisdom, and organize your industry!**

9 The Grand Tour of Japanese Automotive – Overview and Toyota

Christoph Roser, February 27, 2018, Original at [*https://www.allaboutlean.com/grand-tour-overview-and-toyota/*](https://www.allaboutlean.com/grand-tour-overview-and-toyota/)

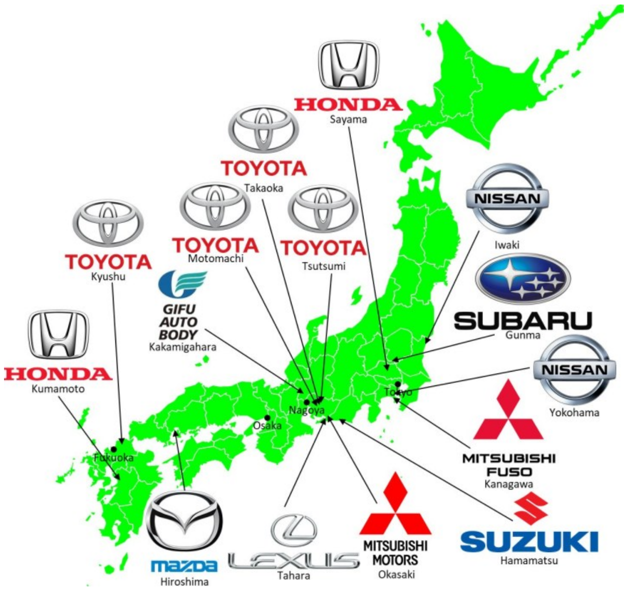


Figure 65: Grand Tour of Japanese Automotive Map (Image Roser)

During Winter 2017–2018, I spent five months in Japan. As part of this visit, I was able to visit factories of all seven Japanese car makers as part of my **Grand Tour of Japanese Automotive Plants**.

This was extremely insightful, and I learned a lot about the differences between the Japanese car makers. Let me give you an overview and some details on Toyota plants before firing off a series of blog posts on the different Japanese automotive companies.

9.1 The Grand Tour of Japanese Automotive Plants

One of the joys of being a professor is the possibility of a sabbatical every few years. This allows us to take half a year off to do research and study (and I would like to thank all German taxpayers for enabling me this great opportunity 🙂). Naturally, I went to my favorite lean playground, Japan. I was working together with my Mentor Prof. Nakano at the SMD Laboratory at Keio University, Hiyoshi Campus, Yokohama, Japan.

Among many other things, I was able to visit almost fifty different plants all over Japan. While I also visited steel mills, food-processing plants, refineries, logistic terminals, machine tool makers, and many other plants, my focus was on automotive. On my grand tour of Japanese automotive, I was able to visit numerous car factories from all major Japanese car makers: **Toyota, Nissan, Honda, Mitsubishi, Mazda, Suzuki, and Subaru!**

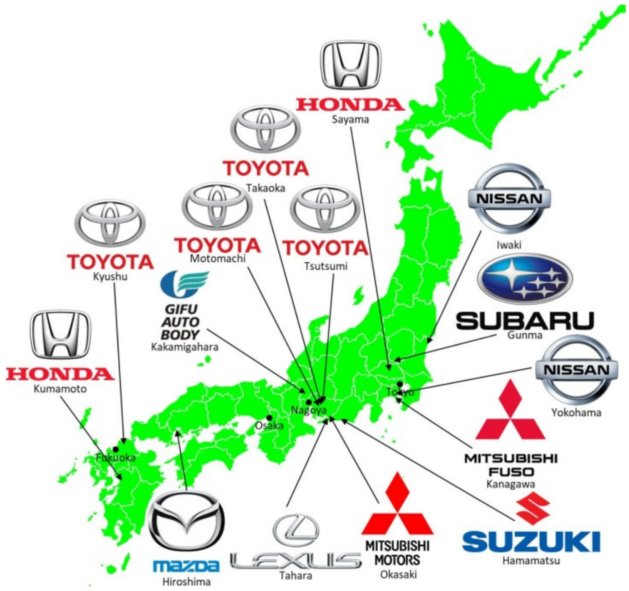


Figure 66: Grand Tour of Japanese Automotive Map (Image Roser)

Overall I visited the following plants belonging or connected to the major car makers, plus a number of smaller suppliers (not mentioned below).

- **Toyota**: Takaoka (3x), Tsutsumi, Motomachi, Tahara (2x), Kyushu, and Gifu Auto Body
- **Nissan**: Yokohama and Iwaki (both engine plants)
- **Honda**: Sayama and Kumamoto (motorcycles)
- **Mitsubishi**: Okasaki (now Renault-Nissan-Mitsubishi) and Mitsubishi Fuso trucks, Kanagawa (now owned by Daimler)
- **Mazda**: Hiroshima
- **Suzuki**: Hamamatsu
- **Subaru**: Gunma Honkojo

Update: A video of a presentation of mine on this sabbatical with English subtitles is now online:

The Video by Roser is available on YouTube as "The Grand Tour of Japanese Automotive – Erkenntnisse und Eindrücke von Toyota und anderen" at https://youtu.be/Ow1WF6c6zw8

9.2 Comparison

During my tours, I collected data on the different plants. The qualitative information will be shown in subsequent posts for different car makers. Here, however, is a short quantitative comparison. Importantly, there is much less exchange of knowledge among the different car makers in Japan compared to Europe or the USA. In Europe and the USA, it is common that employees leave one company and join another, and subsequently their knowledge moves to another company too. In case of top executives, this knowledge can even be a truckload of confidential documents (Ignacio Lopez apparently took along twenty cartons of confidential documents when he changed from GM to Volkswagen).

Figure 67: Job Hopping in Germany vs. Japan (Image Roser)

In Japan, however, it is highly uncommon to switch companies, especially for employees of large companies. Doing so would probably put them again at the very bottom of the hierarchy and salary. Large companies prefer to hire employees directly from university or school, and then form them throughout their careers (see e.g., Consistency at Toyota – The Board of Directors of the Toyota Motor Company).

There are few exceptions. The CEO of Suzuki apparently worked for Denso (Toyota group) when he was younger, and picked up some ideas from the Toyota Production System. Smaller car companies also sometimes use the same suppliers as larger ones (again Suzuki close to Toyota City). And when Carlos Ghosn disbanded the Nissan keiretsu (Japanese industry groups of different legally independent companies that are closely connected through both mutual shareholding and business relation), a lot of suppliers had to turn to other customers to survive, leading to some more exchange of information. But overall, there is little overlap and exchange between car companies. Hence, many of them have their own distinctive style.

9.3 Size

Japan is one of the major nations with respect to automotive production. Below is an overview of the world vehicle production in 2016, arranged by maker (this includes not only cars but also trucks and other commercial vehicles) (Source: OICA).

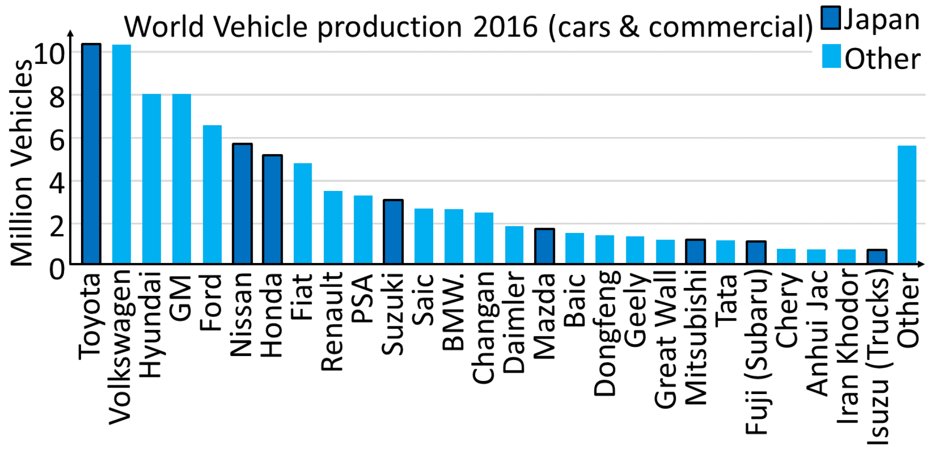


Figure 68: World Vehicle Production 2016 (Image Roser)

Overall, Japanese automotive makers produce 28 million vehicles worldwide, around 30% of the total world production of 94 million. Within Japan itself, 9.2 million vehicles were produced, or around 10% of the world production. The largest car maker in 2016 was Toyota, but since then it has been overtaken first by Volkswagen and then by the newly formed Renault–Nissan–Mitsubishi alliance.

9.4 Efficiency

I estimate efficiency by counting how many workers I see adding value and how many don't at the moment I look at them. This gives me a rough estimate how much time the worker spends actually adding value, and how much is waste (walking, waiting, transporting, etc.).

Below is the overview of these plant visits, with the efficiencies in different plants of different groups. All measurements are for assembly lines, either sub-assembly lines (dashboard, engine, axle) or final assembly lines (final cars, except Honda Kumamoto for motorbikes and Mitsubishi Kawasaki for trucks, the latter with a much higher variety and lower takt time). The graph also shows the weighted averages for a group as well as the overall weighted average (although this is slightly biased toward Toyota since I visited more Toyota plants).

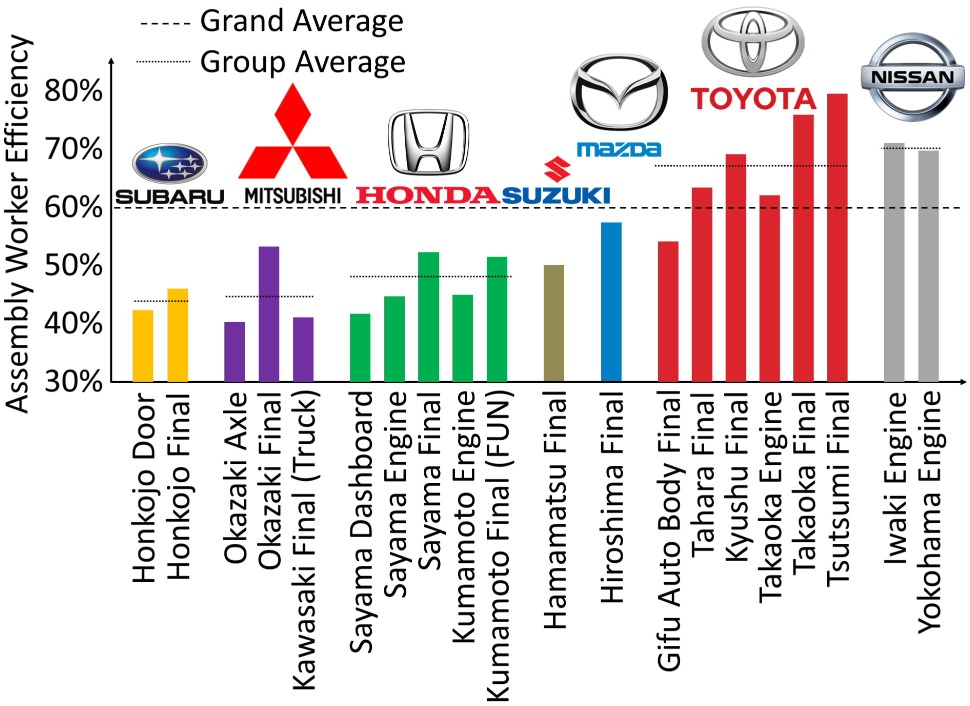


Figure 69: Japanese Automotive Efficiency Comparison (Image Roser)

It can be clearly seen that Toyota and Nissan are the top-performing plants, where the worker spends a whopping 70% of his time actually adding value. I was actually a bit surprised that Nissan exceeds Toyota here, even though the top performing plant is Toyota Tsutsumi. Mazda and Suzuki are somewhere in the middle. Mitsubishi, Honda, and Subaru are the least-efficient plants, where the worker spends less than half of their time adding value. A worker at a good Toyota plant creates twice as much value than at a not-so-good Mitsubishi or Subaru plant.

9.5 Team Size

Part of the reason why both Toyota and Nissan excel with their work performance may be their support structure. The team leader is the first responder for whatever problems pop up at the workplace. However, the more team members a team leader has to support, the less effective will this support be.

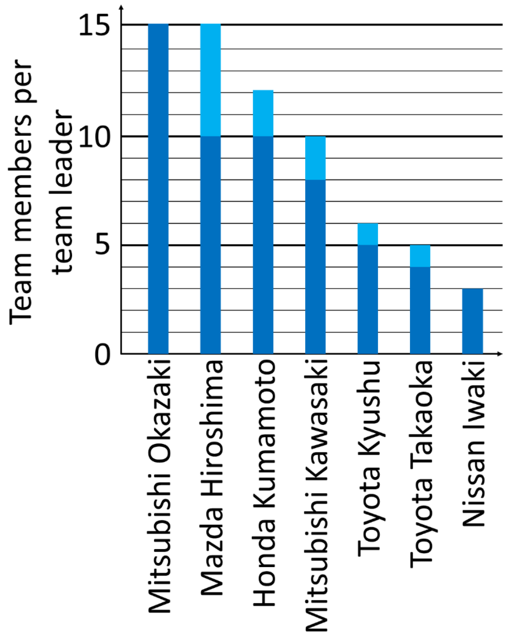


Figure 70: Team members per leader at selected Japanese plants (Image Roser)

Toyota and Nissan have both very small team sizes, and a team leader is in charge of three to six workers at Nissan and Toyota. At the other end, Mitsubishi, Mazda, and Honda have around ten to fifteen workers per leader. In the worst case, a team leader at Mitsubishi has to take care of five times as many people than at Nissan. As a result, the support is spread pretty thin, and problems are more likely to escalate before they can get resolved.

9.6 Working Times

It was also interesting to look at the work times of the different plants as shown in the graph below. Some plants had only one shift (Mitsubishi Fuso, Nissan Iwaki). Work around the clock was only at the Honda Kumamoto and Sayama plant, with an overlap between the shifts for a handover, and the casting operation at Nissan Iwaki, with four days on and two days off shift (you can't really turn off a casting operation, and most casting plants work twenty-four hours).

Interesting are the two patterns with two shifts. Most car makers, except Toyota and Subaru, have optimized their shifts to benefit the work. They maximized the gap between the shifts to have the maximum availability for overtime and maintenance. Toyota previously did this too, but ran into big problems. Working the graveyard shift past midnight is extremely demanding for the workers, as these work times clash with the human biorhythm. This resulted in an enormous turnover for Toyota, and hence they changed it to maximize the gap between shifts after midnight (see Toyota Employee Relationship Crisis and Countermeasures 1990s). All Toyota assembly employees can rest at night, unlike their colleagues from the competition.

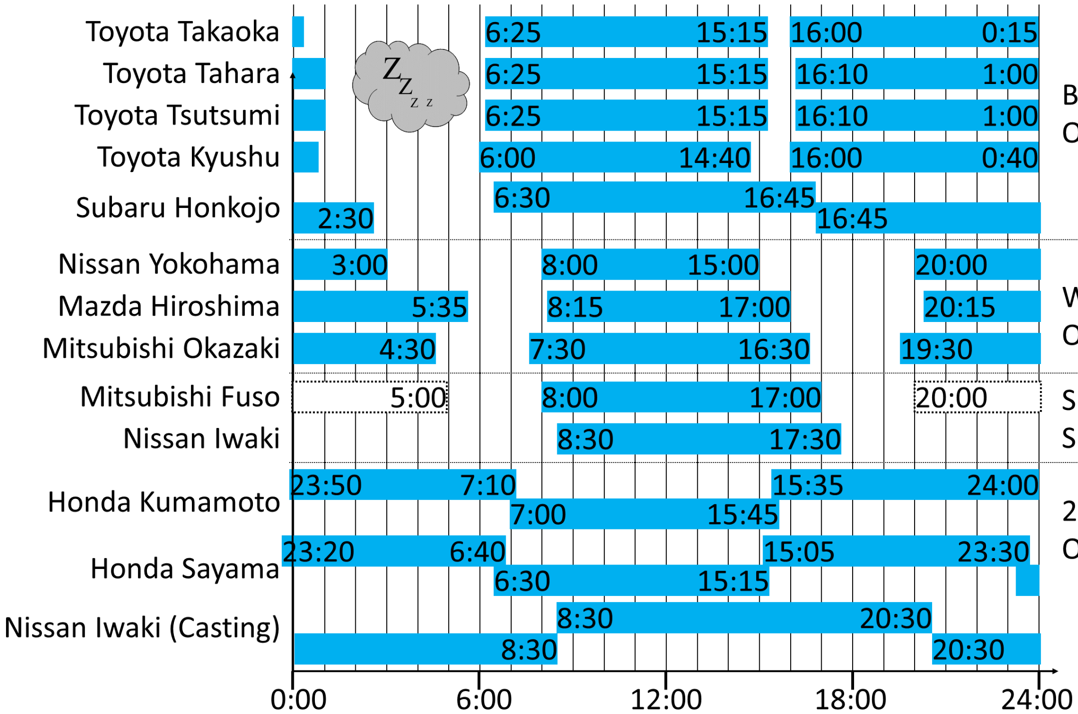


Figure 71: Shift patterns at Japanese car makers (Image Roser)

The shift duration also varied considerably, from seven hours (including breaks) at Nissan Yokohama to over ten hours at Subaru.

9.7 Labor Force

I was also looking a little bit into the gender structure of the workforce. Assembly is often a physically demanding job with constant time pressure (the takt time is anywhere between 40 seconds (Honda Sayama) and 178 seconds (Gifu Auto Body), with most lines using a 60-second takt. Combined with cultural norms, most plants have only 3% to 5% female workers. I did observe some female workers, and they seem to be doing the same job as their male colleagues.

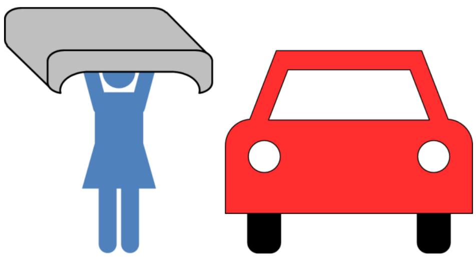


Figure 72: Grrl power … (Image Roser)

I was particularly impressed by one woman who installed the interior roof into cars. She lifted the heavy and large part all by herself out of the supply rack, carried it to the car, and together with another worker installed the roof inside of the car. That is a job I would have difficulties with at twice her weight (rounded, but I am not telling you if up or down ☺).

9.8 Toyota Specific Information

The next few blog posts contain more specific information on Nissan, Honda, Mitsubishi, Mazda, Suzuki, and Subaru plants. I was considering writing a similar blog post on Toyota, but then, my entire blog is mostly on Toyota. I have posts on The Toyota Employee Evaluation System, Anatomy of the Toyota Kanban, Toyota's and Denso's Relentless Quest for Lot Size One, Operator Training at Toyota and Scania, Toyota Employee Relationship Crisis and Countermeasures 1990s, and the Evolution of Toyota Assembly Line Layout to name just a few.

9.9 Changes at Toyota

Figure 73: I'm just a poor boy, nobody loves me. He's just a poor boy from a poor family … (Image Moto@Club4AG under the CC-BY 2.0 license)

However, there are a few changes within the company. The current president, Akio Toyoda, grandson of Kiichiro Toyoda and president of Toyota Motors since 2009, is quite controversial. While some of my contacts think he is the right man for the job, others believe he is destroying the culture unique to Toyota. This worrisome change started around ten years ago when Akio became CEO.

Apparently, Akio Toyoda does not like disagreement and is **creating a culture of "Yes"-men**. Disagreement in upper management quickly ends careers. In fact, managers at Toyota Motors can nowadays quickly fall from grace for minor and subjective issues. One of my contacts compared the situation to "North Korea" (although this may be an exaggeration, as I doubt Toyota has a Gulag for managers fallen from grace).

Other companies are becoming more reluctant to share info with Toyota, even companies within the Toyota group. The formerly free exchange of people within the Toyota group is also slowing down, as some Toyota group companies are reluctant to send their people to Toyota Motors, least they be corrupted by the culture at Toyota. Toyota itself also seems to be hiring more selfish people (see my previous post on that).

Akio also seems to put much more emphasis on product development than on production. While previously these two departments had equal power, nowadays production management is falling behind, receiving less budget, personnel, and attention. It is also more difficult to make a career out of production. There are not many directors left that come from production. I have been told that as a result, the production performance suffers.

If I look at my own data, I can also see a minor decrease in performance. The inbound warehouse nowadays seems to be a bit more crowded than five or ten years ago. An over-the-thumb estimation of the inventory reach also showed that the quantity of inbound material increased from two hours to three hours. The performance of the workers at the final assembly line decreased from 70% to 90% value-adding time to 60% to 80% value-adding time – although this still outperforms any other plants I have seen. But overall, yes, Toyota seems to slowly degrade its essence and culture.

9.10 If You Want to Follow in My Footsteps …

Figure 74: Toyota Takaoka Entrance (Image Roser)

Toyota is, besides Mazda, the only Japanese car maker offering English-language factory tours. The tours are organized through and start and end at their Toyota Kaikan Museum. This visits usually either the Tsutsumi, Takaoka, or Motomachi plant, where you walk on elevated walkways through the factory. At this point I would also like to give thanks to the charming team at the Toyota Kaikan. The ladies conducting the tour also said that they liked my blog, and that they learned more about kanban from it … which … which can mean only one thing … **I am teaching Toyota about Kanban!** … I think I should put this on my resume … 😎.

Figure 75: Toyota Motor Kyushu (Image Roser)

Many other Toyota plants offer tours in Japanese, (e.g., Kyushu or Tahara – both Lexus). In Kyushu you are also on elevated walkways, but in Tahara you walk on the actual shop floor. The Kyushu plant stands out for being far away from the Toyota headquarters in Toyota City. While most Toyota plants feel the same, Kyushu seems to have developed its independent style. A lot of innovations in Toyota originate from Kyushu, maybe because due to the distance, it is less exposed to the corporate norms and politics than the other plants. The J. D. Powers survey since 2009 consistently considers Kyushu among the top five car plants in the world. Many thanks also to the other plants for providing such tours.

Another tour of the Gifu Auto Body plant was done through the C2U Lean Leadership Training in Japan. For tours of the other car makers, see my subsequent blog posts. Until then, **go out, and organize your industry!**

10 The Grand Tour of Japanese Automotive – Nissan

Christoph Roser, March 06, 2018, Original at https://www.allaboutlean.com/grand-tour-nissan/

Figure 76: Nissan Logo (Image Nissan for editorial use)

Nissan by itself would be the sixth-largest car maker (5.5 million vehicles in 2016), although it is now a part of the Renault-Nissan-Mitsubishi alliance, which was the largest car maker in 2017. It is also the world's largest producer of electric vehicles.

As part of my grand tour of Japanese automotive plants, I visited their Yokohama and Iwaki plants, which both make engines. In my view, the manufacturing performance of Nissan is comparable to that of Toyota, making it also one of the most efficient car makers worldwide. Let me show you what I found.

10.1 Introduction

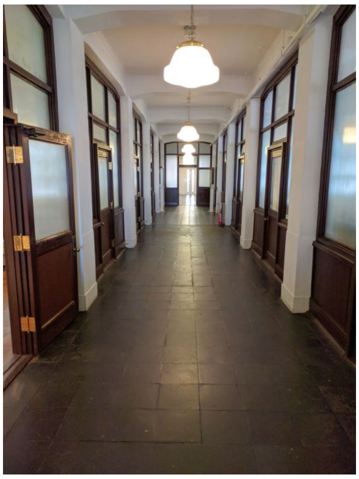


Figure 77: Historic Office Building of Nissan Yokohama (Image Roser)

Nissan started out as a holding company in 1928. They owned foundries and automotive suppliers. In 1933 they took over another company, which included the first Japanese car maker, DAT. Together with other companies, the Nissan group founded Nissan Motor Co. in 1934. Its first plant in Yokohama started operating in 1935.

Now, here it gets interesting. All other Japanese car companies had a Japanese inventor or tinkerer behind it. While the founder and CEO of Nissan, Yoshisuke Aikawa, was very interested into cars, the actual driver behind the technological progress at Nissan was an American engineer, William Gorham (1888–1949).

Figure 78: William Gorham (Image 日本自動車殿堂公式サイト in public domain)

Born in San Francisco, Gorham visited Japan many times together with his father. After graduation he founded an engineering company. Seven years later in 1918, however, he moved to Japan together with his family. He worked for numerous engineering and automotive companies connected to Nissan in Japan, but also for Hitachi and Canon. He changed his citizenship to Japanese at the onset of World War II to avoid deportation, taking the name Gorham Katsundo (合波武 克人).

His work was very influential. He introduced numerous American methods for design, development, and production. He imported numerous machines and entire assembly lines from America. From a technological point of view, Gorham was the godfather of Nissan, and is still held in high regards at Nissan. Hence, Nissan was strongly influenced by American technology from early on, much more so than other Japanese car makers.

This foreign influence continued. During the economic crisis in Japan in 1990, Nissan almost went bankrupt. To improve their situation, Nissan partnered up with Renault in 1999. Renault is here the stronger partner, as Renault holds 43% of Nissan's voting shares, whereas Nissan holds only 15% of Renault's non-voting shares (as of 2018).

Figure 79: Carlos Ghosn (Image Ecole polytechnique under the CC-BY-SA 2.0 license)

This introduces the second highly influential foreigner at Nissan, Carlos Ghosn (born 1954). He turned Michelin around, rescued Renault, and is known as "*Le Cost Killer*." He became the CEO of Nissan in 2001. His "*Nissan Revival Plan*" brought the company back to profitability within only twelve months.

He also seriously disrupted the corporate culture at Nissan. He introduced promotion based on performance rather than seniority, ended the lifetime employment, dismantled the Nissan Keiretsu (business group), and got rid of under-performing suppliers. Despite that, or maybe even especially because of that, he has a very high reputation in Japan, and his leadership style is highly admired.

10.2 Overall Impression

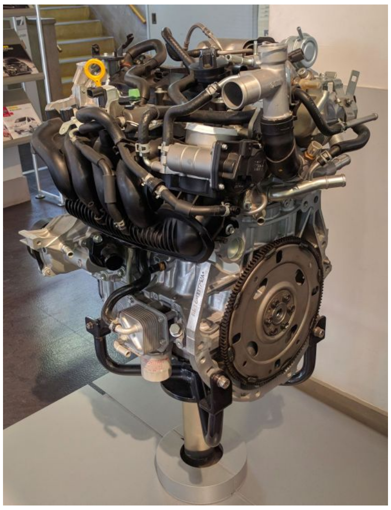


Figure 80: Nissan MR16 DDT Engine (Image Roser)

When visiting both the Yokohama plant and the Iwaki plant, I saw two high-performing automotive plants, the only plants in Japan with a performance level similar to Toyota. Both plants looked very clean, although the Yokohama plant had a strong smell of oil and gasoline.

Yet, after visiting dozens of Japanese automotive plants, Nissan plants feel a bit different. One thing is the higher level of automation that I observed in both plants. Early on, Nissan moved toward robotics and automation, and has much higher levels of automation than many other automotive plants.

A second difference is harder to pin down. To me, it somehow … *felt more like an European or American plant* rather than a Japanese plant (despite almost all workers being Japanese and the plant being more efficient than European or American plants). I am not quite sure myself why I had this impression. Maybe it is because many other Japanese automotive plants have many quick fixes slapped together with some plastic tubing and string to help with assembly. Nissan, on the other hand, uses more-refined technology by bolting together metal profiles. Both approaches work, with Toyota's being cheaper but Nissan's being more sturdy. Maybe this is because Nissan was strongly influenced by Gorham and Ghosn.

10.3 Information Flow

Figure 81: Yokohama Visitor Center (Image Roser)

The information flow at Nissan is overall well organized, using kanban for a pull system. There are different andon throughout the factories, as well as an andon stop buttons or cords at the final assembly lines. The assembly lines work in small teams with one supervisor. The supervisor was always circling around behind his people, ready to jump in whenever there is a problem. Curiously, at Iwaki there were only three workers per supervisor, whereas in Yokohama there were six to eight people per supervisor (Toyota usually around four to five).

Kaizen improvement activities were also quite visible, maybe even more so than other Japanese auto makers, with lots of A3 sheets at different meeting locations throughout the factories. They also often use pointing and calling.

At both plants, Nissan has a board with a wooden slate for each worker or supervisor in the plant. These are nicely printed, and quite fancy. They use it for planning and organizing of the team structure. While such plans are common, only at Nissan did I see such high-quality wooden name tags rather than paper or printed magnets.

10.4 Material Flow

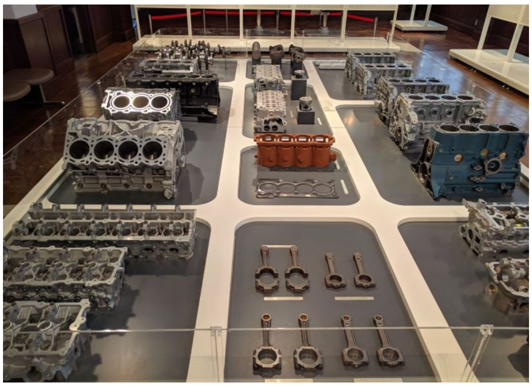


Figure 82: Yokohama Visitor Center Showcase (Image Roser)

The material flow is mostly well organized. Material transport is mostly by AGV, following magnetic tapes on the floor, unless it is automated conveyors overhead, underground, or on top of the floor.

Karakuri Kaizen is common, often with cute names for the karakuri gadgets like "*oiwa-san*" (お岩さん, Mr. Big Rock) or "*ippatsudashi-kun*" (一発出し One Punch Out Buddy). They also like to give some of their machines fancy colors, and a robot was painted to look like a giraffe.

At the Iwaki plant, I did see some pallets that felt "*dumped*" on the middle of the path, indicating that their standard, while good, is not perfect. Both plants seems to have larger inventories than at Toyota.

10.5 Efficiency

Figure 83: Nissan Yokohama Plant Sign (Image Roser)

Nissan plants are usually highly automated. For example, at the milling shop, only five employees took care of two hundred machines. The performance of the assembly lines were also excellent. I estimated that around 70% of the time, the employees add value to the product in both Iwaki and Yokohama. This is close to Toyota's 70% to 90%,and much better than the industry average of 50% to 60%. The engine assembly lines had a takt of around fifty seconds in Iwaki and sixty to seventy-five seconds in Yokohama.

10.6 Comfort

Figure 84: Like many retired Japanese, this old welding robot now draws doodles at reduced speed to entertain customers (Image Roser)

The working times at Yokohama were 8:00AM to 3:00PM and 8:00PM to 3:00AM, giving a five-hour gap between the shifts. This is ideal for maintenance, but difficult for workers especially on the late shift, and Toyota stopped using this method in the 1990s. At Iwaki they had only one shift for the assembly line from 8:30AM to 5:30PM. The foundry worked around the clock in two shifts from 8:30AM to 8:30PM and 8:30PM to 8:30AM, with four days of work followed by two days off. The aggregation site Vorkers.com ranks Nissan pretty high with an overall grade of 3.5 out of 5.

10.7 If You Want to Follow in My Footsteps …

Figure 85: Nissan Historic Office Building (Image Roser)

Reservations for visits to Nissan factories can be made through their website, but this requires some knowledge of Japanese, as they do not offer English tours. The Yokohama factory I visited is their oldest factory, and their visitor center is a pre-war historic office building.

The Iwaki plant is their smallest factory with only 750 employees. Both produce engines, with Iwaki focusing on larger engines for larger cars, and hence due to the smaller demand operates only one shift for the engine assembly (their aluminum foundry is staffed around-the-clock as most foundries in the world). I was also able to see this aluminum foundry, which is usually not part of a plant tour. They claimed that their two-minute cycle time at the foundry was the world's fastest for engine blocks.

Figure 86: Results of the 2011 Japan Earthquake at Nissan Fukushima (Image Nissan with permission)

The Iwaki plant is located in Fukushima, and is only 60 km away from the Fukushima nuclear power plant that was destroyed in the 2011 tsunami, but the plant is outside of the restricted zones. The plant itself was heavily damaged by the earthquake, but was high enough to avoid the tsunami and reopened after only two months. As the floor shifted vertically up to 10cm, the current floor has some odd slopes where they repaired this offset. As there are still aftershocks, the remodeled floor also has lots of smaller cracks.

The Iwaki plant is at 386, Shimokawa-aza-Otsurugi, Izumi-cho, Iwaki-shi, Fukushima 971-8183, and the Yokohama plant at 2 Takaracho, Kanagawa, Yokohama, Kanagawa Prefecture 221-0023.

10.8 Summary

Overall, Nissan automotive plants have an outstanding performance comparable to Toyota, despite their different approach using much more automation. I believe that Nissan plants are also among the world's best automotive plants, besides (behind?) Toyota. I definitely enjoyed the visit (but then, I am a geek for such kind of things). **Now, go out, and organize your industry!**

11 The Grand Tour of Japanese Automotive – Honda Sayama

Christoph Roser, March 13, 2018, Original at https://www.allaboutlean.com/grand-tour-honda-sayama/

Figure 87: Honda Logo (Image Honda for editorial use)

Honda is the seventh-largest car maker in the world (in 2016). It is the largest maker of motor bikes and internal combustion engines overall. During my Grand Tour of Japanese Automotive, I was able to visit two of their plants: **Sayama**, where they produce cars, and **Kumamoto**, where they produce motor bikes and generators. These two plants are very different from each other. Let me give you what I found.

11.1 Introduction

Figure 88: Honda Model A (Image Rikita under the CC-BY-SA 3.0 license)

Honda is actually one of the youngest car makers in Japan, being founded after World War II in 1946 by Soichiro Honda (本田 宗一郎 1906–1991), who always seemed to have a big smile. Their philosophy is structured around respect for the individual and the "*three joys*": The Joy of Buying, the Joy of Selling, and the **Joy of Creating**.

Their first products were motorcycles (actually motorized bicycles). By 1964 they were the largest motor bike manufacturer in the world.

Figure 89: Honda Asimo 2011 Version (Image Morio under the CC-BY-SA 3.0 license)

In 1953 they started to produce power equipment like lawn mowers, boat engines, or generators. In 1963 they expanded into automobiles, initially focusing on the small car segments, but introducing their own luxury brand *Acura* in 1986. They are also known for their Asimo robot, also starting in 1986. They produced aircraft engines since 1986, and their aircraft division had its first flight in 2003.

To be honest, to me it feels like too many different things (cars, motor bikes, aircraft, robots, boat engines, lawn mowers) … it is difficult to focus. From what I have seen, I believe their heart still beats for motorcycles, but with all the other products their focus gets diluted.

11.2 Saitama Sayama Plant (October 2017)

Figure 90: Honda Sign in the Sayama plant (Image Roser)

The Saitama area has actually three plants, Sayama and Yorii for cars and Ogawa for engines. Yorii is the newest plant of the Honda group, whereas Sayama is the oldest one, dating to 1964. The plant is scheduled to be closed in 2022, with the employees being transferred to the new plant one hour away. However, this excuses only in part the unstructured and un-ergonomic conditions in the plant.

11.3 Statistics

Figure 91: Honda vehicle with side mirrors on display at their Sayama plant. (Image Roser)

The plant has a capacity of 1,050 cars per day, and produces 850 in average with 4,680 employees. They claim to have the fastest car assembly line in the world, but when I visited, their final assembly ran at a takt time of one car every sixty seconds, which is normal for automotive. Welding was slightly faster at forty seconds per body, but this is also common in industry. Besides, faster is not always better here. They work in two shifts between 6:30 AM and 11:30 PM, similar to its Kumamoto plant. The paint shop was the location where a generic car body was matched with a specific customer (or sales) order. The final assembly line used a batch size of around five for popular models and colors, but had occasionally the single odd-colored car with low demand in between (neon green, anyone?)

11.4 Overall Impression

As I said above, I was not impressed. Not at all. For the usually good quality of Honda vehicles, I expected Toyota like-performance, but this was a disappointment. The plant was dark, dirty, and disorganized. Illumination was not good, and there were lots of dirty and dark corners. The employees at Honda wear white overalls to emphasize cleanliness, but at Sayama it was not working, and the overalls were often dirty too.

11.5 Information Flow

Figure 92: Not at Honda… (Image Roser)

There was also very little information. There was no form of andon in the plant, except a single one at the final assembly, which also had an andon button to stop the line. When the welding line started beeping due to a problem, we could not see or figure out where or what was the issue; it just stopped and there was no light or anything indicating the location of the problem. We also could not figure out production quantities or if they were behind or ahead.

11.6 Material Flow

Figure 93: Honda Odyssey, produced in Sayama (Image Tokumeigakarinoaoshima in public domain)

Ergonomics was also bad. Only some of the material was on an AGV, and employees were pushing heavy carts with a lot of effort along the paths. A lot of the transport was also by forklift, which usually indicates large quantities with little standardization. One employee was carrying large and unwieldy boxes through the plant.

Material supply was also a mess. They do not have a pull system, and also do not use kanban. The quantity of the material also by far exceeded the material around the Toyota assembly lines. For example, at the injection-molding location there was an inventory of around 3,600 panes, representing sixty hours or almost four days of work. This was an in-house operation close to the point of use, and could have been much better organized. Their seat supply, however, was Just in Time and Just in Sequence.

The oldest material notice I found dated from October 2015, two years ago. Material was just piled around the assembly lines. At one assembly station, I saw a shoebox-sized box of screws sitting alone on the floor, where the worker picked up the screws. This is neither ergonomic nor organized. Most material locations were not labeled or structured. There was little mechanical aid of any kind to help with the material supply at the line, and workers often had to bend or twist their bodies to get material. Heavy doors and seats were lifted out of a supply hanger **by hand** and carried to/in the car **by hand**.

11.7 Efficiency

Efficiency was also not impressive. At one station, a robot was attaching glue to a part, before an employee added some more glue (different type) to the same part. During a plant visit, I usually make a statistic on how many people are adding value when I see them versus how many are not adding value (waiting, walking, transporting, searching, etc.). Toyota is the best I have seen with 70% to 90% of the people adding value. The Honda Sayama plant is below average for car makers with people creating value for the customer less than 50% of the time.

11.8 People

Figure 94: Recycling trashcans at Honda (Image Roser)

On the people side, they were nice and friendly. Honda seems to respect its workers. They also had the second-highest worker satisfaction on the Japanese employer reference and review site Vorkers with 3.81 (Toyota 4.9), and among the second-least overtime with only 22.7 hours per month in average (after Mazda with 22.4).

They also had the fanciest recycling I have seen in a long time, with a total of nine categories of waste.

11.9 If You Want to Follow in My Footsteps …

…then you would need to speak Japanese or at least have an interpreter, and be part of a larger group. You also need to apply two months beforehand through their website. In this case, you can enter a sort of lottery for the Sayama or Yorii plant for a plant tour. Their address is *1-10-1 Shinsayama, Sayama-shi, Saitama Pref., Japan*. Many thanks to Honda for the tour!

11.10 Summary

Overall, I was not impressed by the Sayama plant. Part of it can be explained by its age, another part by it being closed in 2022 (and who wants to invest time in a plant that will be closed anyway), but there was still enough left over to make this a pretty unimpressive plant. I went away with a pretty bad impression of Honda plants. Luckily, Honda Kumamoto was much, much better. More about this in the next post. In the meantime, **go out and organize your industry!**

12 The Grand Tour of Japanese Automotive – Honda Kumamoto

Christoph Roser, March 20, 2018, Original at https://www.allaboutlean.com/grand-tour-honda-kumamoto/

Figure 95: Honda Motorcycle Logo (Image Honda for editorial use)

Honda is the largest motorcycle manufacturer in the world with around 17 million motorcycles sold in 2017 (compared to number 2 Yamaha with around 5.2 million, 2015 figures). In January 2018 I had a chance to visit their Honda Kumamoto plant. This plant gave me a much better and very different impression than the Honda Sayama automotive plant.

12.1 Introduction

Figure 96: Honda Kumamoto Kyushu (Image Roser)

The Honda Kumamoto plant was established in 1976 and is the largest Honda plant in Japan by area. It is their main plant for the production of motorcycles in Japan including their engines, but it also produces garden power tools, generators, and four-wheeled scooters.

A major earthquake in Kumamoto in April 2016 damaged the plant, and it reopened and scaled up production again during the summer of 2016.

12.2 Statistics

Figure 97: Large Goldwing from the "Fun Line" (Image ウェルワイ under the CC-BY 3.0 license)

The plant includes casting, welding, stamping, machining, and painting operations, but my visit focused on the engine and final assembly lines. There are around 3,300 employees in the plant, 8% of them being women.

Honda Kumamoto has multiple assembly lines for engines and motorbikes. The main lines are dubbed the "*Fun Line*" for the big motorcycles and the "*Multi Line*" for the small vehicles and scooters. It also has a line for the generators and other products.

Figure 98: Small Monkey from the "Multi Line" (Image Thesupermat under the CC-BY-SA 3.0 license)

All lines produce in lot sizes of around thirty to fifty vehicles. The takt time is around 2:30 minutes for vehicles, and around five minutes for the other products (generators, power garden tools, etc.). Each motorbike line has a capacity of around four hundred bikes per day. The motorcycle lines had powered carts on tracks going around.

The Fun Line was around 150 meters long with thirty workstations. This line also had fancy monitors at each station tracking process time and often also had details like counting the number of screws tightened to prevent a missed screw. The other lines did not have these digital displays. The Fun Line was actually split into two loops with different types of carts. The first segment had around sixteen workstations and the second segment around twenty to twenty-five stations. They used an overhead crane to move the parts from one segment to the next. The Multi line had only one segment. They use a running changeover, where they simply keep two carts empty for the five-minute changeover process.

12.3 Overall Impression

The plant was squeakily clean. Quite a contrast to Honda Sayama. In Kumamoto, the white uniforms were actually white! It was much more organized and seemed to have much less material. The different shifts and functions were indicated by pins and labels on the sleeves and caps. For example, the first shift had an orange "1," and the second shift a blue "2" label on the hat or sleeve. Also, while the workers in Honda Sayama were in a good mood, the workers at Honda Kumamoto were outright cheerful!

12.4 Information Flow

Figure 99: Stack light with three colors (Image Ktm250-1150gs under the CC-BY-SA 4.0 license)

While Sayama did not use kanban, all material in Kumamoto was kanbanized and they used pull systems. Very good! However, like Sayama they also have no andons or andon stop lines or buttons. The only visual indicators were red/green stack lights on some selected machines. Hence it was difficult to understand how much was produced, or if they were on track.

Unlike Toyota, Honda does not stop the line in case of problems. All quality issues continued to be assembled and moved through the lines to be sorted out at the end. These issues were fixed in a separate repair area. This repair area was about half as large as the entire line. When I visited, there were about sixty motorcycles in the repair area, or around two hours' worth of production, on top of another forty or so motorcycles that were also parked around there, blocking walkways. Altogether, the repair area was the most chaotic section of an otherwise reasonably well-organized plant. Toyota does this much better.

12.5 Material Flow

The material flow was overall good. All of the carts with frames were height adjustable and adjusted their height to match the ergonomic height of the particular assembly. For the smaller Multi Line, they could also be rotated. One particularly short employee also had a raised platform about 10 cm high, 4 meters long, and 1.5 meters wide to work more comfortably.

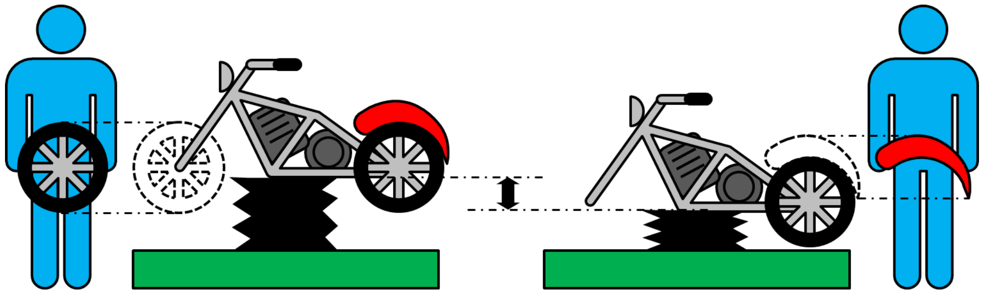


Figure 100: Height Adjustable Bike Assembly (Image Roser)

Honda uses kitting extensively, where workers prepare a kit of parts for the motorcycle. Some material is also supplied by shelves along the line. They said that they do not have issues with mixing up the kits (i.e., not a kit too much or too little during the batch changeover).

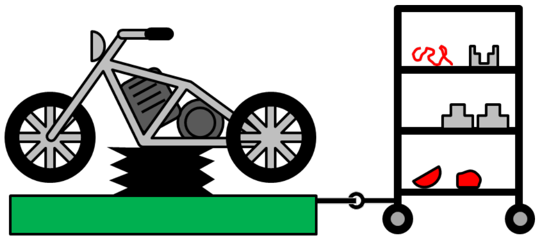


Figure 101: Bike Assembly pulling a Kit (Image Roser)

For the first segment of the Fun Line assembly, the cart pulled a shelf with the kit behind it. The kit was assembled directly on the line before the frame of the motorbike was put on the cart.

The interesting part, however, was the line layout. This line had lots of zigzags as shown below in a top-down view. The advantage of this is that due to the curve the rolling shelf and the cart with the motorcycle are closer together. Thus it is less walking distance for the operator to go and get a cart. This also meant that operators were working on both sides of the line. Please note that if my Japanese serves me right, they told me that they patented that idea.

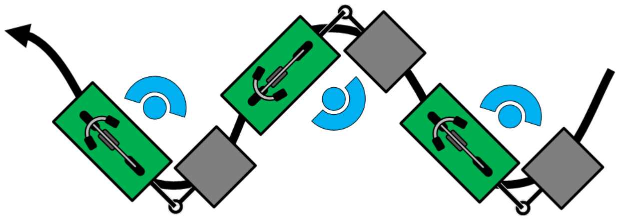


Figure 102: Bike pulling a kit snaking around Corners to reduce walking (Image Roser)

The second part of the Fun Line also used kits, but these were prepared on the floor above. These kits were provided hanging from an overhead railing on both sides moving along with the cart. There was always one shelf hanging, and a separate hanger for the larger front module. These hanging kits were also height adjustable separate from the motorbike carts. Hence, the parts in the kit were always at an ergonomic height for the operator. This is illustrated below. Please note that these hanging kits were actually on both sides along the motorbike (about 1.3 meters away so the worker could move between kit and bike), rather than between the bikes as shown below.

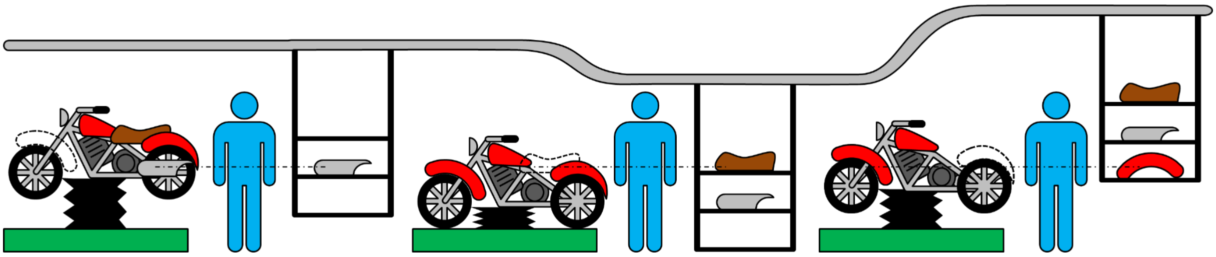


Figure 103: Bike height adjustable hanging kits (Image Roser)

Besides these hanging and pulling kits and the carts themselves, all of the material transport that I have seen was by hand, pushing movable shelves around the factory. There was not too much material around, and the ratio of material and assembly area was good (except of course for the rework area, and one spot where seventy Goldwing fronts – three hours of production – were waiting).

In some spots they also used karakuri kaizen tricks. I also noticed that all the power tools hanging from overhead were hanging quite low, almost at knee height of the operators. Here they sacrificed ergonomics for quality, to prevent these hanging tools from banging into, scratching, and denting the product.

12.6 Shift Change

I was also able to observe the shift change. The plant runs in two shifts from 7:00 AM to 3:45 PM, and from 3:35 PM to 12:00 AM, and yes, there is a ten-minute overlap.

- Most workers from the second shift arrived shortly before 3:30.
- At 3:30, music starts to play for the typical exercise that is very common in Japan. It is called “Rajio Taiso” （ラジオ体操) for radio calisthenics, which was introduced in 1928. Every kid in Japan learns these. Most but not all of the employees of the second shift participated, although some did it very sloppily, moving only the hands rather than the entire arm. The exercise ends at 3:35.

Figure 104: "Rajio Taiso" or radio calisthenic (not from Honda) (Image t.kunikuni under the CC-BY-SA 2.0 license)

- From now on, it is paid time. Between 3:35 and 3:40, the team leader has a meeting with his team. A team leader at Honda Kumamoto is in charge of around ten operators (Toyota: only four), and the team leader I observed had a team of twelve people.
- At 3:40, the second shift walks to the line.
- Between 3:41 and 3:43, the line stops completely for the handover. The workers of the first and second shift exchange information.
- At 3:43, the line starts again. From now on the second shift is working.
- At 3:45, the work time of the first shift is over, and people were leaving (although some put in a few more minutes to count and arrange materials).

12.7 Efficiency

Figure 105: Honda Kumamoto with Bikes (Image Roser)

As usual, I estimated the percent of value-adding work by counting what workers were doing when I looked at them. At Honda Kumamoto, it was similar to Honda Sayama with workers actually creating value slightly below 50% of the time (Toyota 70% to 90% value add). However, as the cycle time is longer, I would give some credit to Kumamoto, and say that considering the differences in products, Kumamoto is a notch above Sayama in terms of efficiency.

12.8 If You Want to Follow in My Footsteps …

… then you would need to speak Japanese or at least have an interpreter. They do tours also for individuals (in my case, I was the only one on my tour). You also need to apply through their website, but it is much less hassle than for Sayama. I got a very personal tour and was able to influence what I could see. Many thanks to Honda for the tour! Their address is *1500 Ozu-machi, Kikuchi-gun, Kumamoto Pref., Japan*.

12.9 Summary

Figure 106: Keep Calm and Stop the Line (Image Roser)

So, overall I did like the plant. It is not on par with Toyota, but it is clean, and they put a lot of work in efficiency and material supply. They also use pull to obtain material. Now if they could only get the remaining information flow right and install andons and stop the line when there is a problem.

Also many thanks to Honda for allowing me to visit and observe their plant. In both cases, I got a very personalized tour, and the tour guides were able to accommodate the special requests of *curious me* to see this and see that.

I learned a lot and got quite a few ideas especially from Kumamoto. I hope writing about this also gives inspiration for your work. Now, **go out, get your material flow in order, and organize your industry!**

13 The Grand Tour of Japanese Automotive – Mitsubishi

Christoph Roser, March 27, 2018, Original at https://www.allaboutlean.com/grand-tour-mitsubishi/

Figure 107: Mitsubishi Motor Logo (Image Mitsubishi for editorial use)

Mitsubishi Motors is the oldest of the major car companies in Japan, established 1917. It is also one of the smaller ones in Japan, with only slightly more than 1 million vehicles produced in 2016. In January 2018, I had the chance to visit their Okazaki plant near Nagoya. I also visited the Mitsubishi Fuso plant in Kawasaki and one of its suppliers, although that is technically another company. Let me give you the gist of the Mitsubishi Motors Plant Okazaki.

13.1 Introduction

Figure 108: Yatarō Iwasaki (Image unknown author in public domain)

The famous three diamonds of the Mitsubishi group date back to 1870, when Yatarō Iwasaki (1835–1885) started a shipping firm. This eventually became the biggest industry group in Japan.

They built their first car in 1917, although it was no commercial success. They built their first commercial vehicle in 1932. During World War II, they were one of the major weapons producers in Japan.

After the war, the US Government dismantled these industry groups and the company was split in different parts. Eventually in 1970, Mitsubishi motors was created as an independent company. Mitsubishi frequently had partnerships with foreign car makers, and in 1990 was rumored to try to take over Honda. Mitsubishi Fuso for their trucks and buses was established as a separate company in 2003, with Daimler being the largest shareholder, holding currently 89% of the shares.

As for corporate responsibility, Mitsubishi Motors does not have a good reputation. There were multiple scandals, dating back to 1970, where they covered up defects and manipulated their fuel efficiency. Their (former) president, Kawasoe, along with other managers was arrested and convicted. Mitsubishi Motors suffered, and retreated. Their Australian plant was closed in 2005, their European plants shut down in 2012, and by 2015 they closed their US plants. Eventually in 2016, Nissan achieved a controlling stake of 34%. Hence, nowadays Mitsubishi Motors is controlled by Nissan (the Nissan-Renault-Mitsubishi alliance), and Mitsubishi Fuso by Daimler.

The famous three diamonds were merely a rock in the jewelry box of someone else, and the morale of many employees suffered from this humiliation. According to Vorkers.com, Mitsubishi workers are among the unhappiest in the Japanese automotive industry with an average ranking of only 2.6 out of 5 (Toyota 4.2).

13.2 Statistics

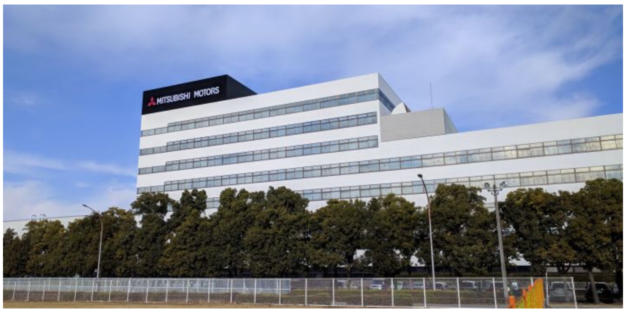


Figure 109: Mitsubishi Motors Okazaki Plant (Image Roser)

Mitsubishi Motors still has five plants in Japan, plus a few in other parts of Asia. The Okazaki plant had a total of 5,500 employees, of which 3,000 were working in manufacturing, with the others in development and testing. They work in two shifts from 7:30 AM to 4:30 PM and from 7:30 PM to 4:30 AM. Toyota once had a similar shift pattern, but changed it after their employee relationship crisis in 1990. They have up to two hours overtime on top of these hours if they do not achieve their daily goal.

Their line takt was sixty-three seconds per vehicle (or fifty-seven cars per hour), producing around 1,000 cars per day, or around 500 per shift. The monthly goal was 20,179 vehicles for January, up from 18,428 in the previous (holiday) month. The assembly line produces in lot size one, and every car on the line can be of a different model.

13.3 Information Flow

Figure 110: Mitsubishi Eclipse Cross, produced in Okazaki (Image Roser)

Mitsubishi Motors seems to use kanban to control their material flow. A lot of the picking of kits is also done using pick-by light. They work in teams with an average size of fifteen people (1,100 blue-helmet workers managed by seventy white-helmet supervisors).

I saw andons showing the target quantity for the given time (286 cars at 14:17), the actual quantity produced (265 cars) and the gap (-21 cars) as well as the total target for the entire shift (501 cars). They had two types of andon lines, a yellow warning line and a red stop line that stopped the line in case of problem.

13.4 Material Flow

Interestingly, for the assembly of the axles and the engine, they turned the car sideways. Later for other assembly work, the car was oriented forward again as shown below. Besides the orientation, this is actually part of a new concept at Mitsubishi (and similar at Toyota) where they try to have an assembly line that can easily be moved or rearranged. The key point is that all equipment is floor mounted or even just put on the floor rather than hanging from overhead. At Mitsubishi, this is called a Tatami Conveyor (畳コンベア), and Okazaki is their first plant with this system. I have written more on this concept (with focus on Toyota) in a previous blog post on the Continued Evolution of the Toyota Assembly Line.

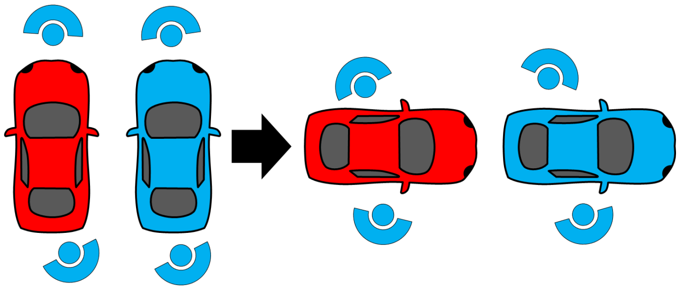


Figure 111: Change of body orientation at Mitsubishi (Image Roser)

Like many other automotive plants, quite a bit of the material is provided in the form of kits that travel along the body on an AGV. As it is common in Japan, these AGVs use inexpensive plastic pipes to create a shelf superstructure.

Very interestingly, they use golf carts as AGVs. I have seen stripped-down golf cars as AGVs before with storage for parts on top, but Mitsubishi uses the entire golf cart for pulling between one and three carts behind it! These are standard golf carts, upgraded with a computer for self-driving and some red/yellow/green status lights on top. They use around two hundred of them for longer distance transport. These golf carts transfer the goods to smaller shelves or AGVs next to the assembly line.

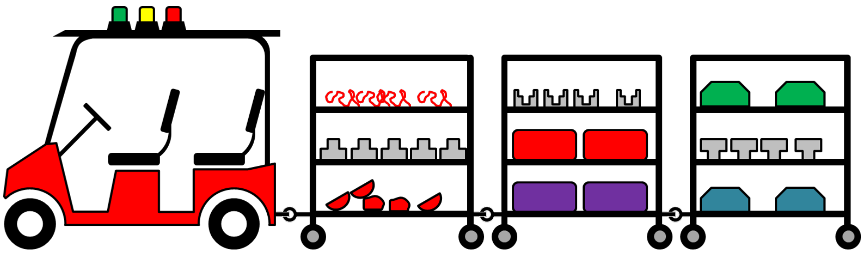


Figure 112: Homemade Mitsubishi Golf Cart AGV (Image Roser)

Overall, the material flow felt organized, although it seemed to be more material than what I was used to at Toyota.

13.5 Efficiency

There seems to be still some hand-welding, painting, and coating. But tires, seats, gas tanks, and dashboards are installed with the help of a mechanical arm, although they do not have a raku-raku seat that goes along with it (mechanical arm with a seat so the worker can comfortably slide in and out of the car while sitting).

Figure 113: Worker with a Stiff Shoulder (Image sunabesyou with permission)

Still, there was lots of manual work, especially overhead work. It may have been just my impression, but I thought I saw a lot of people rubbing their back or rolling their shoulders in discomfort.

As for their production efficiency, I observed around 40% value-added time during the axle assembly and 50% during the final assembly, putting it on the average of Japanese automotive assembly, but far behind Toyota with 70% to 90% value-adding time for their workers. This did not include the problem that caused the stop of the entire line for thirty minutes, which supposedly has *never happened before*. I hope someone someday will fix this "*NeverHappenedBefore*" thing, because it seems to be happening **everywhere all the time all over the world** 🙂. (The only other possibility would be that these "*NeverHappenedBefore*" things happen only if I am in the plant, in which case I would obviously be the cause … somehow.) In any case, the line utilization was supposedly 95.7%.

13.6 If You Want to Follow in My Footsteps …

The tour at Mitsubishi Okazaki was a larger tour with fourteen people. It is one of the very few automotive tours in the world where you can also see (part of) the paint shop and the stamping shop. For registration and the visit, you would need to speak at least some basic Japanese and have to call the plant. They were also the only plant that required me to put stickers on my mobile phone cameras.

13.7 Summary

The plant was clean (although the paint shop was smelly, which is somewhat unavoidable) They also had a nice training area next to the line with a focus on safety, similar to Toyota and Scania. Overall, the plant gave me the impression of a good average Japanese automotive plant. Particularly noteworthy was that they included the paint shop in the tour, and that they use almost unmodified golf carts for material transport. I enjoyed the visit. **Now, go out, and organize your industry!**

14 The Grand Tour of Japanese Automotive – Mazda

Christoph Roser, April 03, 2018, Original at https://www.allaboutlean.com/grand-tour-mazda/

Figure 114: Mazda Logo (Image Mazda for editorial use)

Mazda is the seventeenth-largest car maker in the world with around 1.5 million cars produced in 2016. Most of them were produced in Japan. It is also the only car maker that mass-produced cars using a rotary engine. As part of my Grand Tour of Japanese Automotive Plants, I visited their main Hiroshima plant in January 2018 (one of three Mazda plants in Japan). Here's what I found:

14.1 Introduction

Figure 115: Mazda R360 (Image Roser)

Mazda was founded as Toyo Kogyo in 1920 as a company processing cork. From 1930 onward, they produced motorcycles, and started using the name *Mazda* for its products. They renamed the whole company to Mazda only in 1982. In the 1930s, they also started to produce trucks. During World War II, they also produced weapons. The atomic bombing in Hiroshima also seriously damaged the nearby plant and killed many of the workers and their families. However, the plant opened again only four months after the bomb.

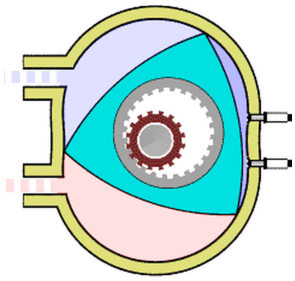


Figure 116: Illustration of a Wankel Rotary Engine. The animated image is available at https://commons.wikimedia.org/wiki/File:Wankel_Cycle_anim.gif (Image Y_tambe under the CC-BY-SA 3.0 license)

They built their first passenger car in 1960, the Mazda R360. This car was aimed at the low-cost segment, undercutting the main competitor Suzuki. Around that time, they also started using the rotary engine developed by Wankel. To date, Mazda is the only mass-producer of cars with rotary engines. Around 1970, they also entered the American market.

In the 1970s, Mazda was considered to be the least-productive car maker. Hence, the 1970 oil crisis also hit Mazda hard, almost causing its bankruptcy, but Mazda was rescued by the Sumitomo Bank. Between 1979 and 2015, Ford held partial ownership of Mazda of up to 33.4%. Hitting a financial crisis again in 1990, Mazda also had its first non-Japanese CEO, Henry Wallace.

14.2 Mazda Common Architecture

Figure 117: Excuse me? (Image Mazda for editorial use)

Part of the cause of the crisis of 1990 was a proliferation of brands at Mazda. For some reason, their strategy in 1990 apparently was to offer a multitude of different vehicles with different designs under their own brands. The brand name **Autozam** had around eight different car models, all starting 1990–1992. The brand name **Eunos** had another nine (again with start of production between 1989 and 1993). The Ẽfini (pronounced Anfini) sold another five models, and the **M2** had another three car models from around 1991. The luxury brand **Amati** was scrapped before it could offer its two cars.

Hence this small car maker started to mushroom its models and brand names. Developers had to work on dozens of different models on different platforms simultaneously. Part variety multiplied, reducing the economy of scale and increasing cost. Consumers got confused by a multitude of brands which they could not even pronounce (Ẽfini?). Luckily they stopped this madness quickly, before it killed the company completely. Only a few of these cars survive as modern Mazda models.

I assume it is especially due to the pain from this mistake that Mazda now goes completely in the other direction. Starting in 2011, they moved all models on the same car platform (common architecture). This scalable architecture is the same across all car models regardless of segment or size. Mazda uses the name **Skyactiv**. Skyactiv is best known for its fuel-efficient engines with a high compression ratio, but it includes a lot of technologies including Skyactiv-Chassis and Skyactiv-Body. Overall, Mazda tries to reduce its cost of complexity by using as many common parts as possible.

The idea itself is not new, and many car makers move into that direction. Best known is probably the Volkswagen *Modularer Querbaukasten* (MQB). However, if you ask Volkswagen insiders about the benefits of its MQB, you get a frown and no comment that I can publish. Mazda, however, seems to do it well and successfully. So successfully, in fact, that Toyota entered a long term partnership with Mazda in 2015. My sources consider this platform approach to be the best in Japan and hence probably in the world. The different departments (design, engineering, etc.) cooperate well, and their design team and concurrent engineering is highly regarded in the Japanese industry. My sources also tell me that Toyota wants to learn from Mazda about its common platform architecture for their own new **Toyota New Global Architecture** platform strategy. They also just announced that they will build a plant together in Alabama, USA. Unfortunately, not much detail is available on this Skyactiv platform yet in English.

14.3 Overall Impression

Figure 118: A small part of the plant. (Image Roser)

The Mazda Hiroshima Plant can produce 1,800 cars per day (plus another 2,200 in their other Japanese plants). Their assembly line is a total 1,800m long in two parts. The plant itself is actually quite big with 223 hectare in two locations. It is 7km from end to end.

The plant looked very clean and organized. Overall, I had a good impression from the plant. The material supply was also in good shape, although the ergonomics could be improved. The information flow was not so impressive, however.

14.4 Information Flow

Figure 119: Not at Mazda… (Image Roser)

There were no andon boards visible. The stations had a small monitor with some information on what to produce, but not an overview of the production numbers. Some stations also had stack lights with two colors. I saw some andon lines that could stop the line, but not everywhere.

The cars also had papers attached to them, but there seemed to be no common standard. Some cars had three sheets (A5 hanging from rearview mirror, and two A4 taped to the hood), while others had only two sheets, often in different locations. The sheets also had a different layout, and some of them even no layout at all but mere plain text.

The group size was one team leader for ten to fifteen workers, much larger than at Toyota with one on four, but comparable to Honda.

14.5 Material Flow

Figure 120: Mazda Skyactiv Body (Image Roser)

The overall layout of the line is in an S shape similar to most automotive assembly lines. Different from Toyota, however, there is only a small buffer of at most two cars between the bends of the line (see Evolution of Toyota Assembly Line Layout – A Visit to the Motomachi Plant in comparison). Depending on the type of assembly in the segment, the vehicle was moved on the ground on a movable platform, or hanging from overhead.

The assembly line is highly flexible, and able to handle different models on the same line. I saw, for example, a small convertible followed by a big wagon. The engine assembly line also has a very high reputation for its flexibility among insiders in the Japanese car industry, assembling four- and six-cylinder engines on the same line. They also avoid transfer machines and prefer universal machines.

The colors of the cars, however, seem to be grouped as there were always multiple cars of the same color in sequence (e.g., five white followed by six black, two blue, and two red cars, presumably to optimize the paint shop). Around 3,000 parts are assembled at this line into a complete car.

The takt time is pretty low with one car every 2:30 minutes (although other plants of Mazda produce up to one car every 1:30 minutes). The stations were 5.5 meter apart, which makes a speed of 2.2 meter per minute. Interestingly enough, the distance between the cars was not constant. Some cars were closer together, while others were farther apart. There was also one gap in the sequence of cars where one car was missing, which they could not really explain why.

Some of the material like the windshields and the dashboards popped up from a hole in the ground Just in Sequence next to the machine. Most of the material, however, moved along one side the line on a shelf on a dedicated AGV containing a kit matching the car to be produced. Some common materials like screws were also available on small carts moving back and forth at the work station.

14.6 Efficiency

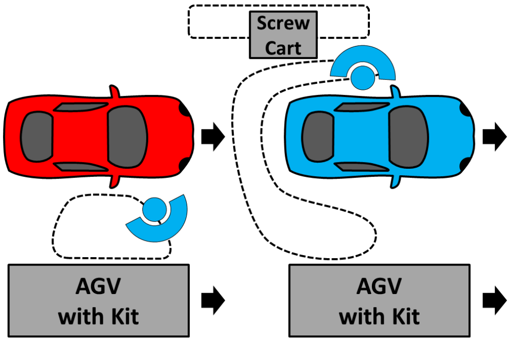


Figure 121: Mazda Material Supply AGV Kit with Screw Cart (Image Roser)

The material supply was not overly ergonomic. I saw lots of bending over and twisting to get the parts. There was not too much technical help in getting the parts. I saw a mechanical lift only for the dashboards. Workers were often walking to/from the AGVs or material supply. The AGV was only on one side, so the workers often had to cross the line to pick up parts. Nevertheless, the balancing of the line was good. Of the workers I observed, 60% were adding value when I looked. While this is below Toyota's 70% to 90%, it is better than Honda's 50%.

Also, while they displayed a magnetic device to pick up screws, I could not see it at any of their screw boxes in the line.

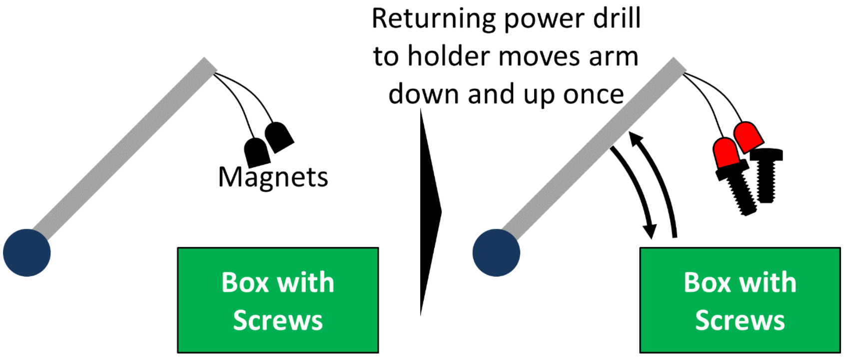


Figure 122: Only on display, not seen in use (Image Roser)

14.7 If you want to follow in my Footsteps

Figure 123: Mazda Hanging Car Logo (Image Roser)

Mazda has probably the best website for organizing a plant visit. All can be done online on their museum website, and registration and tours are offered in English. The groups are larger (in my case, around forty people), and you see the shop floor only from an elevated walkway. Nevertheless, very interesting. The tour starts at their head office in *3-1 Shinchi, Fuchu, Aki,* *Hiroshima Prefecture 735-0028, Japan*, and continues by bus into the plant. Many thanks to Mazda for offering this nice tour!

14.8 Summary

Mazda Hiroshima is a good plant, although not quite as impressive as Toyota. However, they seem to excel with their common Skyactiv platform strategy, so much in fact that Toyota wants to learn from them. I enjoyed the visit. **Now, go out, and organize your industry!**

15 The Grand Tour of Japanese Automotive – Suzuki

Christoph Roser, April 10, 2018, Original at https://www.allaboutlean.com/grand-tour-suzuki/

Figure 124: Suzuki Logo (Image Suzuki for editorial use)

The next stop on my Grand Tour of the Japanese Automotive Plants: **Suzuki**! On December 3, 2017, I visited their location in Hamamatsu. To be completely honest, I did not see the inside of their plants, but the excellent Suzuki Plaza still gave a lot of insight into their production system.

15.1 Introduction

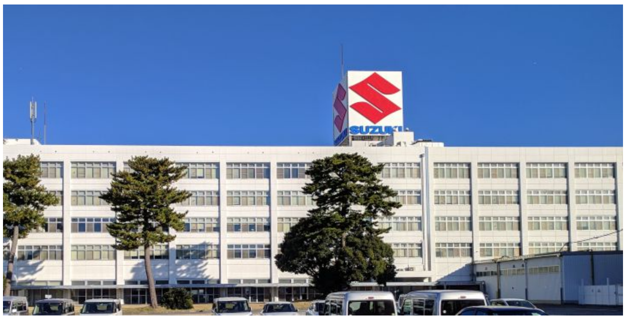


Figure 125: Suzuki Plant Hamamatsu (Image Roser)

The history of Suzuki is actually quite similar to the history of Toyota. Suzuki is one of the oldest companies on my grand tour, being founded in 1909. Like Toyota, the founder, Michio Suzuki, initially invented and produced looms before also starting to produce motor vehicles in 1937 (same year Toyota Motor was founded). They originate from Hamamatsu, which is also less than two hours drive from Toyota City.

While Toyota eventually also produced larger and more luxurious vehicles and started the Lexus brand, Suzuki is known for small and inexpensive cars. With almost 3 million vehicles produced in 2016, Suzuki is the eleventh-largest car maker in the world. Over half of these vehicles are produced in India, and only 800,000 in Japan. However, they are also well known for their motor bikes and outboard engines for boats.

They have six plants in Japan, all within an hour's drive of Hamamatsu. They also have multiple plants all over Asia, especially in India, and in Hungary. The group has a bit over 60,000 employees. Their profit margin is around 5%.

15.2 Suzuki Production System

With its production control system, Suzuki benefited enormously from being close to Toyota. In Japan, employees at automotive companies rarely if ever change to other automotive companies, and Suzuki has next to no former Toyota employees from which it could learn.

However, being located close to Toyota City, Suzuki and Toyota often use the same supplier. Toyota teaches its suppliers in the Toyota Production System, and through this indirect connection, Suzuki learned a lot about the Toyota Production System from its suppliers. Additionally, the current CEO of Suzuki worked briefly for Denso (part of the Toyota group) when he was younger.

Hence, Suzuki has a lot of experience in the Toyota Production System. Their Suzuki production system therefore also includes a lot of the important aspects of the Toyota system like Kanban, JIT, quality circles, leveling, and the elimination of waste.

Different from Toyota, however, Suzuki uses a performance-based wage system.

In terms of philosophy, Suzuki uses the word monozukuri more often and earlier than Toyota. They also work on eliminating the 3M's (Muda, Mura, Muri) and use the seven types of waste. They also like the 4M framework man, machine, material, method.

Specific to Suzuki is their policy on building cars, summed up in five words, or abbreviated in five Japanese characters 小少軽短美:

- **Smaller** (小 shou for small): Make factories smaller to eliminate wasted space.
- **Fewer** (少 shou for few): Less use of energy, movements, walking, and other wastes.
- **Lighter** (軽 kei for light): Save fuel by building lighter cars.
- **Shorter** (短 mijika for short): Minimal movement of goods and people.
- **Neater** (美 hi for beauty): Safe and clean work environment.

15.3 Production Efficiency

The Suzuki assembly line produces a car every sixty-five seconds, which allows 4.5 meters for each process before the next process has to start. Clearly, they are making short cars 🙂.

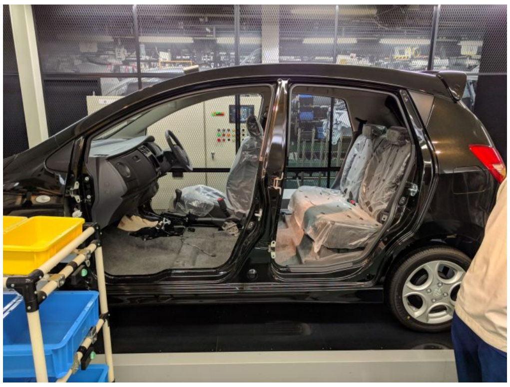


Figure 126: One seat to go… (Image Roser)

In terms of efficiency, Suzuki does not quite achieve the levels of Toyota. Production at Suzuki feels more labor intensive and involves lifting. For example, at Toyota all seats are usually installed using a mechanical lifting device.

At Suzuki, however, only the rear seat bench is added using a mechanical lift. Both front seats are added to the car by hand, requiring heavy lifting by the workers.

Figure 127: Suzuki Plaza showing how a seat moves between cars (Image Roser)

The mechanical lift for the rear seats is also not as smooth as the one at Toyota. The worker at Suzuki has to go through multiple motions and turns before the rear seat is in place, using more movements than at Toyota.

The front seats are delivered from one side of the line. Obviously, one seat has to go to the other side of the line to be installed from that side. Rather than delivering the seat over or under the line, they use a nifty device which pretty much shoots the seat between the gap of two cars.

Figure 128: Wheel installation (Image Roser)

Similar applies to the wheel installation. The wheel is provided to the worker in an upright position, but the worker has to lift it to the car, rather than using a mechanical lift. The worker then proceeds to add four screws by hand, screwing in the first few threads so that the screw does not fall out. Only then does a machine take over and screw the screws in all the way and tighten then.

Both the heavy lifting and the cumbersome adding of the screws is much better solved at Toyota, feeling much more efficient. At another station, a plastic door cover was hammered in place using nothing but a fist. While this may be fine once, doing this repetitively will hurt the worker's hand.

Overall, based from what I have seen, the worker is using his time productively only 40% of the time, with up to 60% of the time waiting, walking, and transporting. In comparison, a worker at Toyota is value adding 70% to 90% of the time.

15.4 Worker Satisfaction

Not all is well with the workers at Suzuki. According to the Japanese employer reference and review site Vorkers, Suzuki workers give their own company a pretty low ranking of 2.7 out of 5, which puts them at the bottom of the Japanese automotive industry, next to Mitsubishi with 2.66. In comparison, Toyota ranks best with 4.19.

With respect to overtime, they are the worst automotive company in Japan with an average of 39.7 hours of overtime per month. That is like one extra week per month overtime. Best is Mazda with only 22.4 hours overtime per month. Remember, this is Japan, where overtime is very common. Still, Suzuki does not seem to be an overly happy place compared to other car makers in Japan.

15.5 If You Want to Follow in My Footsteps …

The Suzuki Plaza is an excellent showcase of the process of making a car, from design to production. It also goes into the history of Suzuki, and (of course) has selected models on display. However, you need to reserve your visit through their Suzuki Plaza website, which unfortunately is available only in Japanese. Try using Google Translate if needed. The location of the plaza is 〒432-8062 Shizuoka Prefecture, Hamamatsu, Minami Ward, Zoracho, 1301.

Many thanks to Suzuki for their very nice museum. Anyway, on to the next Japanese car maker as part of the Grand Tour of Japanese Automotive Plants! In the meantime, **go out and organize your industry!**

16 The Grand Tour of Japanese Automotive – Subaru

Christoph Roser, April 17, 2018, Original at
https://www.allaboutlean.com/the-grand-tour-of-japanese-automotive-subaru/

SUBARU

Figure 129: Subaru Logo (Image Subaru for editorial use)

Subaru is the smallest of the Japanese car makers, with barely a million vehicles per year in 2016, which makes it the 23rd-largest vehicle maker in the world. Yet, since it produces almost exclusively four-wheel-drives, it is also the largest maker of four-wheel-drives. Despite its small size Subaru is highly profitable. During my grand tour of Japanese automotive, I visited Subaru in February 2018. Here are my findings.

16.1 Introduction

Figure 130: Pleiades, the stars of Subaru (Image NASA, ESA, AURA/Caltech, Palomar Observatory in public domain)

Subaru is actually a subdivision of Fuji Heavy Industries, only recently (2016) renamed to Subaru Corporation. They make all kinds of aircraft, vehicles (including Subaru), pumps, generators, wind turbines, and more. The group originates from the first aircraft maker in Japan, founded in 1918.

The name "Subaru" comes from the Japanese word *subaru* (昴) for the Pleiades star cluster. The constellation also inspired the logo of Subaru.

Figure 131: Subaru P1 (Image Roser)

They built their first car in 1954, the Subaru 1500, also known as P1. Nissan owned 20% of Subaru between 1968 and 1999. Hence, Subaru still uses a lot of Nissan suppliers.

General Motors took over the shares from Nissan between 1999 and 2005. Toyota started to buy shares of Subaru, currently owning 16.5% of Subaru. Together they developed the Toyota 86, sold as Subaru BRZ or Toyota 86 (GT86 and FT86).

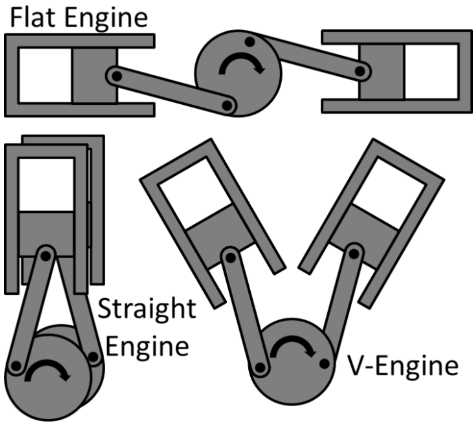


Figure 132: Combustion Engine Types (Image Roser)

Engineering wise, Subaru differs quite a bit from most other car makers. Since 1966 they have almost always used a flat engine instead of a straight engine or a V engine. This gives Subaru cars a quite low center of gravity. They also make the only flat-engine diesel in the world. Since 1972 they have also produced almost exclusively four-wheel-drives (what they call all-wheel-drive since all wheels are powered all the time). Many cars also have a gear box that can drive the wheels slower than the engine (a step-down gear), useful for very rough terrain.

The company is rather small for a car maker, but has found its niche with its technical aspects. Also surprising is that despite their small size, they are highly profitable, making 282 billion yen net income on 3,325 billion yen revenue, or over 8%. They also make most of the cars for the world market within their plants in Japan, rather than having a plant abroad. They only have one plant outside of Japan, in Lafayette, Indiana, USA.

16.2 Overall Impression

Figure 133: View of the Subaru Main Plant (Image Roser)

Most manufacturing at Subaru happens within a short radius around their main plant in Gunma Prefecture. They have a total of four plants within short driving distance: the main plant (Honkojo) along with the Yajima and North Plant for cars, and the Oizumi plant for engines. A one-hour drive away is the Kitamoto plant and a test and development center.

Overall, they seem to centralize most production close to their main plant, similar to Toyota in the past in Toyota City. Nowadays, however, Toyota has many more plants all over the world.

Nissan was recently in the news with a small scandal where the final inspection was done by workers that did not have the official government certificate to do the inspection. Less well known is that Subaru apparently did the very same thing.

The main plant itself was unimpressive. It is a typical automotive plant. While the floor was clean, there was a lot of dirt on all the overhead pipes and struts. The area where they tested the final cars had a distinct smell of exhaust gas, despite some ventilation system. Fine for me as a visitor, but not nice if you have to work there every day.

They did have, however, the longest shifts of any plant I visited. They work in two shifts, from 6:30–16:45 and 16:45–2:30. Hence there are over ten hours between the beginning and the end of the first shift. Despite their long hours, they have a four-hour gap at the dead of the night, allowing their employees to catch at least some sleep (similar to Toyota, but unlike Mazda or Nissan, where their workers are working at 4:00 a.m.). Similar to other Japanese automotive plants, they have a paltry 2% female workers.

16.3 Information Flow

Figure 134: Subaru BRZ, joint development with Toyota (Image Roser)

The information flow is not quite as good as I would like it to be. There were only a few small andon boards. Unlike many other plants, the worker also does not have the power to stop the line. If there is a problem at Toyota, they would pull the andon cord to stop the line. At Subaru, I have been told that if there is a problem, the worker has to make a call to a supervisor before the line gets shut down. I would guess that as a result, the workers are much more hesitant to escalate an issue, and more issues may simply be put down the line. Hence it is a bit surprising to me that Subaru enjoys a good reputation for quality.

The tour guide also was not quite sure what kanban are (although, as in many plants, the guide was a lady specializing more in PR than in engineering). As in most other plants, they use pick-by-light for kitting.

16.4 Material Flow

Figure 135: Subaru 4W Drive Train and Flat Engine (Image Roser)

The plant had a total of two assembly lines in the plant, with takt times of 62.4 and 70.8 seconds. I saw the faster one. With the material flow, I noticed that there is quite a bit more material at the sidelines of the assembly lines than at Toyota. I did some counting at the stamping shop, and saw about two days' worth of stamped side panels, which is okay.

They use mechanical lifting devices to lift tires up for assembly, but still use a hand tool to put in the bolts, which afterwards get tightened with an automatic tool. The flexible assembly line doesn't need batches and can make cars in any order. They did seem to optimize the color sequence, however, as I frequently saw two or three cars with the same color in sequence.

16.5 Efficiency

As usual I measured the efficiency of the assembly line workers by counting how many people were adding value when I saw them and how many did not. Here, Subaru turned out to be the bottom of the barrel when I observed them. Their door subassembly line workers used their time well only 42% of the time, and the final assembly was only marginally better with 46% of the time adding value. This is much lower than Toyota or Nissan, and is actually comparable to truck assembly lines with much slower takt times and much more custom-made products.

16.6 If You Want to Follow in My Footsteps

Figure 136: Subaru Exhibition Hall (Image Roser)

You can apply to their factory tours online through their website, but both the application and the tour is in Japanese. The visit is for their main plant at *1-1 Shoyacho, Ota, Gunma Prefecture 373-0822, Japan*. The tour shows you their exhibition hall with many Subaru models and its history.

The tour itself goes on overhead walkways through a part of the main assembly line. It also visits the stamping shop, which actually few other tours do, and the body welding. At the welding shop you get a very good view of the door welding process. I would like to thank Subaru for offering these free tours!

16.7 Summary

Overall, I enjoyed the visit, even though there seems to be much potential for improvement. This was the last car maker on the list of my grand tour of Japanese automotive during my sabbatical in winter 2017/18. But I will definitely visit more plants in the future, and maybe have an even closer look at Nissan, whose recent efficiency seems to outperform Toyota. I will definitely keep you posted if I learn more about Japanese car makers. I also hope that this grand tour was of interest to you, regardless if you make cars or not, and gave you some ideas or inspiration to **go out and organize your industry!**

17 Effect of Prioritization on Waiting Times

Christoph Roser, April 24, 2018, Original at https://www.allaboutlean.com/effect-of-prioritization-on-waiting-times/

Figure 137: Juggling Clocks (Image MaxPixel in public domain)

Prioritizing one part over others is an easy way to speed up the production of the prioritized part. However, if too many parts are prioritized, the performance of the others will suffer.

My general recommendation is to prioritize no more than 30% of your production volume. In this post I will look in more detail at this relation and verify this assumption (*TL;DR: this is correct!*). This post is based on a masters thesis by my student Yannic Jäger.

17.1 Introduction

Figure 138: Supermarket Checkout (Image Robert Kneschke with permission)

Imagine you are waiting at a supermarket checkout. Based on the number of people in front of you, you can make a reasonable guess on when it will be your turn. However, if another customer would have a gold member VIP card, he could cut in line and be the next person that is served. If there is only one VIP member cutting in in front of you, your initial estimate would still be reasonably good. However, the more VIP members there are, the longer the poor and unimportant Non-VIP customer have to wait. In this post I will show you these relations in more detail.

In my previous blog posts I have written extensively on how to prioritize, and how NOT to prioritize, production (or other) systems. Back then I recommended not prioritizing more than 20%–30% of the parts. The detailed data below will confirm this estimate.

17.2 Simulated System

To simulate the system, we used a simple one-process system. By adjusting the random arrival time and the random service time, we tested different utilizations between 75% (low utilization) to 95% (very busy system). We did not test 100%, because this would cause an infinite queue. The system processed two types of parts, simply called A and B. Both parts had the same randomly distributed processing time. For simplicity's sake, we had a lot size of one and no set up times, breakdowns, or other disturbances.

Our system was set up for an exponentially distributed inter-arrival time with an average inter-arrival time of 6 minutes, or an arrival takt of 10 pieces per hour.

The processing rate is log-normal distributed, varied, with simulated values of 13.33; 12.50; 11.76; 11.11; and 10.35, giving an utilization 0f 75%; 80%, 85%, 90%, and 95% respectively. The standard deviation of the log-normal distribution was set up so that the coefficient of variation (standard deviation divided by the mean) was always 25%.

17.3 First-Come-First-Served Base System

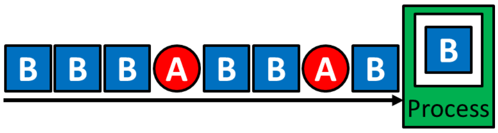


Figure 139: Baseline Example System without prioritization (Image Roser)

As a baseline, we simulated the system with only one part, and with two parts without any prioritization. All parts were processed on a first-come-first-served basis. It makes no difference if you have only one part or if you have two parts without any prioritization, the system behaves identical. The only factors influencing the average waiting time are the relation between the total arrival rate and the total departure rate, which create different utilizations.

The average waiting time is shown below. As expected, it is an exponential relation. The higher the utilization, the longer the average waiting time. The average waiting time would go to infinity at 100% utilization (see also the Kingman formula here). It makes no difference if there is only one part type or two different part types, or if the percentage is A or B, as long as there is no prioritization and the total average arrival rate is 10 parts per hour.

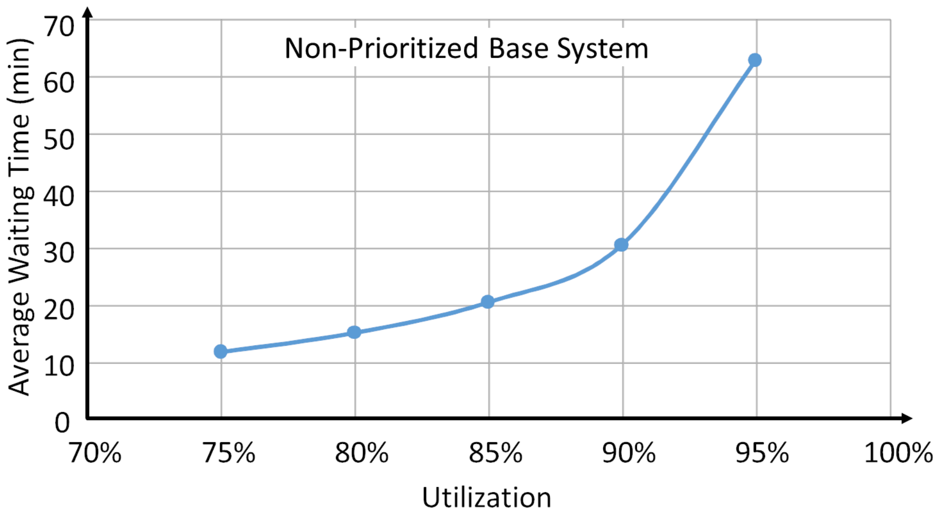


Figure 140: Average waiting time of non-prioritized parts (Image Roser)

17.4 Prioritized System

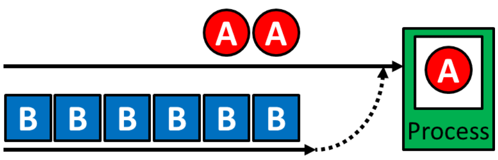


Figure 141: System with prioritization (Image Roser)

Of course, we want to know the effect of prioritization. Hence, we now prioritize our parts. Parts of type A and B are waiting in separate queues. If there is one or more part A waiting, it always takes priority over any part B. Within the A queue and the B queue, we maintain FIFO respectively, although this would not influence our results.

We varied the percentage A using values of 0.1%; 10%; 20%; 30%; 40%; 50%; 60%; 70%; 80%; 90%; and 99.9%, spanning pretty much the entire range between almost no part A, and almost only part A.

17.5 Resulting Waiting Time

Below are the results for different percentages of prioritized parts A and different utilizations. You can also see the baseline of a non-prioritized system of similar utilization and overall arrivals and departures. This baseline would also be the weighted average of the average waiting time of A and B together.

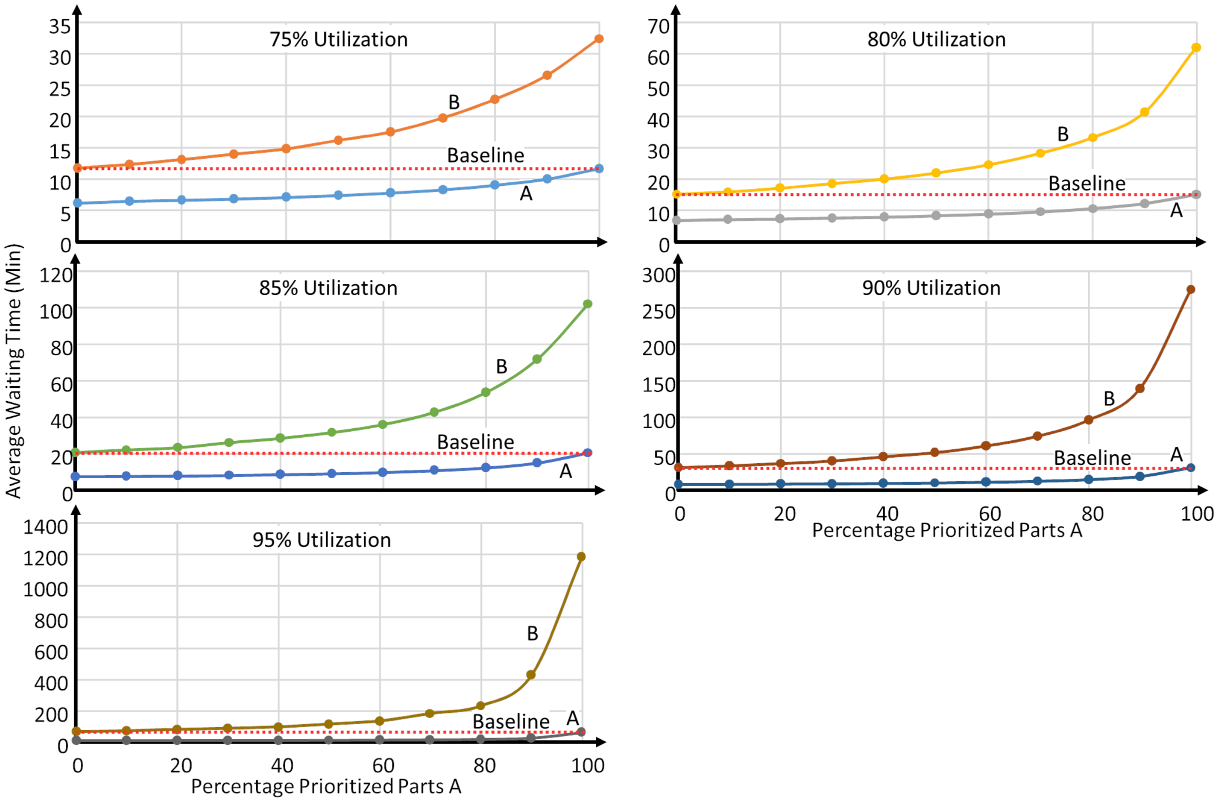


Figure 142: Average waiting time of different prioritized systems (Image Roser)

The baseline always goes through the waiting time of 0.01% A parts (i.e., 99.9% B parts) and 99.9% A parts, as these are effectively only-B and only-A parts, and should behave like the unprioritized system.

Looking at the graphs above, you can see that having a few prioritized A parts will be beneficial for the A parts, without much drawback for the B parts. For example, up to 30% A parts, the A parts will pass through the system much faster, but slowing down the B parts only marginally.

However, as you increase the percentage of prioritized parts, the benefit will be less and less, until there is no longer any benefit to the A parts. But at the same time, there is a huge disadvantage and punishment for the B parts. If you prioritize, for example, 90% of the A parts, they behave very similar to the baseline system. However, the B parts are punished harshly.

17.6 Resulting Percentage Improvement over Unprioritized System

The effects can be seen very clearly in the graphs below, shown for different utilizations. The waiting time of the prioritized part A can be reduced to 13%–50% of the original system depending on the utilization. However, as you prioritize more parts, the effect becomes less and less, although even 70% prioritized A parts is still a significant improvement over the average.

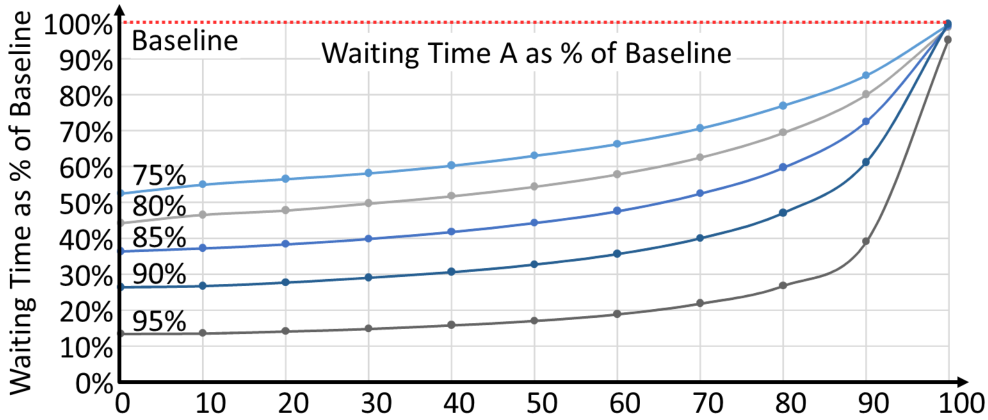


Figure 143: Reduction in waiting time for prioritized part (Image Roser)

The real kicker and the reason why I recommend not prioritizing more than 30% of your parts is the behavior of the B parts. This is shown below for different utilizations. If only a few A parts are prioritized, the waiting time of the B parts is increased only slightly. For example, with 30% A parts prioritized, the waiting time of B increases 20%–30%. Not ideal, but manageable.

However, the waiting time increases exponentially. With 60% prioritized A parts, the waiting time of B doubles. For even more prioritized A parts, the waiting time increases to 300%–1800%, which is very likely to dissatisfy a customer waiting for parts.

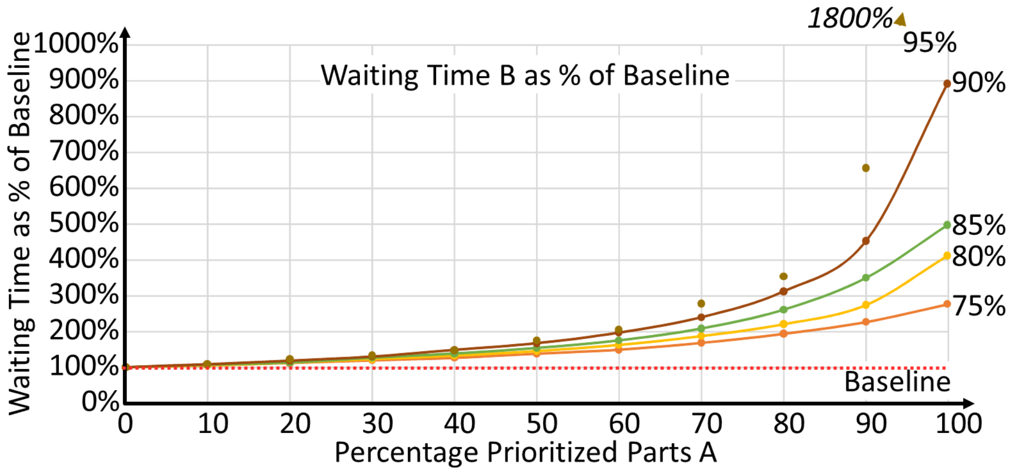


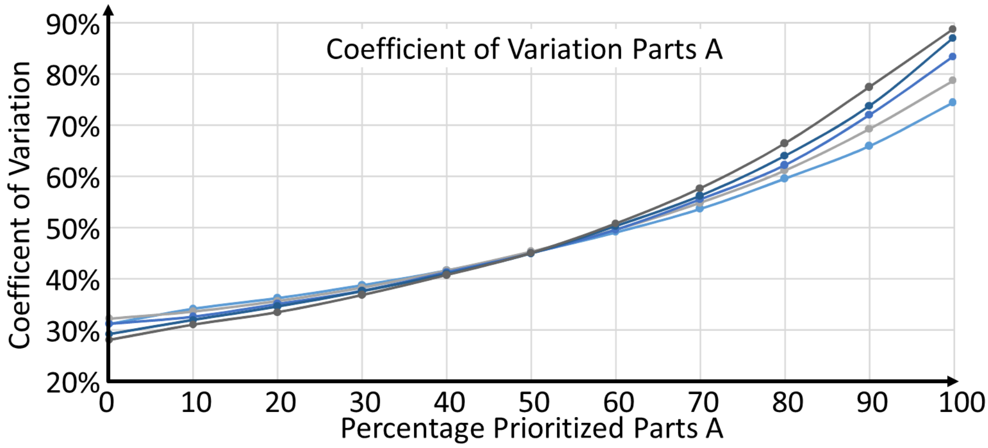
Figure 144: Increase in waiting time for non-prioritized part (Image Roser)

17.7 Coefficient of Variation of the Waiting Time

Another aspect worth looking at is the coefficient of variation in the waiting time (calculated as the standard deviation of the waiting time divided by the mean waiting time). These coefficients of variations are shown below for parts A and B depending for different prioritizations. The graph also shows the different utilizations as different lines, although these have little influence here.

Interesting is that with increasing prioritization, the coefficient of variation goes up. This means that **the standard deviation is increasing more than the mean!** From the point of view of the production planner, this is a very bad thing. A good production planner can handle longer lead times by including this in his planning schedule. However, if the standard deviation increases faster than the mean, it becomes more difficult to plan. The parts may be finished much earlier than planned, or much later than planned.

This means that being prepared for a frequent excessive delay over the average, you need to put the material in stock (if it is made-to-stock), or promise a much later delivery time (if it is made-to-order), or otherwise apologize profusely to the customer and feel the wrath of your boss because the delivery performance suffers (for both MTO and MTS)



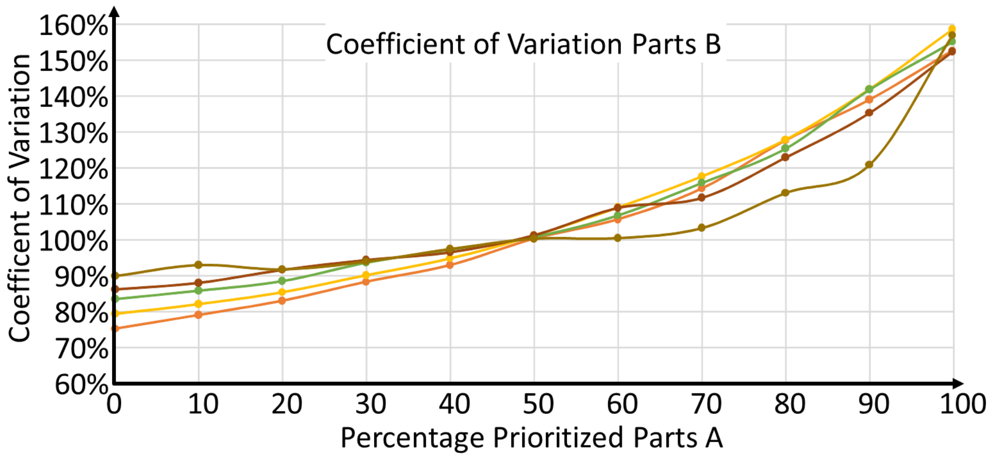


Figure 145: Coefficient of variation of waiting time (Image Roser)

In sum, not only does your waiting time increase, but the fluctuations increase even more, resulting in stock increases, late deliveries, low delivery performance, and unhappy bosses and customers.

17.8 Lesson Learned

Figure 146: HOT HOT HOT … (Image Olaf Speier with permission)

Overall, it remains important to not prioritize too many parts. While the intent of accelerating the important parts is understandable, the benefit decreases with increasing prioritization. At the same time, the "*unimportant*" parts get more and more punished, and their waiting time increases exponentially. At one point these "*unimportant*" parts will become important again due to their very long lead times. Now, **everything is important** (and your boss doesn't want to hear that this also means that nothing is really important). The production planner feels like he is getting an endless stream of hot potatoes that are needed right away, while the system does not have the capacity. At the same time, the **planability goes down as the fluctuations increase!**

Therefore, folks, please do not prioritize more than 30% of your production! This maintains a benefit for the prioritized parts, without damaging the not-so-important parts, while keeping fluctuations manageable (or at least not much worse than the initial system. **Now, go out, prioritize smartly, and organize your industry!**

17.9 Source

Jäger, Yannic. 2017. "*Einfluss von Priorisierung auf das Verhalten eines Produktionssystems.*" Master Thesis, Karlsruhe, Germany: Karlsruhe University of Applied Sciences.

18 Leading with Confidence

Christoph Roser, May 01, 2018, Original at [*https://www.allaboutlean.com/leading-with-confidence/*](https://www.allaboutlean.com/leading-with-confidence/)

Figure 147: A confident manager (Image Ashrafhage under the CC-BY-SA 3.0 license)

A lot about leadership is confidence. Yet confidence does not always come naturally, but has to be worked on. In fact, a leader that is always confident is scary to me. Let me give you my thoughts on confidence in leadership.

18.1 Having Confidence in Yourself

Figure 148: Man hits thumb with hammer (Image Osterland with permission)

In leadership, confidence is important. You need confidence in yourself that you are doing the right thing. However, this is no easy thing to do. It would be easy if the decisions you have to make were clear and obvious. Most people can answer the question "*Shall I hit my thumb intentionally with a hammer?*" with a confident "*No!*"

However, the more uncertainty you face, the lower your confidence will be. Most leadership functions involve some uncertainty. In fact, the higher up you are in hierarchy, the more uncertainty you have in your decision making. "*Shall I build the new plant in location A or B?*" or "*Which product should I invest my resources in?*" have no clear answers.

As a result, a decision you make can end up being wrong. As a leader, this risk usually cannot be avoided. If your leadership position would not have this uncertainty and the difficulty in making decisions, you could be replaced with someone with less education, experience, and – most importantly – less salary 8-O.

If you feel that you sometimes lack confidence in your decisions, don't worry; that is common. Most managers regularly face self-doubt when making decisions. That is a completely normal behavior. **You are not the only one who worries!**

You need to trust your abilities and experience. Hopefully, you are in a position where you know the product and the business and have related experience. At least one person believed enough in you to put you in this position in the first place. This person probably also had some uncertainties in making this decision, but (hopefully) he keeps these uncertainties to himself to make your life not more difficult than it already is.

18.2 Fake It Till You Make It

Figure 149: Superhero Boy with Cape (Image Chris & Karen Highland under the CC-BY-SA 2.0 license)

When facing self-doubt, some people go down the wrong path and feed this doubt. They let these worries nag at their confidence, reducing the confidence until it is gone. Don't make that mistake. Realize that your decision has uncertainties, and while you can always try to get more information, at one point **you have to make a decision despite the uncertainty!**

Knowing that, instead of fueling your doubts, you have to reduce them. To a certain degree, confidence can be faked. You have to fake it till you make it. Pretending to be confident will lift your spirits and your confidence.

18.3 Spread Confidence

Appearing confident is also necessary for a leader. The people you manage have the same insecurities as you, sometimes even more. If their leader is doubting himself all the time, then their own doubts will increase. Hence it is necessary to (mostly) maintain an appearance of confidence toward your people, even if you have some doubts. Certainly do not exaggerate the doubts you have toward your people. After all, that is what your boss (presumably) does too.

At the same time, you must not overdo it. I have had leaders myself that tried to sell me a total shit-show as the best thing since sliced bread. This, in turn, damaged my view of the leadership. Hence, overall you have to **find some middle ground between overconfidence and constant worries when facing your people!**

18.4 The Risk of Overconfidence

Maybe you have come across a leader who was always fully confident in his own abilities and decisions. That is scary! People that are always confident often have no clue what they are talking about. This effect even has its own name, the Dunning-Kruger effect, named after David Dunning and Justin Kruger and their study in 1999.

The less someone knows about a topic, the less he knows about the myriad of things that can go wrong, and hence the more he believes in his own abilities. Similarly, a very skilled person can see all the potential troubles, and therefore underestimate his ability to perform. Low-ability people do not realize their incompetence, whereas high-ability people think that others surely must know this too, and hence can do it too.

This Dunning-Kruger effect has been tested widely on things like the skill in reading, driving, medicine, tennis, chess, and more. Interestingly, while the effect is strong in North America, it is nonexistent or even reverse in Japan, where everybody is expected to fail unless they don't.

18.5 Psychopaths in Leadership

Figure 150: Manager with Knife (Image ajr_images with permission)

Psychopathy is a personality disorder that shows lack of empathy, impulsivity and poor risk assessment, and boldness with high self-confidence. Hence, a psychopath rarely doubts his own decisions.

Psychopaths are much more common in management than in the normal population. About 1% of the population are psychopaths, but between 3% and 10% of managers had clinically significant psychopathy. (Another frequently cited study with 21% psychopaths in leadership was retracted after publication, see below for source). While 10% does not mean that every manager is a psychopath as some sensationalist news put it, it is a significant number.

Psychopaths may be attracted to management as they seek power and influence, but their ability to appear confident often helps them to get promoted to higher positions, where they then wreak havoc on the performance of the company. Please do not turn into a psychopath. However, appearing confident will not only help with your leadership but also with your career.

18.6 Having Confidence in Others

Figure 151: Trust your people. (Image Traimak with permission)

Having confidence yourself is difficult enough (unless you are a psychopath). It is even more difficult if the people around you constantly question your decisions and increase insecurity and doubt. Hence, you yourself can do your part by trusting your people. In many cases, your people know their area of work better than you do, and hence can make better decisions.

Will it always be the right decision? Surely not, as they also have to work with their uncertainty. But you can help them by trusting them, in particular the experienced employees with a proven track record. If it is a newbie with no experience, feel free to question and probe his decisions, but do not make life tougher than it already is for people who know what they do.

Hence, know that making decisions involves uncertainty, and that you have to consider this when making a decision. But do not mull over your own insecurities; instead, try to appear confident to others and try to support others in their confidence. **Now, go out, lead with confidence, and organize your industry!**

18.7 Source of the RETRACTED article

Nathan Brooks & Katarina Fritzon: **RETRACTED ARTICLE**: *Psychopathic personality characteristics amongst high functioning populations*, Crime Psychology Review Vol. 2 No. 11 Pages 22-44, 2016.

19 How to Do Brainstorming

Christoph Roser, May 08, 2018, Original at https://www.allaboutlean.com/how-to-do-brainstorming/

Figure 152: Brainstorming (Image alotofpeople with permission)

A lot of lean is about problem solving, and most of these problems are complex and difficult. Otherwise, someone would have solved them already. Hence, I would like to introduce you to different creativity techniques for problem solving. Most of them can be used in groups to access the collective wisdom and creativity. Most of them are also suitable to develop a number of alternative solutions, of which you can pick the best ones (see my previous post on Japanese Multidimensional Problem Solving). Many of them can be combined in sequence. Let me start with the most common one, brainstorming:

19.1 Applicable Problems

Figure 153: Problem (Image carballo with permission)

Brainstorming is a simple technique. It can generate a large number of ideas but is best suited for less-difficult issues. If you need a detailed analysis and lots of data to generate ideas, brainstorming will be less suitable. For example, it would be more difficult (but not impossible) to brainstorm what stocks to invest, since you may need lots of fundamental data to aid this decision. I like to use brainstorming as an opening creativity technique, to be followed up by more-advanced creativity techniques later on.

19.2 Preparation for Brainstorming

Figure 154: Your Brainstorming Team (Image Flamingo Images with permission)

To prepare for brainstorming, you would need a group of people, ideally at least three and no more than ten. If there are more than ten, chances are that some won't participate but remain quiet and in the background. Naturally, the group should be people with at least some experience with the problem, not just some random people you drag off the street. Older and experienced people are valuable, since they obviously know a lot about the problem. However, younger ones with less experience are also valuable, since they don't know yet all the things that "*obviously don't work.*" They are more ready to challenge conventional wisdom.

Figure 155: Teamwork (Image seanlockephotography with permission)

It also helps if the group gets along well and is comfortable with each other. If you need to include different levels of hierarchy, try to make the span not too wide. Workers are most comfortable and open with other workers, a bit less so with their boss, and even less so with their boss's boss, and so on. Ideally, you also include people from different functions. There could be people who have to work with the problem on a daily basis (e.g., the machine operators or foremen). There could be people who set up the system (maintenance or production planning). There could be people who are affected by the problem (e.g., logistics). Try to get a diverse group. All of this, of course, also applies to a workshop team in general, as brainstorming is only one of the first steps of problem solving, and ideally there is a consistent team throughout the problem-solving process.

As for equipment, you would need a pin board and cards, or alternatively large Post-its. You need these to write down the ideas. They have to be movable so participants can write on the board directly, and you can later arrange the ideas into groups. A flip chart can be helpful, but a flip chart alone is not enough.

19.3 The Brainstorming

Figure 156: Lets get creative… (Image denisismagilov with permission)

Assuming you have introduced the team already, you would need to introduce the problem. This can be verbal or with a slide or two. Don't overdo it with the slides! The participants need to know what problem needs to be addressed. The group can optionally help to rephrase the question. At the end, you need to have one (!) question that the group needs to brainstorm ideas for.

The moderator then starts the actual brainstorming process, and the group generates ideas. These ideas are written on the cards (or large Post-its), either by the participant or by the moderator, and attached to the board. Here we have a few options:

- Having the participants give the ideas verbally with the moderator writing them down works well for groups that get along with each other.
- Having the participants write multiple ideas on cards before they are collected by moderator to read aloud can help with groups that span multiple hierarchies or that have other conflicts.
- Asking in sequence around the table, with each participant giving one idea before the next participant gives an idea (with the option to skip if there is no idea), is also possible. This

can be written down by the moderator or the participant. The advantage is that even the quieter participants are encouraged to contribute. It also makes it a bit harder for people to be passive, as everybody is asked to create ideas.

The cards should be large enough that the participants can read all of them all the time (as this assists the idea generation process). This idea generation should go on as long as the ideas are flowing, often around fifteen minutes. The moderator can assist by asking some questions (e.g., can it be rearranged, transformed, replaced, combined, etc.?)

Figure 157: Creative Brain (Image kirasolly with permission)

In a next step, the cards are arranged into groups. In all likelihood, there may be quite a few similar ideas. The moderator arranges these while interacting with the participants ("*Would this fit here?*", "*That seems to be similar to this…,*" etc.). If the participants have additional ideas based on this discussion, they should of course be included. Eventually there should be a number of different solution approaches on the board. These should be given meaningful headers by the group that the moderator adds to the board. These headers are the basis for the subsequent problem-solving process that may include a ranking of the ideas (feasible or less feasible) and further refinement.

19.4 Brainstorming Rules

Figure 158: Creative Ideas (Image afxhome with permission)

There are a few points that are very important for a successful brainstorming session.

- **Quantity over quality**: The goal is to generate lots of ideas. Evaluating them will come later.
- **Encourage crazy ideas**: Do not under any circumstances talk down an idea as crazy or foolish. Stop any of the participants in their tracks if they down-talk the idea of others. A lot of inventions and solutions come from ideas that were crazy and outlandish ("Heavier than air flight? What nonsense. What's next? Strap someone to a canister full of combustible fuel and shoot them into space?"). Absolutely and positively encourage crazy ideas. It is much better to sort them out later than to never have a crazy but good idea in the first place. Even if the crazy idea does not work, it may give inspiration to another participant for a related but more feasible idea.
- **No evaluation during idea generation**: Related to the previous bullet point, do not judge or evaluate ideas during the creation. This would stifle the creativity and can potentially make participants hesitate to contribute for fear of embarrassment by their peers (or the moderator).
- **Ideas over people**: Especially with groups including leadership, there is a risk that "the top guy is always right" ("Yes-men"). Try to encourage creativity beyond merely agreeing with the top guy in the room. Furthermore, also especially with leadership, participants have the need to get credit for their ideas to get ahead for the next promotion. It is perfectly

okay to take someone else's idea and improve it. Try to prevent wasting time on the ownership of ideas, and rather put it into creating more ideas.

19.5 Summary

Figure 159: Problem & Solution (Image Kenishirotie with permission)

Overall, brainstorming is a tried-and-true technique to start idea generation for not overly complex problems. It is a good first creativity technique, to be augmented by other creativity techniques later on (see subsequent posts). As brainstorming is common, however, there is the risk of ambivalence or boredom by the participants to do "*this stuff again,*" especially if previous brainstorming sessions may have been less well moderated. Yet in my view, brainstorming is a useful technique and can be used for many (not all) problems. Next week I will write more about other creativity techniques. In the meantime**, go out, tickle the gray cells in your brain and the brains of your people, and organize your industry!**

20 Fishbone Diagrams and Mind Maps

Christoph Roser, May 15, 2018, Original at [*https://www.allaboutlean.com/fishbone-diagrams-and-mind-maps/*](https://www.allaboutlean.com/fishbone-diagrams-and-mind-maps/)

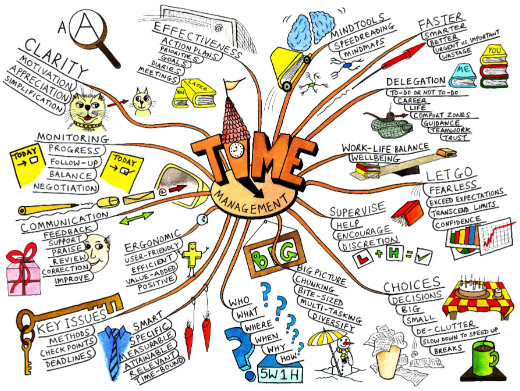


Figure 160: Mind Map (Image jean-louis Zimmermann under the CC-BY 2.0 license)

A lot of lean problem solving requires creativity. There are many creativity techniques available to help generate ideas for problem solving. In my last post I presented brainstorming, which is a freewheeling creativity technique. In this post I will show you some creativity techniques that have a more structured approach. These include mind maps and fishbone diagrams. Both can be used in groups, but they are also helpful if you need to tackle problems on your own.

20.1 Fishbone Diagrams

Figure 161: Where the idea comes from… (Image Lamiot under the CC-BY-SA 4.0 license)

Let's start with fishbone diagrams (also known as Ishikawa diagrams, if you prefer Japanese, although this is only the name of Kaoru Ishikawa and not a Japanese word).

You can do this on your own or in a larger group. If you use a group, you should have a diverse group including different functions (see my post on brainstorming). If your group spans different levels of hierarchy or if there are conflicts among the team members, you may choose to have them write cards or give ideas in turn to mitigate the internal conflict.

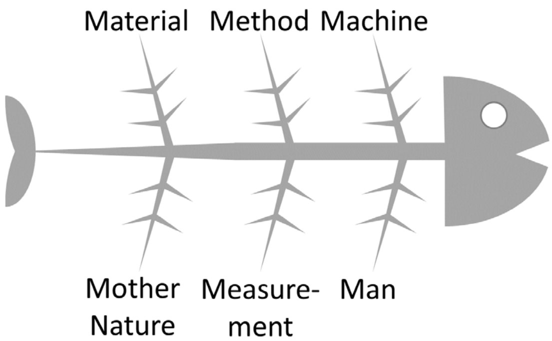


Figure 162: A basic Fishbone Diagram (Image Roser)

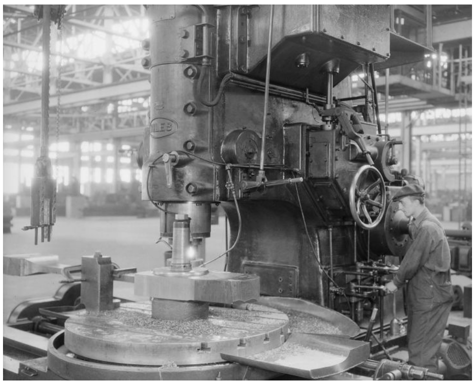


Figure 163: Man, Machine, Material, Method (Image Lewis Hine in public domain)

You start with the problem, which would be the head of the fish. Starting from the head of the fish, you draw different bones, one for each category of issues that could affect the problem. There are quite a few options for these bones. Most common is *man, machine, material, method* (also known as 4M). But there are quite a few additional options:

- **Man, Machine, Material, Method**: Also known as 4M. The most common one.
- **Man, Machine, Material, Method, Management, Milieu (Mother Nature), Measurement, Money**: Also known as 8M, an expansion of the 4M. Various combinations exists for 5M or similar.
- **Product (Service), Price, Place, Promotion, People/Personnel, Process, Physical Evidence**: Another possible structure. This one is less focused on manufacturing and more focused on people and supply chain. Depending on your problem, you may not use all of the branches.
- **Surroundings, System, Supplier, Skills, Safety**: Yet another structure, again you may choose which ones you pick. This is also less focused on manufacturing and more on (inbound) logistics.

However, these are only suggestions. I have seen plenty of good fishbones not using any of these standard bones. **The label on the bones has to make sense for your problem, and does not need to conform to the above structures!**

Anyway, with this fishbone diagram, you create a structure using the different bones. Next, the group (or only you if you are on your own) try to find things that affect the problem through the different bones. This can be either in sequence, or you just add ideas as they pop into your mind. The overall approach is not that different from brainstorming, except for the underlying structure.

After generating ideas, you hopefully have a better picture of the cause of the problem. Next, you can sort these causes based on their significance and develop approaches to solve your problem.

20.2 Mind Map

You may have heard about this technique too. In a mind map, you try to structure your thoughts around a problem. This can also be done in a group, although I most commonly use this approach if I work on a problem on my own.

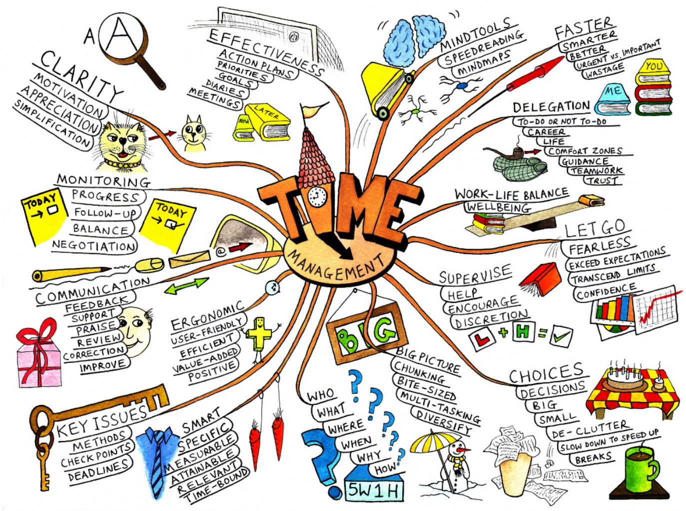


Figure 164: Mind Map (Image jean-louis Zimmermann under the CC-BY 2.0 license)

In the center of a large sheet of paper (on your own A4 [A3 is even better], flipchart, or whiteboard for larger groups), write down the problem you want to solve. Starting from this central problem, create branches in all directions based on thoughts and ideas you have about that problem. With the fishbone diagrams above, you used a predefined structure (4M, 8M, and so on). Now you have complete freedom about the structure. The branches and sub-branches don't have to be general, but can be specific to your problem. There is software available for digital mind maps, but in my experience a paper-based mind map is usually much richer and more creative.

Figure 165: Drawing a Mind Map (Image AndreyPopov with permission)

To use a private-life example, when buying a house you could have "*location,*" "*price,*" "*parking,*" "*floor space,*" and so on. The branches can have sub-branches, sub-sub-branches, and so on. They could even loop together and form a connection with other branches again. When I am doing my own mind maps, I also like to use not only text but also draw doodles and use colors and highlighters to emphasize and visualize my ideas.

After a mind map is sufficiently developed, it is again time to step back and start evaluating the ideas. Similar to brainstorming, do not under any circumstances evaluate ideas beforehand. Also prevent others from talking down the ideas. In almost any creativity technique, it is necessary to separate the idea generation from the idea evaluation.

20.3 Brainstorming Variants

There are also a few brainstorming variants. These provide a more formal approach while still following the basic idea of brainstorming. Personally, I find these a bit restrictive and overly formalized, and prefer the classical brainstorming over these forced variants.

20.4 6-3-5 Technique

Figure 166: 6-3-5 sheet (full resolution available at https://www.allaboutlean.com/wp-content/uploads/2018/05/6-3-5-Sheet.png) (Image Roser)

The 6-3-5 technique is based on six people giving three ideas within five minutes on a sheet of paper before giving their sheet of paper to the next person and receiving a sheet from the previous person. In the next five minutes, they add three more ideas or expand on the three (or more) ideas above from the previous person. After thirty minutes, (six people with five minutes each), there should be 108 ideas on the paper.

You would need a preprinted sheet having three columns (for the three ideas) and six rows (one for each person). While the original method stipulates six people, it also works with slightly more or less than six. The original brainstorming rules still apply, and you should explicitly allow crazy ideas.

20.5 Fast Networking

Figure 167: Groups Of People (Image kjpargeter with permission)

Another approach called fast networking is basically multiple brainstorming sessions in parallel, addressing different sub-problems of a larger and more complex problem. It is useful for complex problems that can be split into sub-problems, and also allows more people to join. Each subgroup includes three to five people, works for around five minutes on their sub-problem, and another five minutes on structuring and grouping of the possible solutions. Finally, the teams are presenting the results back to the main group, getting feedback and more ideas from the main group.

A very similar approach called "**Gallery Walk**" uses the approach of *fast networking*, but rotates the groups through the different problems. The rotation can be faster than with the *fast networking*, and teams can rotate every three minutes.

20.6 Summary

Overall, I find brainstorming very useful for me on my own, and the fishbones better for larger groups. The brainstorming variants are not that useful for me, but maybe you like it. The choice of a creativity technique is personal for each moderator, and some moderators prefer one while others prefer others. There are more techniques available, some of which I will present to you in the next post, where the moderator improves creativity by altering the initial question. This will include one of my favorites, creative provocation. In the meantime, **map your mind, and organize your industry!**

21 Creative Provocation, Reverse Brainstorming, and Analogy

Christoph Roser, May 22, 2018, Original at https://www.allaboutlean.com/creative-provocation-and-others/

Figure 168: Crazy Office People (Image Poznyakov with permission)

After showing you the details of a few basic creativity techniques, I now get to my most favorite one: creative provocation! It is a bit more advanced, but I had huge successes with this one. It is part of a group of techniques that alter the initial question to foster more creativity. I will also show you reverse brainstorming.

21.1 Reverse Brainstorming

Figure 169: The view is different upside down… (Image Eden, Janine and Jim under the CC-BY 2.0 license)

The reverse brainstorming technique simply inverts the initial question. Instead of asking how to solve a problem, ask how to make it worse. For example, if your goal is to reduce costs, ask how to increase costs. The fundamental approach is similar to brainstorming. However, there are a few important differences:

1: This should not be the first creativity technique you use. I find it best to start with a normal brainstorming, and then in a second round use reverse brainstorming to create a bit more creativity.

2: Some guidebooks recommend around sixty minutes for this topic, but in my experience that is much too long. I have used this technique a few times, and my feeling was always that this is fine for a few minutes, but if you do it too long, the mood in the group will sour, and they may grumble about wasting time on making things worse. They are right. Do this reverse brainstorming only briefly! The goal is not to have lots of ideas on how to make things worse, but rather to get some more ideas for improvement while thinking about what could make it worse. It is hard to give an exact time recommendation, as I usually watch the mood of the group and end the technique before they get unhappy. Sometimes this is after five minutes, sometimes after fifteen. But these five to fifteen minutes are helpful for getting the group out of conventional thinking and helps them be more creative.

Figure 170: Glowing Brain (Image raspirator with permission)

3: This should also not be the last technique. Reverse brainstorming helps to freshen up the mind, and this should be utilized in another round of creativity techniques. My preference here is the creative provocation (see below).

Organizationally, this reverse brainstorming is similar to brainstorming but shorter. The (reversed) question is stated, and ideas are collected for a few minutes. You may have to overcome some resistance in the group, as this is (quite obviously) the wrong direction. It helps to explain why you are doing this, that this is only a short interval, and that soon the question will go into the right direction again. Again, keep this short, and soon thereafter revert the question back to the normal one and ask if any of these "negative" ideas can also be reversed into positive ideas.

21.2 Analogy

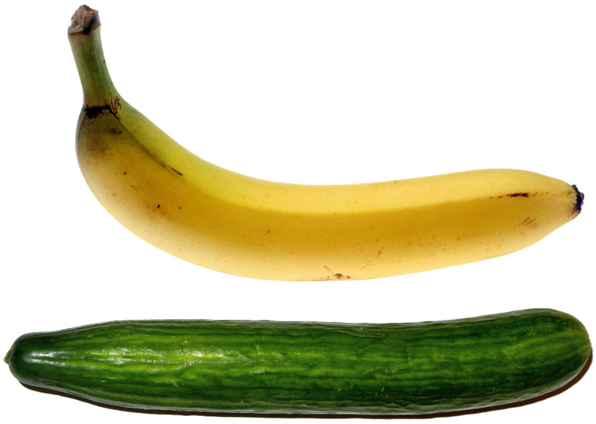


Figure 171: Banana and Cucumber (Images Renee Comet and WiseMan42 in public domain)

Another technique that rephrases the question is the analogy. The original question is used, and changed into a similar question in a different area. For example, if you plan to select a new site for a plant, you could use a similar question for a new town to move to for a new job. Many of the possible answers would be similar or overlapping. Or, if you develop a new product, use a similar product as an analogy.

This method succeeds and fails with the quality of the analogy. Hence, invest some time beforehand thinking about possible analogies. If you do not have a good analogy, try to avoid this method. Even if you have a good analogy, do not invest too much time into this method. Similar to reverse brainstorming, this technique is best used sandwiched between two other techniques (e.g., normal brainstorming and creative provocation). Its biggest benefit is to move the mind off the normal beaten paths, and it allows the participants to explore new ideas. In all likelihood, it is not one participant who will create a completely new idea based from this analogy, but that one participant has an analogy idea that inspires another participant to an idea for the original problem.

21.3 Creative Provocation

Figure 172: Stressed Worker (Image Wayhome Studio with permission)

Finally, we get to my all-time favorite creativity technique: creative provocation! This is an advanced technique, especially for the moderator. It requires full attention of the moderator for success. While you can do normal brainstorming easily while being hungover, jet-lagged, or having a toothache, creative provocation requires your full attention and at least some understanding of the problem at hand. Furthermore, this technique must follow another creativity technique. It can be the last one in a series of creativity exercises, although there should be eventually another round for final solution afterward.

Based on a previous creativity technique, the moderator has to understand what holds the team back. In this creative provocation, this problem is then explicitly forbidden and excluded from the question. A core element of the solutions so far is no longer permissible. The challenge for the moderator is which part to forbid.

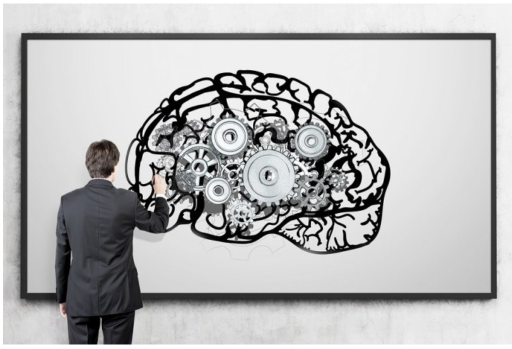


Figure 173: Brainpower! (Image ismagilov with permission)

For example, I had a workshop where we designed the layout of an assembly line. The team had the problem of how to return the work-piece carrier back to the beginning of the line. In this creative provocation, I explicitly gave them the challenge that they are not allowed to use any work-piece carriers. This resulted in some grumbling from the team, but eventually they got to work. And – lo and behold – this resulted in a solution that the team was very proud of. The final solution included a lot of the ideas from this round, and also no longer had a work-piece carrier.

Another example was the shop floor layout, where the team had constant problems with the two-way roads taking up too much space. The creative provocation was to limit the team to one-way roads for this section of the factory. Again, the team grumbled, but soldiered on and found a solution. The final solution incorporated the one-way roads, and the team was ecstatic about this solution. One seasoned lean expert told me that this was the best-moderated workshop he ever had participated in (Thank you, Martin!!!).

After the creative provocation, you relax the constraints again and again allow the use of the part you forbade for the creative provocation. This creative provocation can be repeated with different constraints depending on the need for the workshop.

21.4 Buzzword Lists

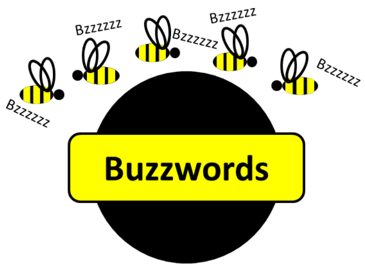


Figure 174: Buzzwords (Image Roser)

Yet another approach to improve creativity is buzzword lists. These can be injected in any of the creativity techniques to create even more creativity. They are sometimes called Osborn Buzzword Lists, named after Alex Osborn (1888–1966), the author of brainstorming. The list is a couple of suggested verbs to modify the original question:

- **Adapt**: Can I use something similar? What could I emulate?
- **Modify**: Can I change the meaning, color, taste, shape, motion, odor, form, or other things?
- **Magnify**: What can I add? Can I do it more often? Stronger? Higher? Longer? Larger? Heavier?
- **Minify**: What can I reduce? Can I do it less often? Weaker? Lower? Shorter? Smaller? Lighter?
- **Substitute**: What or who else can be of use? Other ingredients/parts/materials/techniques/power/place…?
- **Rearrange**: Can the components be rearranged? Can the layout/pattern/sequence/place be rearranged?
- **Reverse**: Can I change the direction, roles, orientation? Can I do it inside out or upside down?
- **Combine**: Can I merge things? Can I blend things together?

This buzzword list can be used to revive a creativity process that has slowed down. Of course, not all words apply to all situations. You as the moderator have to choose which modifications you would like to ask. Additionally, you can also throw the entire list at the wall as fodder for thoughts for the entire team.

I have used all of the above techniques, and they do have their uses. However, I have spent most workshop time on creative provocation, usually with stunning results. In my next post I will combine the techniques of this and the last few posts for my boilerplate creativity workshop structure. Until then, **go out, keep on tickling your gray cells, and organize your industry!**

22 My Workshop Structure for Creative Problem Solving

Christoph Roser, May 29, 2018, Original at https://www.allaboutlean.com/problem-solving-workshop/

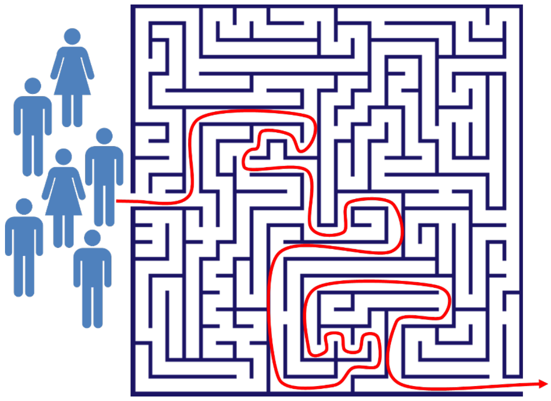


Figure 175: People before Maze (Image Roser)

In lean manufacturing – or in fact, in any kind of production system – you have to solve problems. Depending on the problem, you may need a creative solution and have to access the wisdom of the crowd. For this I have a workshop structure that I frequently use for problems that have lots of different options. Let me show you my workshop structure with which I've had quite good results.

22.1 Type of Problems

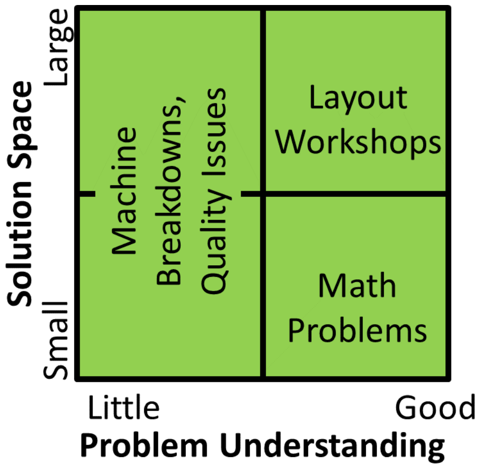


Figure 176: Problem Matrix (Image Roser)

First of all, while the workshop structure below is good, it won't be able to solve all problems. In my view, there are different kinds of problems, which can be grouped based on how well we understand the problem and how many possible solutions there are.

- **Good Understanding, Few Solutions**: This is for problems where the path is pretty clear and it just has to be done. An example is solving a mathematical equation.
- **Good Understanding, Many Solutions**: You have a reasonable understanding of the problem and can estimate the impact of your changes onto the system, but there are many different possible solutions that have to be explored.
- **Little Understanding, Many Solutions**: These are problems where you don't even know what the problem is exactly. Examples are machine breakdowns or quality problems. You known the problem, but you don't really know the root cause. In this case, you need to put the majority of your time into root-cause analysis.
- **Little Understanding, Few Solutions**: You don't really know what is going on, although there are only a few solutions. Since you don't understand the problem well, you don't

know the number of possible solutions. Hence this is overlapping with the "*little understanding, many solutions.*" It may be that the quality problem or machine breakdown has only one cause and you have to find it. You probably also would need to invest time into the understanding of the problem.

In any case, the following workshop structure is designed for problems where the group understands the problem reasonably well and can estimate how changes to the system influence the system, although there are still solutions hidden that they cannot (yet) imagine. Yet the many different possible solutions present a challenge.

A common example is a layout workshop to create a new layout for a production system. There are almost unlimited different ways for how to place the machines and materials on the shop floor. The workshop group knows at least somewhat how the placement affects the performance, but has trouble choosing one out of the many different ways to do it. This is where this workshop structure can help.

22.2 The Team

Figure 177: Teamwork (Image seanlockephotography with permission)

As usual for such problem-solving workshops, the team should be cross-functional. It could include an engineer, a controller, or a programmer depending on the problem to be solved. It should definitely include at least one worker, and possibly more, who actually work with the system. It could also include one manager responsible for the area to ease the decision-making process. It should also, of course, include you as a moderator. Altogether there could be between five and ten people involved. Please note that since ten people are too many for a good working group, we will split it later into sub-teams of three to four people.

22.3 The Workshop Sequence

22.4 Introduction

Figure 178: Shaking Hands (Image geralt in public domain)

The introduction is common to many workshops. Introduce yourself. Have the people introduce themselves. Maybe collect the expectations of everybody on a pin board. Introduce the problem at hand. This could take thirty or so minutes. Often it can also be helpful to visit the actual location of the problem. In other words, for a layout workshop, visit the shop floor if possible. This could be another thirty minutes.

22.5 First Round of Solutions

Figure 179: Portraits of people thinking (Image olly2 with permission)

The key to solving these kind of problems where the approach is understood but the solution space is big is to generate many possible solutions in a short period of time (see also my post on Japanese Multidimensional Problem Solving). Hence we split up the group in sub-teams of three to four people and have them work out a solution approach independently. If possible, these teams should also cover different functions. Do not make a worker-only team and an engineering-only team, but mix them. Important: We don't want to have a fully worked-out solution, but rather a rough concept. Do not fill in all the details yet; only generate a first workable idea. Give them around thirty minutes, which should be enough for a first idea.

Also, if possible, put the sub-teams in separate areas or even separate nearby rooms so they can work independently. Provide them with the necessary materials to work the problem, ideally based on paper. For example, for a layout workshop, give them a large printout of the shop floor map, plenty of paper in different colors, scissors, tape, glue, and so on. Let them work on the problem without giving much instruction on the problem-solving method. This first round usually serves more as a learning curve for the team and rarely generates the final solution. Another important point is that even though you as the moderator may be eager to step in and contribute, restrain yourself. Observe the teams, observe their ideas, and, most importantly, observe with which aspects of the problem they struggle.

After the thirty minutes are over, bring the teams back into the main room, have them present each other their solutions, and allow for some discussion. The entire group should list a few benefits and problems with each of these solution. This may take another fifteen to thirty minutes. Hang the solutions including their pro/cons on the wall, as they will be relevant later.

22.6 Second Round of Solutions

Figure 180: More People Thinking (Image Aaron Amat with permission)

For the second round, you as the moderator will introduce a challenge. Based on the problems these teams had before (as per the list of problems on each solution), restrict their design space to force them to work around the solution. This approach is called creative provocation, and I wrote a whole blog post on this, as it is my favorite creativity technique. For example, if a team has problems with getting workpiece carriers back to the starting point, force them to NOT use workpiece carriers. This restriction can be different for each team, as each team may have different problems with their solutions. Deciding this "restriction" is actually quite a bit of brain work for you, and hence I told you in the first round not to participate but to observe. This should give you plenty of time to think about a restriction.

The team may grumble a bit, but have them again separately do another solution within thirty minutes. This second round is not a refinement of the first solution, but instead a completely new solution. Optionally, you can shuffle the teams around a bit and move, for example, one team member in each group to another group. After thirty minutes get them together again and have them present to each other and list the pros and cons of the different ideas. Hang the results on the wall again.

If the problem needs more ideas and if you have the time, you can repeat this in a third round, with or without a creative provocation.

22.7 Last Round

Figure 181: One idea will work … (Image garloon, with permission)

In preparation for the last round, the team again looks at all previous solutions (which should be hanging on the wall), and as a group discusses the benefits and disadvantages of each solution. Steer the discussion toward a solution that includes all of the benefits but none of the disadvantages. Eventually ask the team if they want to generate another solution based on what they have learned. Almost always they say yes (if not, one solution is probably good enough already).

Hence they work out another solution. However, this time the team works as one group, creating only one solution. Also, do not give any restrictions on the solution space. If necessary, allow for more time, maybe up to sixty minutes. Afterward, there is no need to present, since everybody knows the solution already, but you still should list pros and cons.

For selecting the solution to be implemented, ask the team which one of these (now five to ten solutions) they like best and want to apply to the problem. Almost always, it is the solution from the last round. In some cases the team may indicate the desire for another round. In this case – time permitting – repeat the last round once more. But at the end you should have one solution with which the team is happy and which can then be finalized for implementation.

22.8 Wrap-Up

Figure 182: Solving Puzzle (Image VadimGuzhva with permission)

The wrap-up also includes standard workshop methods. Give every member of the group the chance for feedback, and ask them if their expectations (the card from the introduction) has been satisfied. Maybe have them present the solution to the higher-ups. Definitely thank them for their support, and close the workshop (but still keep them updated on future events toward the implementation).

So there you have it. This is the basic structure for my workshops for problems that have many possible solutions. I have had quite some positive experiences with these in the past. Keys for success are many different solutions, some creative provocation, and a multifunctional team. Hopefully this will also help you to solve similar problems in your location. **Now go out, gather your team, create solutions, and organize your industry!**

23 Disabled Employees in Manufacturing – Omron Taiyo in Japan – Part 1

Christoph Roser, June 05, 2018, Original at https://www.allaboutlean.com/disabled-employees-in-manufacturing-omron-taiyo-in-japan-part-1/

Figure 183: Omron Taiyo Kyoto Workers (Image Roser)

In every country, a part of the population has temporary or permanent disabilities that handicap their working ability. While in Japan, I was able to visit two factories of Omron Taiyo, in Kyoto and Beppu, where the majority of the employees have a disability. This was quite an enlightening experience for me, and I would like to share it with you. Due to the length of this post, I have split it into two parts.

23.1 Introduction

Figure 184: Wheelchair and Stairs (Image Thomas-Soellner with permission)

In Japan, about 4 percent of the population is disabled. In the US it is around 12 percent, and in Europe around 14 percent, although the definitions differ and hence the numbers are not that easy to compare. Especially in Japan, disabilities still carry a large stigma. Japanese society values uniformity, and there is a lot of pressure on the individual to contribute to the collective. People with disabilities sometimes look or behave differently, and often have trouble finding employment. While there are state subsidies available, in Japanese society it is often a shame to take from society without giving back. In the past, many families hid their disabled children to avoid embarrassment, although fortunately this is changing.

Figure 185: Blind in Japan (Image とほほのほ under the CC-BY-SA 4.0 license)

As for everyday life for disabled people: Japan has extensive preparations and markings for blind people, including yellow raised (tactile) lines on most sidewalks and even voice-guidance systems for public toilets (See Tales from Japan – Lean in the Japanese Public Toilet for a description and a video). However, there is little done for wheelchair users, and there are steps everywhere and few wheelchair-accessible ramps. To ride a train, you have to inform the station attendants beforehand so they can help with a mobile bridge to get onto the train. Traveling is possible, but very cumbersome.

23.2 The Omron Taiyo Story

Figure 186: Kazuma Tateishi (Image Roser)

Omron Taiyo is a joint venture between Omron and Japan Sun (Taio). Yutaka Nakamura (中村裕博) was active as a doctor for the 1964 Summer Paralympics in Japan. He was surprised that no Japanese athletes participated in the parties at the end of the Olympics. It turned out that most Western disabled athletes had a source of income, whereas the Japanese athletes simply could not afford to participate in the parties. Even worse, while foreign disabled athletes were cheerful and had fun, Japanese athletes felt hopelessness and despair.

Mr. Nakamura was embarrassed by this and wanted to change things. He founded Japan Sun with the goal to help disabled workers, and then sought companies for a joint venture to open a factory with many disabled employees. Between 1965 and 1971, he asked about three hundred different companies, including all the big names in Japan, like Toyota, Nissan, Honda, and so on. They all declined since they were worried about a drop in productivity.

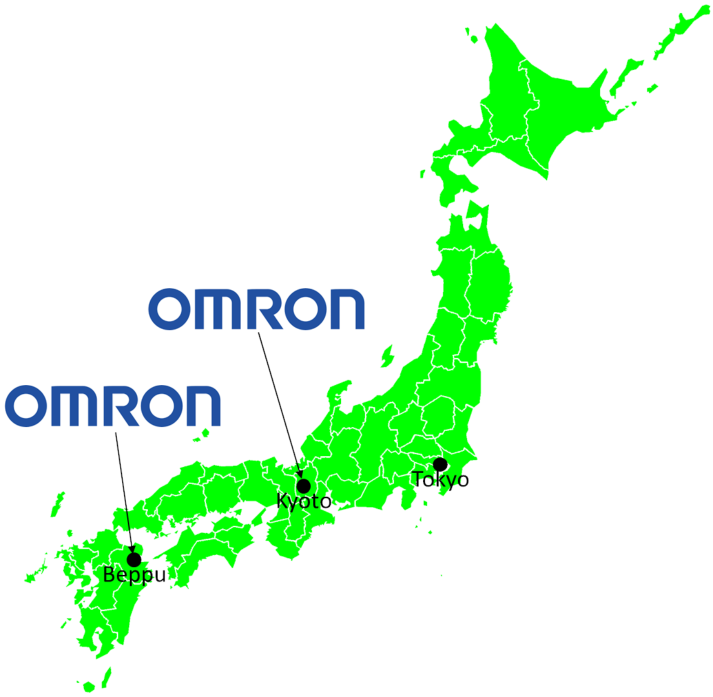


Figure 187: Omron Taiyo Locations (Image Roser)

Even more recently, I remember Toyota proudly boasting that they had 1.95 percent disabled employees – but with this they barely satisfied the government-required minimum of 1.8 percent (since then raised to 2 percent). Only in 1972, Mr. Nakamura found a like-minded spirit in Kazuma Tateishi (立石一真), founder of Omron. Together they established Omron Taiyo in Beppu in 1972, and later in 1985 also Omron Taiyo in Kyoto, both with Omron as the majority owner. Their motto is: "**Not a Charity, but a Chance!**" Their mission is:

- Expand employment of disabled people.
- Maintain quality, cost, and delivery to the satisfaction of the customer.
- Contribute to society by sharing our know-how in employment of disabled people. (Side note: Most Japanese companies have a contribution to society in their mission statement.)

Figure 188: Omron Kyoto Company Sign (Image Roser)

A lot of people were skeptical, and thought this was just something to make the disabled feel better and that this would never make money. **To the surprise of everybody, Omron in Beppu was profitable from the first year, and so was Omron Kyoto!** This was a major embarrassment to other companies that declined the cooperation (nowadays you would call it "public shaming"), and there are now a total of eight joint ventures with other companies, having around seven hundred disabled employees. These joint ventures include: Omron (2 plants), Sony, Honda (2 plants), Denso, Mitsubishi, and Fujitsu. The last two are next door to Omron Beppu.

Omron Taiyo Beppu has 64 employees, 31 of which are disabled (48 percent). Omron Taiyo Kyoto has 184 employees, 147 of which are disabled (80 percent). Their mother company Omron has 3.44% disabled employees. These employees fall into three categories according to the Japan government statistics:

- **Physically Disabled Persons** lacking physical abilities (e.g., unable to use some of their limbs or with missing limbs, blind, deaf, etc.)
- **Intellectually Disabled Persons** lacking intelligence (an example I was given was an employee who could speak and see, but could not connect these two. If you tell him to pick up a screw, he knew what a screw was, but could not identify the screw on the table. If you showed him what to do, however, he did a quite good job).
- **Psychiatric Disabled Persons** having emotional or personality disorders (an example I was given was an employee who every day at 9:00 had an orange drink from the vending machine. When the vending machine was out of stock, his world just fell apart and he could no longer work on that day).

Most employees at Omron are physically disabled (~70 percent of the disabled employees in Beppu and ~60 percent in Kyoto). All employees have at least one functioning arm, and for safety reasons no blind people are employed.

23.3 The Factory Tours – Part 1

I was able to visit both factories, and the tour guides were very patient in explaining the details in broken English. One of them even had coffee with me afterward for a chat. One of them was a manager, and both were in wheelchairs. As for their personal fate putting them in wheelchairs, both cases were an unfortunate mix of being young and owning a motorbike. Motorbike accidents at age nineteen and twenty-one respectively put them permanently in wheelchairs.

The visit started with an introduction of the company and a company video, then I was given a tour of the facilities. I was pleasantly surprised that I was able to take photos, as long as I didn't capture the employees' faces.

The factories produce electronic goods like timers, sensors, power supplies, thermometers, and sockets. Their production is high-mix low-volume, with Kyoto having 1500 different products in production. The Kyoto plant also had a SMD machine making printed circuit boards.

Figure 189: Omron Kyoto Workspace (Image Roser)

For obvious reasons, both factories were wheelchair accessible, all tables had enough space to accommodate a wheelchair, and all tables were at the same height. Most machines were easily moveable and could be rearranged quickly. As a side effect, these taller tables were also much more comfortable for an oversized foreigner like me, whereas normal Japanese tables are all a bit tight for me.

The light switches and elevators were also wheelchair accessible, and the cords for lights hanging from the ceiling were long enough to be reached from wheelchairs. Both factories extensively used jigs to help with assembly and, for example, assist employees who have only one working arm. Most of these jigs were created in a small workshop in the factory by the employees themselves.

Figure 190: Pick by Light at Omron Kyoto at 130% of the speed of a non-disabled worker (Image Roser)

They also used pick-by-light systems. The employee at the pick-by-light station was intellectually disabled, yet he was intensely focused on his work. His body had a rhythmic movement sometimes found in people with mental disabilities, but he incorporated this in his work well. While I am not a doctor, his symptoms seemed to be related to autism. Surprisingly enough, the guide told me that he was able to work much faster than the average non-disabled employee, averaging 130 percent performance over an "able-bodied" person. He works very fast, but has little understanding and judgment of what he is doing.

Figure 191: Connecting the dots … (Image Roser)

In the next post, I will continue my description of the factory tour, literally connect the dots, and talk more about the financial situation and also how this compares to other companies with fewer disabled employees. **Until then, stay tuned, enable your disabled employees, and organize your industry!**

P.S.: The company offers tours through their website www.omron-taiyo.com. Japanese skills would be helpful, although the site is in English. Many thanks also to Omron and the two tour guides for the tour.

P.S.S.: Many thanks to Tim Wolput from Lean Japan Study Tours for pointing out these companies to me!

24 Disabled Employees in Manufacturing – Omron Taiyo in Japan – Part 2

Christoph Roser, June 12, 2018, Original at https://www.allaboutlean.com/disabled-employees-in-manufacturing-omron-taiyo-in-japan-part-2/

Figure 192: Omron Kyoto Shopfloor (Image Roser)

In my last post, I started to describe the factory tour at Omron Taiyo, where more than half of the employees are disabled. This post continues this interesting tour, also looks into the financial situation of their employees, and gives some suggestions for other companies.

24.1 The Factory Tours – Part 2

Figure 193: Floor markings and material card with same markings. Where do you go? (Image Roser)

Very interesting was also their material and information flows. Many intellectually disabled workers would not understand instructions like "Bring this box to the warehouse," since they cannot really connect the words and the locations in their minds. However, they are able to follow colored lines and dots. Hence, there are lots of different-colored markers on the floor, matching the markings on the material. The intellectually disabled workers simply "connect the dots" as shown on the image.

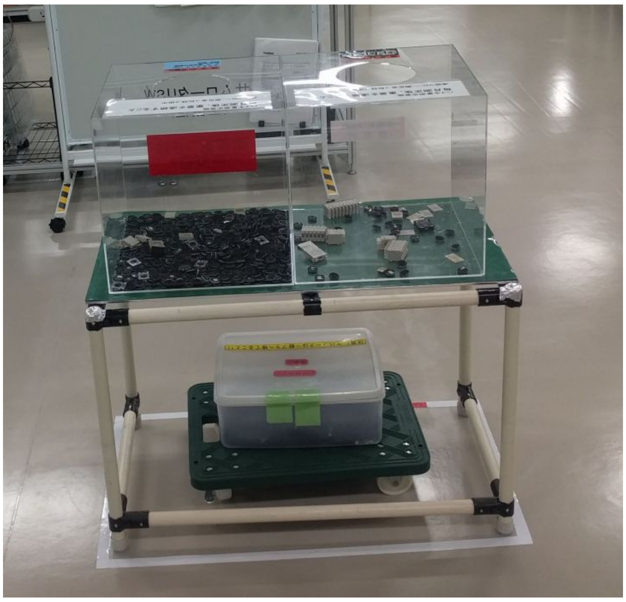


Figure 194: Boxes for defects (Image Roser)

Another visualization were boxes for defective parts. These boxes were transparent, and it was easy to see how many defects have accumulated.

They also have a kaizen employee suggestion system and kanbans, and use supermarkets extensively. Their kaizen activities are always on the shop floor. Managers are subject to a 360-degree feedback, where they are given feedback from their employees, their bosses, and their colleagues. Most workstations also have andon signal boards. Automatic workstations are filled before a break so that the machines continue to work throughout the break period. Their production lines seem to be a bit faster than in other factories. The switch line made six hundred switches per hour, or one every six seconds. Hence, the work content at a work station is only six seconds, which is less than what is considered optimal in other factories (thirty seconds to two minutes). Not quite sure why – if the limited mobility requires more customization of a task and reduces flexibility, or if intellectually disabled workers would have difficulties with longer cycle times.

Figure 195: Wheelchair Vacuum Cleaning (Image Roser)

Many companies in Japan value cleanliness, and Omron Taiyo was no exception. Their method of cleaning wheelchair wheels when entering the factory, however, was quite ingenious. They had a piece of sheet metal in the floor with holes that were attached to a vacuum. However, since there were many holes, it would have to be a quite strong vacuum. Therefore they put a little spring loaded brush-topped stopper in each hole. Only if there was pressure on the brush did the hole open, and the vacuum cleaned the underside of the wheels or shoes.

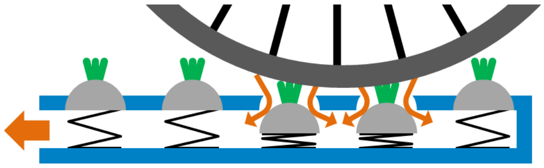


Figure 196: Wheelchair cleaning Vacuum (Image Roser)

Compared to other companies, these companies do have higher absentee rates. Around 10 percent of the workforce is on sick leave on an average day. Note that sick leave is not paid in Japan. In any case, due to the higher fluctuation in the workforce, they do indeed need a bit more inventory to buffer these fluctuations, as they cannot let the customer wait.

24.2 Financials

Figure 197: Automatic Line at Omron Beppu (Image Roser)

The wages are not generous, but they are enough to live on. A new employee receives 140.000¥ per month (about $1,300 US), an experienced one gets around 180.000¥ (about $1,650 US), and the manager I spoke to received around 200.000¥ (about $1,800 US). On top of this, they receive a bonus (which is often one to two months' salary per year) and also receive an additional pension for the disabled from the government. Overall they can afford their own place and a car. The company also has large dormitories for their employees next to the factories. This is common in Japan, and I have lived in such dormitories when I was working for Toyota. Many other companies that employ disabled people pay much less. For example, the Swan bakery in Tokyo that employs many disabled people pays around 100.000¥ per month (about $900 US), although bakery wages are generally lower.

More important than money, however, is the impact on their self-respect. As I said earlier, Japan is a very communal society, and everybody is expected to contribute for the good of the society. Being unable to work is quite a stigma, and having work again and receiving a salary can be quite a boost for the self-esteem. One employee was so happy that when he got his first tax statement about how much taxes he owed the government, he framed it and put it on his desk as a proof that now he is contributing to society. I wish I could be as happy paying taxes …

24.3 Changing the World …

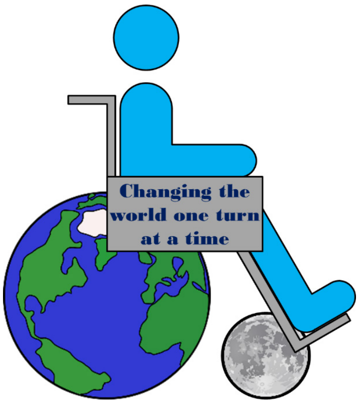


Figure 198: Changing the World for handicapped people (Image based on Pixabay in public domain)

Omron Taiyo does its bit to make the world a better place, to give a chance (not a charity) to disabled people, and to foster acceptance of disabled people in the society. As for myself, I never had much opportunity to interact with disabled people, and the whole topic is something new for me. Hence I approached these two tours a bit anxious. What is the right way to behave, what do I do so I don't offend my counterparts, and so on. I knew the best way is to just behave normally, but, you know, if you try to behave normally, it is all a bit … off.

With this mind-set of mine, we started the visit with a presentation and a video. After forty-five minutes, we were ready to go to the factory. I stood up to go to the factory, and then was surprised that my counterpart did not stand up, but rolled to the door in his wheelchair. In retrospect this should have been obvious, but at that moment I was surprised. I totally forgot that he was sitting in a wheelchair, and I just had a completely normal conversation like I would have with any other Japanese (with the limitation that my Japanese is quite bad).

Anyway, I like to think that these visits to Omron Taiyo in Beppu and Kyoto helped me to become a better person myself and made me feel more at ease around people with disabilities. In Beppu the guide even had a drink with me in the dormitory cafeteria afterward, and we chatted a bit about life, just like I would with everybody else (again, considering my limited Japanese skills). Omron Taiyo is changing the world, and it definitely helped me to change a bit for the better. Many thanks to my two tour guides in Kyoto and Beppu for their patience!

24.4 Improvements for Other Companies

Figure 199: Priority seating on Japanese trains. (Image Namazu-tron under the CC-BY-SA 3.0 license)

I believe Omron is an impressive example on how to not only give work to disabled people, but to make it profitable. As their motto is "A chance, not a charity!" this hopefully gives inspiration to other companies. Also, while many Omron employees satisfy the legal definition of disabled, there are also many other similar but less drastic problems.

24.5 Old, Pregnant, Infirm …

Figure 200: One day we all will be old… (Image olly2 with permission)

A common problem in industry is the aging workforce as a result of an aging society. Workers will get older, and their bodies may no longer be working as well as when they were young. Others may have a temporary injury that limits their ability to work, but not severe enough for complete absence. And others may be pregnant, which is neither a disability nor a disease, mind you, but which may limit the work that can be done by these women.

Using jigs, visualization, and ergonomic workplaces can also help these employees. It is usually a combination of finding a suitable workplace and changing the workplace so that it is suitable for the employee. For example, I know one plant manager that keeps one low automated manual assembly line of smaller products to give work to pregnant employees. Lifting aids can be used to help employees with back pain. Larger print on instructions and information is also more gentle on elderly eyes. On a motorbike assembly line, I have seen a particularly short employee whose station had a wooden plattform 15cm high, 1m wide, and 4 m long for him to work on the assembly. So there are many things you can do for your people depending on your circumstances.

24.6 Healthy Employees

Figure 201: Male and Female Worker (Image Wayhome Studio with permission)

Above were a lot of ideas to allow the disabled and otherwise infirm to work productively. But these ideas would also work for otherwise healthy and able employees. Ergonomics keeps them healthier, and visual management reduces their errors, as does poka yoke (mistake proofing). Hence, a lot of these ideas benefit the entire workforce.

This completes my two-post series on my factory tour of Omron Taiyo in Kyoto and Beppu. It was very insightful for me, and I wanted to share these insights with you. Now, go out, enable everybody to use their full potential, and organize your industry!

P.S.: The company offers tours through their website www.omron-taiyo.com. Japanese skills would be helpful, although the site is in English. Many thanks also to Omron and the two tour guides for the tour.

P.S.: Many thanks to Tim Wolput from Lean Japan Study Tours for pointing out these companies to me!

25 Toyota Standard Work – Part 1: Production Capacity

Christoph Roser, June 19, 2018, Original at https://www.allaboutlean.com/toyota-standard-work-1/

Figure 202: Let's talk about standards! (Image Sikovs with permission)

Toyota is excellent with their **standard work**. They use a series of worksheets to simplify the creation of these standards. These are sometimes also know as the "famous 3 slips". The first one is a **production capacity sheet** to define what capacity you have available. The second one is a **standard work combination table** to define when the operator is doing what. The third one is a **standard work layout sheet** to help with the layout and arrangement of the machines. While there are many different ways of doing this, I like the Toyota approach. Since this is a larger topic, I've broken it into multiple blog posts. Lets start with the Production Capacity sheet.

25.1 Why Standard Work?

Figure 203: Why Standards? (Image Horia Varlan under the CC-BY 2.0 license)

If there are different ways that things can be done, then some of these must be better than others. The idea of standard work helps employees perform consistently. Please note that **any good work standard – or even any good working procedure – needs a lot of input from the people who actually do the work!**

The naming of this method and the three sheets that I will show you in this and the next two posts is by no means used consistently across the lean community, and there are many different similar names. At Toyota this is known as **Standard Work**, which is also the name John Shook uses. However, this may lead to confusion with the more general *standardized work* or *work standards* (meaning there is a standard of some kind, but not necessarily this method). Kei Abe called it **Man/Machine Balance**, but this was not gender neutral and hence was changed to **Operator/Machine Balance** in the USA. Kiyoshi Suzaki calls them **Work Combination Charts**, which Michel Baudin shortened to **Work Combo**. Definitely many thanks to Michel Baudin for letting me know all those many names and their origins.

25.2 Where to Use It

The **production capacity sheet** helps with the calculations of the line capacity, and the **standard work layout** helps with the line layout. The **standardized work combination table** defines the working standard of the operator. Each of these address a specific issue in planning and standardization.

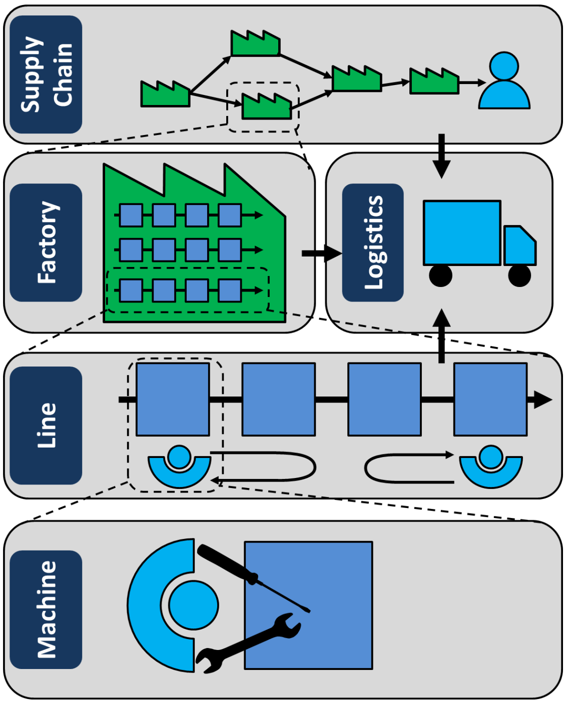


Figure 204: Our focus is the line layout! (Image Roser)

25.3 Preparations

Figure 205: Warehouse manager writing on clipboard (Image WavebreakmediaMicro with permission)

Before we can start, we need a few pieces of information. We need to know what the line has to do. **The different process steps need to be defined or known**. Ideally, we already have a line, but it would also work for a yet-to-be-built line as long as we know the process steps.

We need to know the target speed of the line. How fast should the goods be produced? Key metrics here are the cycle time and the customer takt (or line takt) (the ratio between the two is the OEE). The resulting metric here is the target cycle time. How fast should each machine be (without breakdowns, delays, and other losses) measured in seconds (or minutes, hours, etc.) per piece?

We need to know the **speed of each machine**, including the time needed for the operator and the time needed at which a machine can work without the operator as well as. At Toyota, this is usually measured using stopwatches (if the line already exists). Other countries where the unions disagree with stopwatches need to use different methods, usually a system of predetermined motions (e.g., MTM). The key metrics here are the manual work time and the additional machine work time. This is such important data that Toyota has a standard sheet for this purpose, the "Production Capacity Sheet":

25.4 Production Capacity Sheet

The production capacity sheet is an overview with the basic data and some simple calculations regarding the machines in the line. I have created an Excel spreadsheet, based on the Toyota spreadsheet, which also does some simple calculations. Below is the overview of the sheet, but since it is a bit small, let me break this down into pieces:

Production Capacity Sheet

Part Name	Corner Body Assembly	Part Nr.	224-08/15	Date	03.02.2018	Manager	Jane Doe	Section

Sequence	Process Name	Machine	Manual Time		Machine Time		Total Time		Lot Size	Change Over Time		Process Capacity
			Min.	Sec.	Min.	Sec.	Min.	Sec.		Min.	Sec.	7 hours
1	Welding Nut 1	WN2001	0	3	0	25	0	28	100	1	0	881
2	Welding Nut 2	WN2014	0	5	0	21	0	26	1000	0	30	968
3	Riveting Flange	RMx-20	0	7	0	27	0	34	1000	0	30	741
4	Riveting Cover	RMx-12	0	6	0	36	0	42	500	0	15	600
5	Quality Check	n/a	0	20	0	0	0	20	1	0	0	1260
6							0	0				#DIV/0!
7							0	0				#DIV/0!
8							0	0				#DIV/0!
		Total	0	41								

Figure 206: Toyota Production Capacity Sheet (Image Roser)

25.5 Production Capacity Sheet Header

The header contains the usual things you find in the headers: The name of the part to be produced, the part number for the software system, a date, a responsible person, and also a plant section. An example is given below. Feel free to modify these as needed in the Excel sheet.

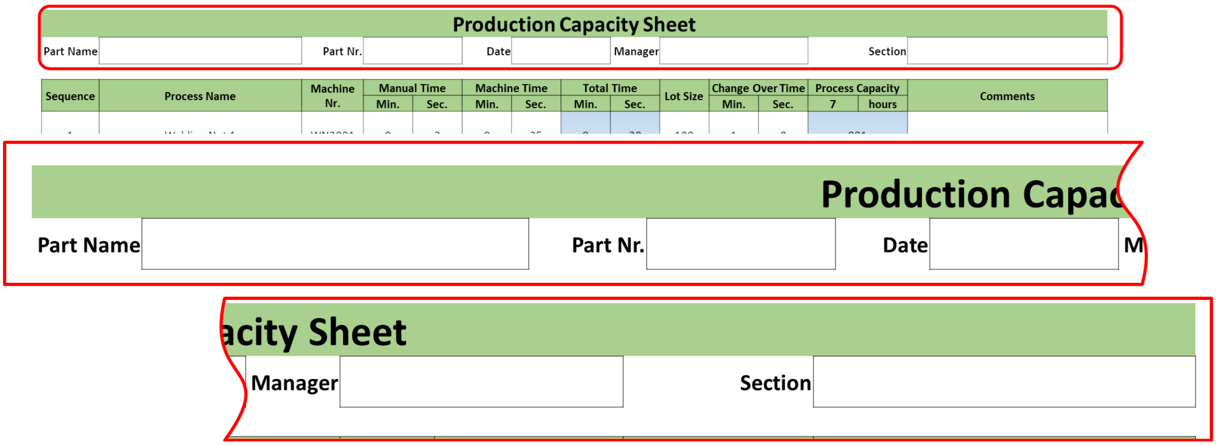


Figure 207: Production Capacity Sheet Header (Image Roser)

25.6 Production Capacity Sheet Process Times

Next we get to the actual data. We list the processes/machines that have to be done. Below is the detail from the data sheet, filled in with example data.

Sequence	Process Name	Machine Nr.	Manual Time		Machine Time		Total Time	
			Min.	Sec.	Min.	Sec.	Min.	Sec.
1	Welding Nut 1	WN2001	0	3	0	25	0	28
2	Welding Nut 2	WN2014	0	5	0	21	0	26
3	Riveting Flange	RMx-20	0	7	0	27	0	34
4	Riveting Cover	RMx-12	0	6	0	36	0	42
5	Quality Check	n/a	0	20	0	0	0	20

Figure 208: Production Capacity Sheet Processes (Image Roser)

First add the machine names and numbers in sequence, so you know which machines you are talking about. Next add the working times, distinguishing between manual work time and machine-**only** work time. The spreadsheet will calculate the total time for you.

All machine times would have to be faster than the target cycle time. If a machine is slower than the target cycle time, it won't have enough capacity to supply the customer. You need a faster machine or a second machine.

25.7 Production Capacity Sheet Change Over Times

In the next few columns comes the info on the lot size and changeover time. As you can see below, you add the lot size and the duration of the changeover into the cells. You can also change the duration of a shift in the header below process capacity (here 7 hours).

Lot Size	Change Over Time		Process Capacity	
	Min.	Sec.	7	hours
100	1	0	881	
1000	0	30	968	
1000	0	30	741	
500	0	15	600	
1	0	0	1260	

Figure 209: Production Capacity Sheet Change Over Times (Image Roser)

The Excel sheet will automatically calculate the maximum process capacity based on the manual and machine work times and the changeover time. This capacity is simply calculated as follows:

$$Process\ Capacity = \frac{Operating\ Time}{Manual\ Time + Machine\ Time + \frac{Changeover\ Time}{Lot\ Size}}$$

25.8 Production Capacity Sheet Totals

Finally, you will see a "Total" line at the bottom. Curiously enough, this is only for the total of the manual work times. But, if you think about it, this makes total sense. The **total manual work** must be less than the takt time, otherwise the line is too slow. Hence, this number is needed. The total for each individual process is in the "**Total Time**" column already, needed to check if the machines are fast enough. Having a "**Total of the Total**" is of little use here. Hence, even though it is easy to calculate the totals of the machine time and the total of the totals, you don't need it, and hence you do not clutter the sheet with unneeded information.

Production Capacity Sheet

Part Name	Corner Body Assembly	Part Nr.	224-08/15	Date	03.02.2018	Manager	Jane Doe	Section

Sequence	Process Name	Machine	Manual Time		Machine Time		Total Time		Lot Size	Change Over Time		Process Capacity
			Min.	Sec.	Min.	Sec.	Min.	Sec.		Min.	Sec.	7 hours
1	Welding Nut 1	WN2001	0	3	0	25	0	28	100	1	0	881
2	Welding Nut 2	WN2014	0	5	0	21	0	26	1000	0	30	968
3	Riveting Flange	RMx-20	0	7	0	27	0	34	1000	0	30	741
4	Riveting Cover	RMx-12	0	6	0	36	0	42	500	0	15	600
5	Quality Check	n/a	0	20	0	0	0	20	1	0	0	1260
6							0	0				#DIV/0!
7							0	0				#DIV/0!
8							0	0				#DIV/0!
		Total	0	41								

Total	0	41

Figure 210: Production Capacity Sheet Sums (Image Roser)

25.9 Goodies for Download

During this short series of posts on the Toyota Standard Work approach I have used an Excel spreadsheet. For your convenience here is the spreadsheet as well as a PDF version thereof. Both documents are provided under the Creative Commons CC-BY-SA 4.0 license, meaning you can use them freely, but should give credit to me on AllAboutLean.com.

- Toyota Standard Work Excel Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.xls
- Toyota Standard Work Adobe Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.pdf

Now you have the data basis to do the standard work. I will describe the standard work combination table in the next post. Hopefully, this was not too dry for you, and I promise it will all start to make sense in the next post. Until then, stay tuned, and **go out and organize your industry!**

PS: I learned about this (and many other things) at the highly interesting C2U Lean Leadership Training in Japan and from Michel Baudin.

26 Toyota Standard Work – Part 2: Standard Work Combination Table

Christoph Roser, June 26, 2018, Original at *https://www.allaboutlean.com/toyota-standard-work-part-2/*

Figure 211: More on Standard Work (Image Mazirama with permission)

Toyota has a nifty way to plan the work of an operator using their standard work charts. In my last post I explained the **production capacity sheet** to define what capacity you have available. In this post we will talk about the second of the "famous three slips", the **standard work combination table** to define when the operator is doing what. A subsequent post will show a **standard work layout sheet**.

26.1 Introduction

The standard work combination table plans the work of **one operator** during a work cycle. Hence it is useful primarily for manual cyclic work that repeats (nearly) identically for every part produced. Prime examples are any assembly procedures, but it also could include other manual processes that are primarily cyclic. Below is an overview of the worksheet with sample data. Don't worry about the complexity, as we will go through it bit by bit.

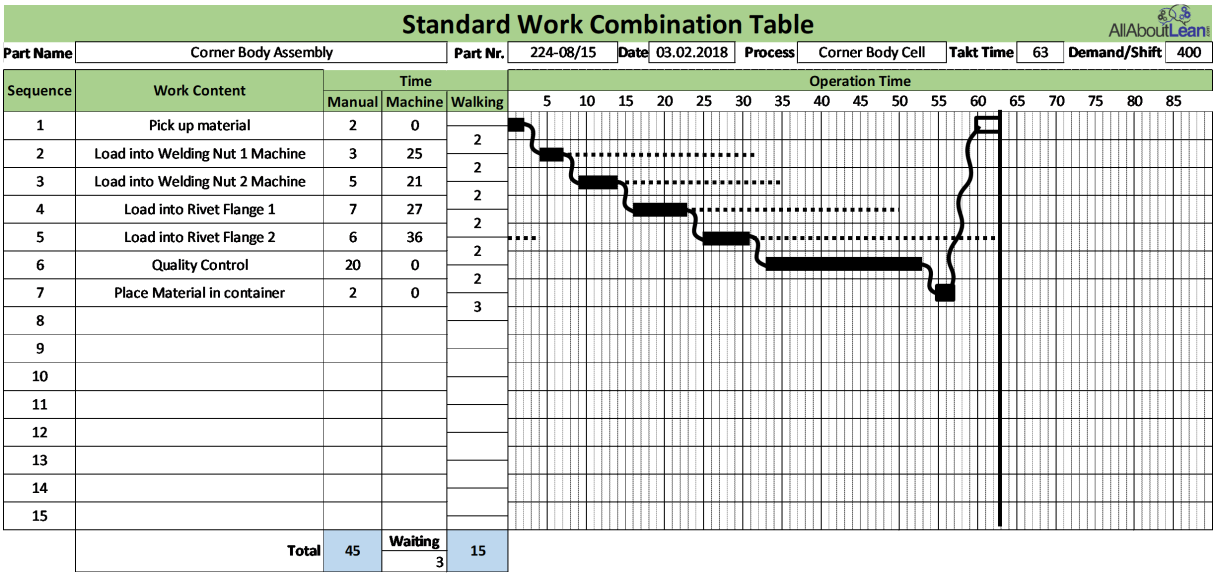


Figure 212: Toyota Standard Work Combination Example (Image Roser)

26.2 The Header

The header contains the usual stuff found in these types of documents, like part name and part number as well as a date. Below is a zoom-in into the header (split into two lines for easier reading)

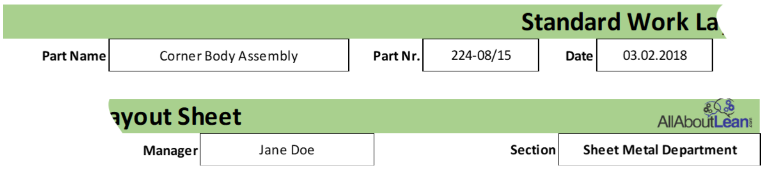


Figure 213: Toyota Standard Work Combination Header (Image Roser)

The process is the process to which this standard applies. Depending on your situation, this could be an entire line or cell, or a subsection, a single machine, or even a part of a single machine. It represents whatever the work is that the operator has to do. Remember, this sheet represents only one operator, and multiple sheets have to be created if you have multiple operators.

The takt time is the target speed of the operator. Every how many seconds does he have to complete a part. Please note that the takt time is the average speed, and the cycle time would be the ideal speed. The difference is the different wastes (or losses) like breakdowns, interruptions, lack of material, and so on. These differences are also the OEE. For example, if your OEE is 80%, then you lose 20% of your time due to unforeseen waste. Hence, in this case in the West, we would take a target cycle time of only 80% of the takt time to account for these losses. Toyota in Japan does not do that, and instead uses short-term unplanned overtime to catch up (i.e., the employees can go home if they have reached the target output). This of course makes it easier to plan, but depending on your country or company's legal framework and the view of the unions, this may not be possible, hence we usually use a cycle time that is faster than the takt time. You have to decide this for yourself, but be aware of this issue.

The demand per shift is simply the available work time during your shift divided by the takt time. In the example above, it is a seven-hour shift (or 25,200 seconds) divided by 63 seconds per part, giving you an available capacity of 400 parts per shift.

26.3 The Data Column

The data column lists the work content that needs to be done in sequence. It also contains the duration of the manual work and the duration of the machine-only work for every step as well as the walking distance between the different steps (if applicable). The adding of the data is simple; the challenge is more about getting the data. If you have data sheets available, make sure that the numbers are correct and current. If you have a line to measure and your unions permit measurements, then please check directly on the shop floor.

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

Figure 214: Toyota Standard Work Combination Data Column (Image Roser)

At the bottom is a row with totals for both manual work time and walking time. I did not forget the total machine time – this simply does not matter. The sum of all machines is irrelevant here! Instead, there is a space to add the waiting time. This is done after the main part of the sheet is completed. The sum of the manual work, waiting time, and walking time is the time needed by the operator, and this should equal the takt time.

26.4 The Combination Table

Now comes the interesting part: the combination table. Here you graphically add the different times into a small chart. Below is an example:

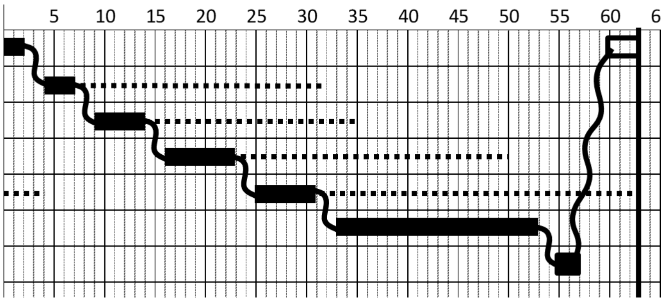


Figure 215: Toyota Standard Work Combination Table (Image Roser)

26.5 Basic Legend

There are a few different features representing different information contents. Below is an overview of a very simple combination table, with the different symbols highlighted. These are the most important symbols, but there are some more in my view optional ones below.

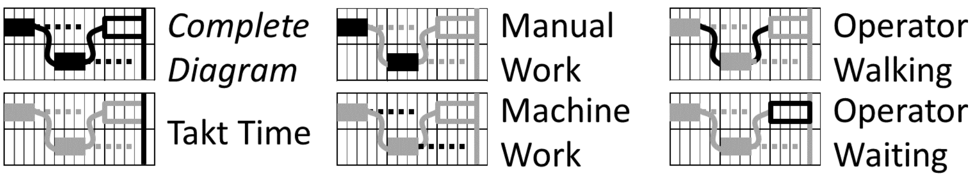


Figure 216: Toyota Standard Work Combination Legend (Image Roser)

- The **takt time** is a vertical line. The work for the operator (manual or otherwise) must not exceed this line.
- The **manual work** is a black rectangle, the length of which represents the time for the manual work. This is the work that the operator has to do, either by himself or with a machine.
- The **machine work** is a dashed or dotted line. This is the time a machine is working independently from the operator. If the machine works together with the operator (e.g., a manual drill), it would be part of the manual work time.
- **Walking** of the operator is represented by a squiggly line. The squiggly line also shows how long it takes the operator to walk. This time is difficult to measure, but a rule of thumb is that **an operator can walk two steps in one second**. Another rule of thumb is that **anything above two seconds is too far** and you may consider rearranging the machines. The squiggly line may be difficult to do on a computer, but at Toyota these sheets are designed to be filled out by hand, which is better anyway. If the operator works only at one station, walking may not be necessary.
- **Waiting time** of the operator is represented by a rectangular box, the width of which represents the duration (or sometimes using a double arrow). Waiting time happens if there is time left for the operator between completing his work and the end of the takt time. This is usually at the end of the cycle. However, there may also be additional waiting times in the middle of the cycle if this is necessary for a technical reason (e.g., insert part, wait for a quick machine check, then press button to start). If possible, avoid waiting, since it is one of the seven types of waste.

26.6 Extended Legend

For completeness' sake, Toyota also has three more symbols, although these may not be completely necessary in my view. Below are these variations:

Figure 217: Toyota Standard Work Combination Extended Legend (Image Roser)

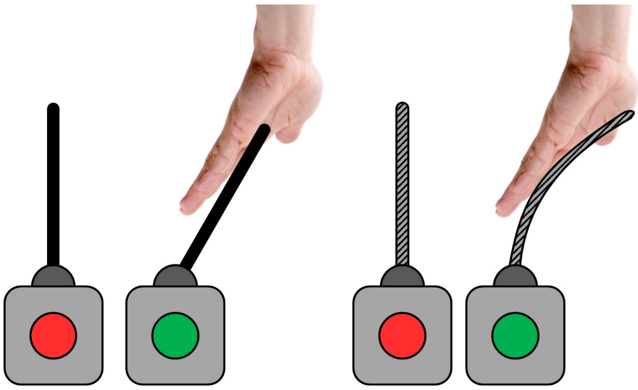


Figure 218: Animated Nagara switch. Animated image can be found at https://www.allaboutlean.com/chaku-chaku-line/ (Image Roser)

Start while walking means the operator presses a switch while walking. These are often so-called **Nagara switches** that can be activated with a stroke of the hand. This could be incorporated in the previous process. If it is a separate process in between that merely needs to be started, then this symbol may make sense, but then why don't you start it automatically based on the status of the surrounding processes?

- **Work while walking** represents the operator doing some work (e.g., putting two parts together) while walking. In my view this could also be represented simply by another line in the diagram.
- **Multi-point operation** represents a process where the work is done more than once. For example, if you have to add three screws to a part before starting the machine, you would write "3" over the manual work rectangle. This too could be included in the work description.

In my view, these three additional symbols are not completely necessary, but they do not hurt either. As with most methods in lean manufacturing, the goal is NOT to strictly follow some guidelines (except maybe PDCA), but to achieve results. Use the symbols that help you in your work, invent new ones if you see the need, but most importantly achieve your goals!

26.7 Some Tips and Tricks

There are some tips and tricks that may help you with using this sheet. First of all, it may not be a problem if a machine time exceeds the takt time. In this case the machine time just continues "at the beginning of the cycle" (i.e., from the beginning of the graph again as shown below).

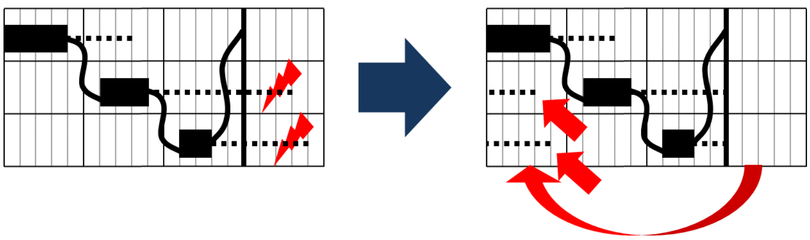


Figure 219: Toyota Standard Work Combination Exceed Takt (Image Roser)

Sometimes you may have work that has multiple steps or even all of the steps at the same workplace, and the operator does not need to walk between steps. I know of three different ways how Toyota visualizes this situation in the chart. All three of them have a separate line for each sub-step and are shown and explained below.

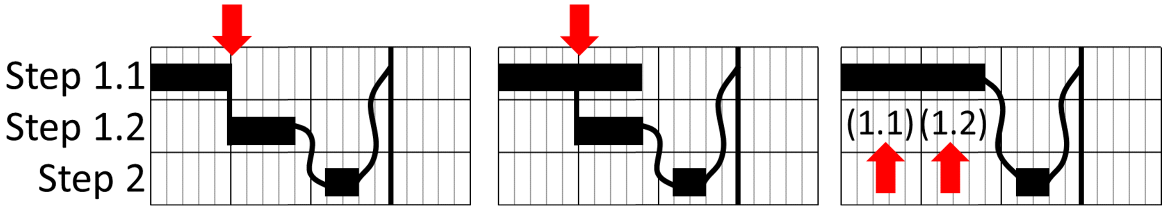


Figure 220: Toyota Standard Work Combination No Walking (Image Roser)

One way is to simply have a separate box for each work step, and make a vertical line connecting the boxes instead of a squiggly walking line. This would be my preference. Another option is to have a long box covering everything, and make smaller boxes below for the sub-steps. Finally, you can also make one long box and write the numbers of the sub-steps next to it, with a separate line for each sub-step.

You may be wondering why Toyota has three different ways to do the same thing. I believe such methods at Toyota are merely a guideline, and people invent additional ways if needed for their purpose. You should do the same. This sheet is not a religious canon, but a tool that you can shape and adjust to fit your purpose. **Make the tool fit your needs, and not the other way round!**

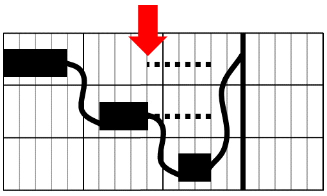


Figure 221: Toyota Standard Work Combination Simultaneous Start (Image Roser)

Sometimes you may have the situation that a machine can only start if two separate manual steps are completed. In this case the dashed line for machine operation starts only after the required steps are completed.

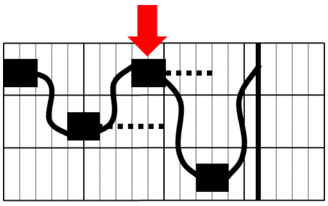


Figure 222: Toyota Standard Work Combination Backstep (Image Roser)

In some other cases the operator may have to loop back to a previous machine before the cycle is completed. Simply make a squiggly line upward to represent the operator walking back to a previous process. The data columns may have additional information about the time needed for the sub-steps (e.g., "2 / 2" for two seconds manual work in the first and two seconds in the second box). Similar applies to the machine time and the walking time.

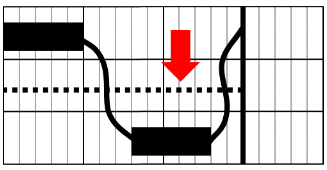


Figure 223: Toyota Standard Work Combination Continuous Operation (Image Roser)

Finally you may have a continuously running machine (e.g., a washer, a dryer). This is represented by a dashed “machine work” line that extends from zero to the end of the cycle.

26.8 Benefit of the Standard Work Combination Table

The standard work combination table serves two purposes. First, it helps you to get the work standardized and to create a sequence of steps for the operator to do in his cycle.

More importantly, however, it helps you to improve the cycle. Walking and waiting times are clearly visible in the process, and the total walk and wait time is also summed up at the bottom of the data columns. Hence, it helps you to take away waste out of the cycle. Not quite as visible but also a part of this optimization is to look a the steps itself and see if you can reduce movement (hands, eyes, etc.), for example by placing parts and tools closer.

26.9 Goodies for Download

During this short series of posts on the Toyota Standard Work approach, I have used an Excel spreadsheet. For your convenience, here is the spreadsheet as well as a PDF version thereof. Both documents are provided under the Creative Commons CC-BY-SA 4.0 license, meaning you can use them freely, but should give credit to me at AllAboutLean.com.

- Toyota Standard Work Excel Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.xls
- Toyota Standard Work Adobe Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.pdf

Okay, this was a longer article, but I do like the simplicity of this approach. Hopefully it can help you in your daily work. Now, **go out, make sure your people have cyclic work, and organize your industry!**

PS: I learned about this (and many other things) at the highly interesting C2U Lean Leadership Training in Japan and from Michel Baudin.

27 Toyota Standard Work – Part 3: Standard Work Layout

Christoph Roser, July 03, 2018, Original at https://www.allaboutlean.com/toyota-standard-work-part-3/

Figure 224: Standard Illustration (Image tashatuvango with permission)

This post is the third in this series on how Toyota plans standard work. The first one was the **production capacity sheet** to define what capacity you have available. The second one was a **standard work combination table** to define when the operator is doing what. Finally, the third of the “famous three slips”, presented in this post, is a **standard work layout sheet** to help the layout and arrangement of the machines.

27.1 Introduction

This sheet is a simplified layout of the line to show the route of the worker, the inventory, safety- and quality-related information, and information on the takt time. Below is an example of such a layout. Please note that this chart is most helpful if an operator has to operate multiple machines, and hence has to walk. If an operator works only at a single spot without moving, then this chart may not really be necessary.

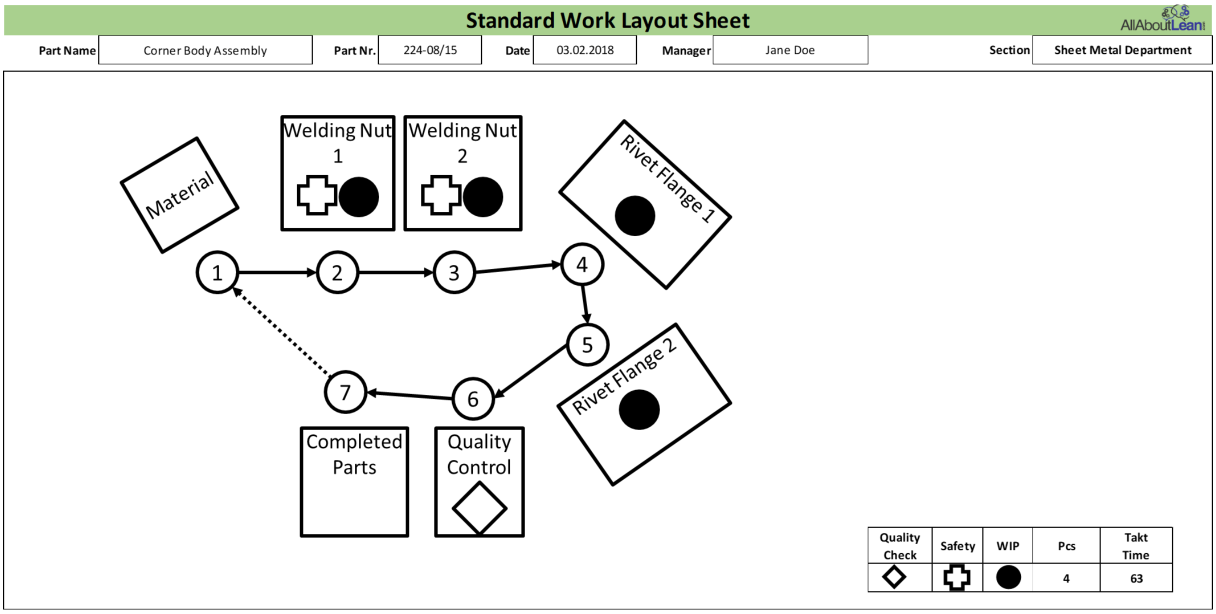


Figure 225: Toyota Standard Work Layout Example (Image Roser)

27.2 Header

The header of the sheet contains the usual information related to the process: Part name, part number, date, person in charge, and section. Feel free to expand or remove from this as needed.

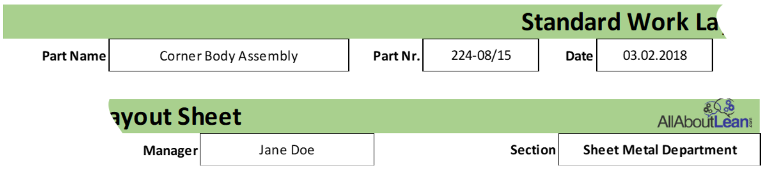


Figure 226: Toyota Standard Work Layout Header (Image Roser)

27.3 Filling Out the Chart Area

The chart area contains the main information. There are a couple of symbols in use, but they are best explained in showing you how to draw such a chart.

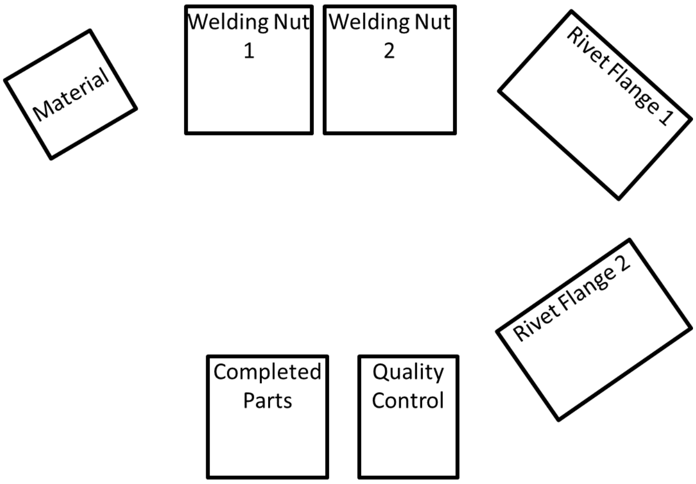


Figure 227: Toyota Standard Work Layout Step 1 Machines (Image Roser)

The first step is to draw boxes for the different processes and material supplies. These should be roughly placed as they are on the shop floor, but there is no need for exact measurements. A brief name or label will help to identify the boxes (e.g., "Welding Nut 1" or "WN2001").

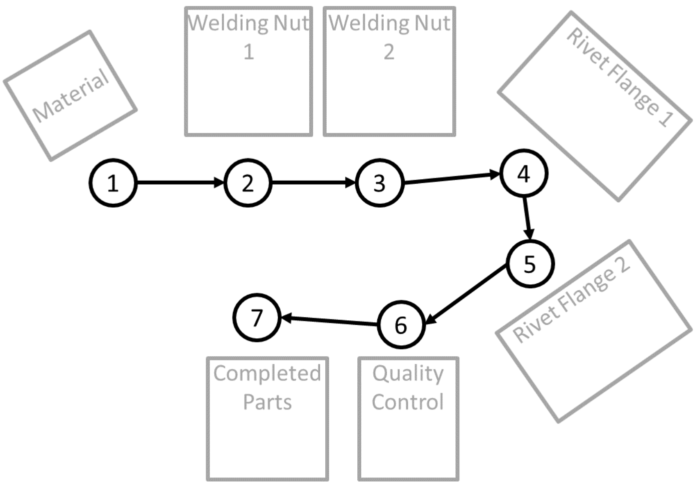


Figure 228: Toyota Standard Work Layout Step 2 Walking (Image Roser)

Next, we add the different work contents as numbers in circles. These numbers should correspond to the numbers in the standard work combination table. Lines with arrows indicate the walking path. Here it would be clearly visible if a worker has to backtrack and visit a previous station before the end of the cycle.

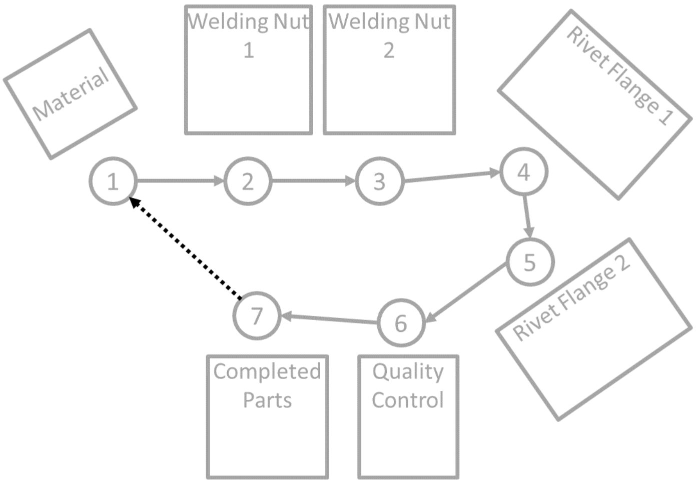


Figure 229:Toyota Standard Work Layout Step 3 Walking Back (Image Roser)

For the last segment where the worker simply walks back to the first station, a dashed arrow is used. This is to highlight this walking as the end of the cycle.

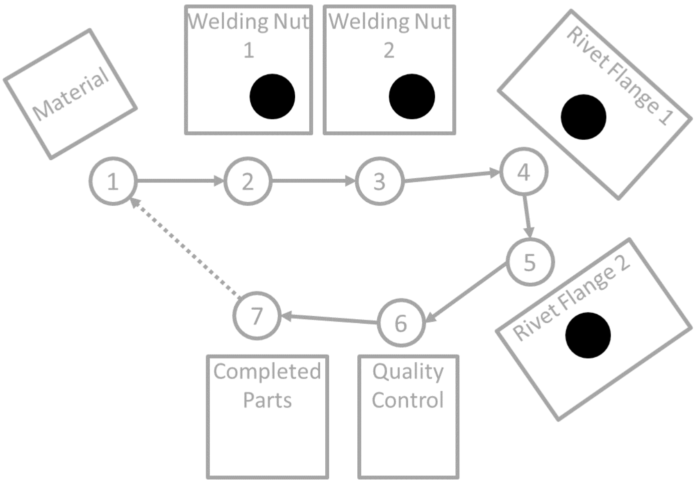


Figure 230: Toyota Standard Work Layout Step 4 Material (Image Roser)

Now we add the WIP. Each machine that holds a part gets one black circle for one part of WIP (or more circles if there is more than one part in the machine. Use numbers if your machine contains a lot of parts). You don't have to count the part that the operator is carrying or handling, but only the parts that are left in the machine after the operator moved on.

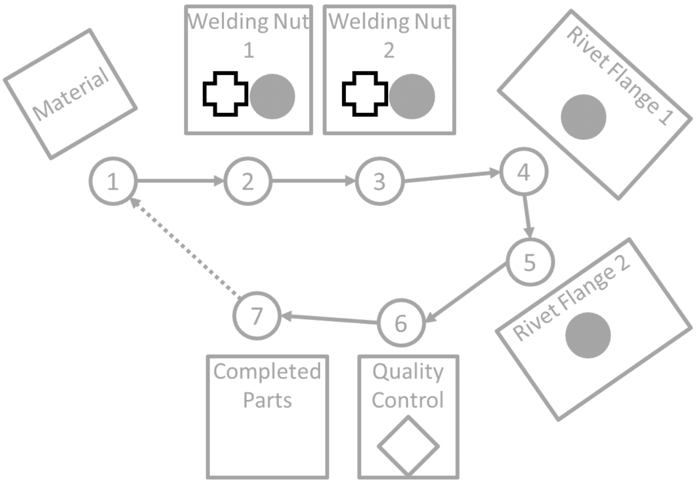


Figure 231: Toyota Standard Work Layout Step 5 Safety (Image Roser)

Figure 232: First Aid Green Cross (Image Roser)

After the parts, we check which machines are critical for safety. These machines get a outlined "plus" mark. This mark comes from the green cross that is often used for first aid kits. Considering which machine may have safety concerns helps to put attention to safety.

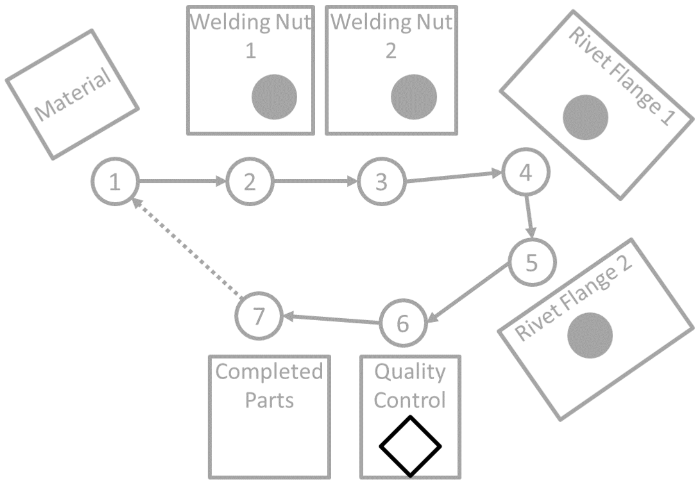


Figure 233: Toyota Standard Work Layout Step 6 Quality (Image Roser)

The last step in the chart focuses on quality. An outlined diamond rectangle is drawn at steps where the quality is checked.

There are variations possible. For example, you can have a layout for every single worker in the system. Or you could have a layout that includes the loop of multiple workers. Toyota usually prefers to have one chart per worker, but – as always – you have to adjust the tool to fit your problem.

27.4 Summary Information

There is not much summary information. At the lower right corner of the chart, you have a small legend on which you can add the WIP quantity and the takt time. The WIP should correspond to the number of WIP circles in the layout. The takt time is the same as the one from the previous Standard Work Combination Table.

Quality Check	Safety	WIP	Pcs	Takt Time
◇	✚	●	4	63

Figure 234: Toyota Standard Work Layout Final Data (Image Roser)

27.5 What's Next?

You have filled out three pages, the **production capacity sheet** to define what capacity you have, the **standard work combination table** to define when the operator is doing what, and the **standard work layout sheet** to have a look at the layout, safety, and inventory. Now the real value of this approach begins!

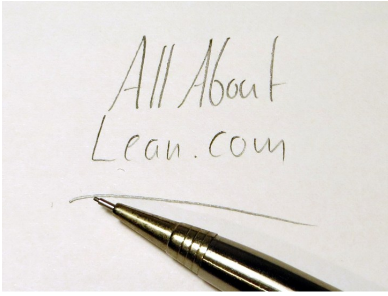


Figure 235: AllAboutLean written in Pencil (Image Roser)

You (possibly with a small team) should go systematically though all pages again and see what you can improve. Can you reduce walking time? Can you move processes closer to each other. Is it possible to reduce WIP? Can you improve safety? Based on these considerations, you modify and adjust the pages. Toyota people (and Japanese in general) extensively use pencils to erase, correct, and improve these worksheets. Depending on the complexity of the problem, there may be quite a few iterations before you are satisfied (for now).

Now comes the implementation part. The plan has to be implemented, machines may have to be moved, workers need to be trained, and so on.

Finally, following the philosophy of PDCA, you should check if the implementation actually provides the desired results. This check should be not only right after the implementation, but also a few weeks later. Most ideas work right after implementation but fall apart soon thereafter. Hence a delayed check is often a good idea.

27.6 Goodies for Download

During this short series of posts on the Toyota Standard Work approach, I have used an Excel spreadsheet. For your convenience, here is the spreadsheet as well as a PDF version thereof. Both documents are provided under the Creative Commons CC-BY-SA 4.0 license, meaning you can use them freely, but should give credit to me at AllAboutLean.com.

- Toyota Standard Work Excel Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.xls
- Toyota Standard Work Adobe Spreadsheet https://www.allaboutlean.com/wp-content/uploads/2018/06/Standard-Work-Sheets_v04.pdf

This closes the short series on the Toyota standard work approach. As always, I hope that this is helpful for your daily work, or at least gives you inspiration for new ideas on how to approach things. Also, don't be afraid to modify and adjust the approach to fit your needs. **Now, go out, get your work flowing, and organize your industry!**

PS: I learned about this (and many other things) at the highly interesting C2U Lean Leadership Training in Japan and from Michel Baudin.

28 All About 5 Why

Christoph Roser, July 10, 2018, Original at https://www.allaboutlean.com/all-about-5-why/

Figure 236: 5 Why Graphic (Image Roser)

If you're doing lean, you will encounter people telling you to do "**5 Why**" everywhere. And the method sounds simple, just ask "Why?" five times to find the root cause of a problem. However, there is a surprising amount of depth to this, as well as some pitfalls. Let me elaborate:

28.1 A Simple Method?

Figure 237: Is it child's play? (Image Lukassek with permission)

The technique of "5 Why" can be found everywhere on the web. Googling "5 Why" gives slightly over 3 million results. The basics of 5 Why is rather simple. You just ask the question "Why?" five times to find the root cause of a problem. This is often illustrated with a simple example like:

- The car will not start.
- **Why?** – The battery is dead.
- **Why?** – The alternator is not functioning.
- **Why?** – The alternator belt has broken.
- **Why?** – The alternator belt was worn out.
- **Why?** – The car was not maintained (the root cause). *(Source:* Wikipedia "5 Whys"*)*

Figure 238: 5 Why can be aggressive (Image studiostoks with permission)

This technique is popular in literature, and also with management, at least in theory. While some sources describe it in more detail, many others oversimplify the process, in which case it may look like this: The manager simply asks the subordinate "Why?" five times in a row, after which the subordinate has found the root cause and can get to work fixing it. There is no mental involvement needed for the manager. **If it were only that simple …**

28.2 The Proper Way to Ask Why

28.3 What Kind of Problems Can Be Solved with 5 Why?

5 Why is a technique that follows a path rather linear to a single root cause. Hence, **it is usually best with problems that probably have only a single root cause**, or at least very few root causes. The more possible causes a problem has, the more difficult it will be to use this method.

For example, if your problem is "Our company is not making money!" 5 Why may not be the right method. While it will eventually lead to one answer, it is highly doubtful that this is the most important one, and in all likelihood it is not the only cause. In this case, other methods like fishbone diagrams or brainstorming may yield better results.

As always, before setting out to solve a problem, **make sure it is a relevant problem!** In your work, you will encounter a myriad of problems, only a few of which you can solve. Invest your time and the time of your people in a problem that will make a difference for your company (see, for example, my post How to Manage Your Lean Projects – Prioritize).

Once you have the problem defined, think about how to approach the problem. 5 Why may or may not fit all problems. Do not start with "I want to do 5 Why" and then think about which problem you could solve. **Always start with the problem!**

And, as always in lean, whenever possible go to the site of the problem and have a look directly at the current situation: **Go to Gemba!** (many thanks to Thomas Meyer for the suggestion)

28.4 Who Do You Want to Ask?

5 Why can be done with a larger group, one-on-one, or even by yourself. The people involved need to know about the problem and have the ability to analyze its causes. It is okay to ask the mechanic in charge why the machine breaks, but it would probably not help to ask the accountant.

28.5 Evaluate and Verify the Answers

Figure 239: Dead End (Image Vaikoovery under the CC-BY 3.0 license)

The success of 5 Why depends a lot on the quality of the answers. If the answers are guesses, then the outcome will be random. Let's take the example from above, "The car will not start," where the first answer was "The battery is dead." If this is correct, the path of the questions will continue successfully. However, if the answer was wrong, and the car was out of gas, then you will end up with a false root cause. Changing the maintenance standards for the battery will not help you with an empty gas tank.

Figure 240: Found the scapegoat! (Image Лобачев Владимир in public domain)

Another popular answer (at least in Germany) is to blame someone else. “The car will not start. Why? It is the fault of the other person/department/company/etc.” This, of course, is not helpful. Focus on the process, not the people.

Also, causes are often mixed up with symptoms. Make sure that with each why, you get the next cause of the problem.

Hence, with every answer you and/or your team needs to verify if it is correct, useful, and the only or at least the most likely answer. In some cases this may be obvious; in others it may require some testing and data collection.

28.6 How Many Whys?

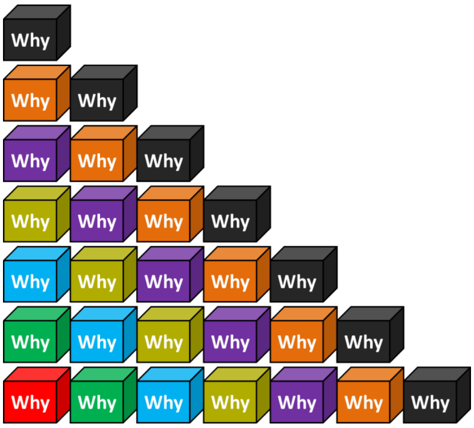


Figure 241: Why Matrix (Image Roser)

The method is known as 5 Why, and most examples show exactly 5 whys. However, this is only a rule of thumb, and also a catchy name (“6 Why” feels odd). In fact, I rarely exceed 3 Why. Maybe my mind jumps over steps. Take again the example from above, “The car will not start,” where the first why could already be: “**Why?** The alternator belt has broken,” followed by “**Why?** The car was not maintained.”

Using the example above, it is also easy to imagine more than 5 whys. It is easy to continue the example above from “Why? The car was not maintained,” to “Why? Maintenance is overworked,” to “Why? There are too few people,” to “Why? The budget was cut,” and so on. <sarcasm> Only on AllAboutLean.com do you get **8 Whys** for the price of 5 ☺ </sarcasm>

Hence, **the number of whys can be flexible!** More important than the number of whys is knowing when to stop. You should continue to ask why (and verify the answers) until you arrive at an answer where you can fix the problem for good. **Often, 5 Why ends when an answer points to a process!** A part can be fixed, but this fix is only good until the part breaks again. Changing a process, however, is much more likely to prevent the problem from arising again.

Also, if your last "Why?" ends up pointing to the fault of an employee, it may be worthwhile to ask "Why?" at least once more. A mistake by an employee is often due to lack of training, lack of time, lack of tools, overwork, or other organizational causes. Thanks to David Norby for the suggestion.

28.7 Multiple Root Causes

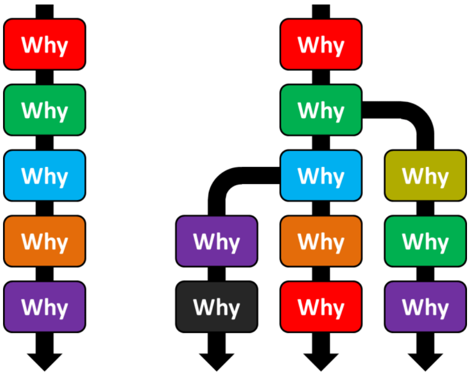


Figure 242: Single and multiple root causes (Image Roser)

Another common problem with 5 Why is multiple root causes. A given problem may have more than one cause that contributes to the problem. It is possible to track these branches and ask "why" questions following up each individual branch. However, the more branches there are, the more cumbersome it will be. Hence, as described above, 5 Why is usually best suited for problems with few or even one possible root cause.

28.8 The Therefore Test

After going through the 5 Why, there is also a test going back in reverse. This is called the "therefore" test or "So what" test. This is a test to check the validity of the answers. While not foolproof, it may help you to make sure your logical chain is correct. Using the example above it would look like this:

- The car was not maintained.
- **Therefore** therefore the alternator belt wore out.
- **Therefore** the alternator belt broke.
- **Therefore** the alternator was not functioning.
- **Therefore** the battery was dead.
- **Therefore** the car did not start.

(Many thanks to Phil Ledbetter for the suggestion!)

28.9 Caveats

5 Why is good for problems with few or even only one root cause. However, often you don't know beforehand about the root causes. If you do know the root cause, the whole process of finding the root cause in the first place may not be necessary. This brings me to the formality of the method.

Figure 243: Dig deeper! (Image jimbomack66 under the CC-BY 2.0 license)

Occasionally this method is mentioned as a full-blown 5 Why workshop, where a team is assembled to be asked "Why?" five times. I find that risky. You don't know beforehand how the process will split. You don't know beforehand how often to ask why. And telling your people beforehand that you will ask them "Why?" five times is more likely to annoy them than excite them.

Hence, I believe this method is not suited as the program for a formal workshop, but more as an internal method for the moderator. **Do not announce that you are doing "5 Why," but instead just do it as you see it fit!** It is, after all, only an aid to help you dig deeper. It also should not be your only tool in your toolbox in finding the root cause, but should be combined with other approaches.

Figure 244: Wherefore? (Image Madrabothair fro with permission)

At least in German you can vary the wording, where "Why" can be translated to "*Wieso,*" "*Weshalb,*" "*Warum,*" and "*Weswegen,*" giving you already four variants for the five whys. In English, however, you are stuck with "why." The only other variant I know is "Wherefore," but this is terribly archaic, and you should avoid using it unless you habitually wear a frock and a monocle. Nevertheless, try to get some variation in your questions or risk sounding like a nosy kid.

28.10 5 Why to Find the Root Problem

5 Why is one of many methods to find the root cause for a problem. However, I also use this frequently in the other direction to find the **root problem to a given solution**. When I talk with managers on the shop floor, I often ask them what they consider to be their biggest problem they want to address. And all too often, I get a response like: "We want kanban."

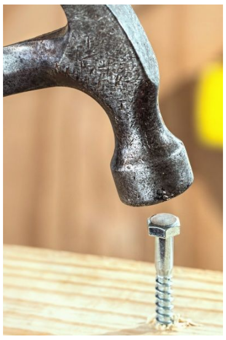


Figure 245: The right solution? (Image stevepb in public domain)

Ding-ding-ding – WRONG! Kanban is a solution, not a problem. I am a firm believer in starting any lean activities from a problem. Just copying the solution of someone else will fail. And kanban is a solution that may or may not fit the problem at hand. Hence, I often find myself going 5 Why in the other direction, for example like this.

- We want kanban.
- **Why?** Well, because Toyota does it successfully.

- **No, really, why do YOU need kanban?** Because we often have stoppages due to lack of material.
- **Why?** Because the material arrived too late.
- **Why?** Because our material flow is chaos.
- **Why?** Because our order and reproduction process is disorganized.
- Okay, so your problem is actually a disorganized order and reproduction process. Let's move forward from that.

You get my point? Sometimes you first have to find out what is really the problem before solving it.

28.11 Something Different: 5W1H

Let me also quickly introduce a method that sounds similar but is for a different purpose. 5 Why is sometimes abbreviated as 5W, but this risks being mixed up with **5W** and its variants **5W1H** and **6W**. The 5W (or 6W) and the 1H stand for

- **Who** (was involved)
- **What** (happened)
- **Where** (did it take place)
- **When** (did it take place)
- **Why** (did that happen)
- **How** (did it happen)(for 5W1H)
- **Which** (will you make/do)(for 6W)

The sequence is, by the way, not standardized. Nor is the exact list of questions. Some users prefer "**To whom**" over "why", or add a second H with "**How much**". There are lots of possibilities here, too, to fit this method to your needs (Thanks to Koen van Dam for the suggestions). This is not so much a method for root-cause analysis but rather a structured set of questions to get the overview of a situation. This set of questions covers the breadth of a topic rather than the depth. As such it is also useful, but for a different purpose.

28.12 Summary

5 Why on its own is a quite limited tool. It is also not suitable as the main structure for a full-blown formal workshop. However, as an underlying approach to dig deeper for the actual root cause, it is quite useful. As with most lean tools, it is not so much the tool as the skill of the user that determines the success. **Now go out, keep asking why, and organize your industry!**

29 What Exactly Is Jidoka?

Christoph Roser, July 17, 2018, Original at [*https://www.allaboutlean.com/jidoka-1/*](https://www.allaboutlean.com/jidoka-1/)

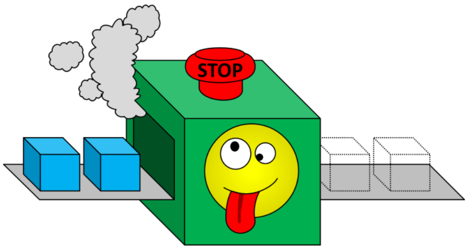


Figure 246: Broken Machine in Jidoka (Image Roser)

Jidoka is a term commonly used in lean manufacturing, and widely considered one of the pillars of the Toyota Production System, the other being Just in Time (JIT). However, while the word *jidoka* is often used to impress others, the ideas behind it are much less frequently found outside of Toyota. Maybe this is because so many people interpret jidoka differently. In this first post of a three post series on jidoka, we look at what jidoka actually is.

29.1 A Bit of Linguistics

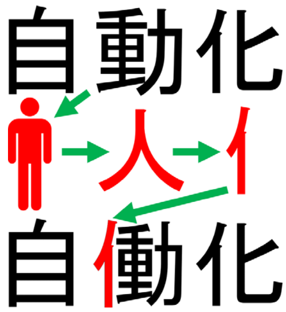


Figure 247: Jidoka (Image Roser)

Jidoka (also written *jidouka* or *jidohka*) is a Japanese word modified by Toyota. The original word was 自動化 (pronounced *jidōka* with a long "o"*)* and simply means automation. The *kanji* in the word mean

- 自 for self, oneself
- 動 for motion, change, confusion
- 化 for the action of making something.

Toyota did a play on words by changing the middle *kanji* from 動 to 働. The new *kanji* means work or labor. This *kanji* has two more strokes on the left, a so-called radical, which represents 人 for human or person. Since it is squished to the side of the other *kanji,* it is written a bit distortedly.

The new word 自働化 is also pronounced *jidōka* and – confusingly enough – translated by most dictionaries also as "automation." However, the meaning at Toyota is quite different, and very far from "automation." The commonly used English word for jidoka is *auto***no***mation*, based on *autonomous* and *automation*. Others call it *intelligent automation*, and again others describe it as *automation with a human touch* (remember the additional character 人 for human).

29.2 What Is Jidoka?

Jidoka is defined differently depending on who you ask. It may be an automatic stop of the process in case of irregularities, multi-machine handling with semi-automated machines, partial automation, or the automation of dangerous, demanding, and dirty work. (Many thanks to Michel Baudin and his book Working with Machines for the list.)

The way I know it and the way I will describe it in more detail below is that jidoka means a process stops automatically if there are any irregularities. Subsequently – if possible – try to eliminate the reason for the stop.

29.3 When to Stop the Process

Figure 248: Stop Sign (Image unknown author in public domain)

Stopping the process in case of trouble is essential for a good production system. Jidoka is the concept of stopping the process **automatically** if there are problems or abnormalities. Such stops can be for a multitude of reasons.

29.4 Quality Issues

Figure 249: Keep Calm and Stop the Line (Image Roser)

Probably one of the main reasons to stop a process is if there are quality problems. A couple of things can happen if you pass quality issues down the value stream.

- The defective part continues to be processed, and value is added to a defective product that may have to be thrown out. If you build a complete engine where the cylinder is misaligned, you throw out the complete engine and not only the engine block.
- Even if the product can be salvaged, the more work was done after the defect, the more effort it will take to fix the issue. If the defective engine is already in the car, then a lot of work may be needed to remove the engine again for repair.
- The delay between the cause of the problem and the detection of the issue may lead to many more defective problems because the problem is not identified early on. If your machine tool is misaligned, all parts produced since the first defect will have the same defect.
- Finally, for one-off issues, a delay between the cause and the detection may mean that the problem is no longer active when we want to fix the issue. This can make it more difficult to determine the cause of the problem and to find a solution. It does, however, give a great opportunity for the blame game, where everything is somebody else's fault.

In sum, stopping the process early on reduces the follow-up costs of defects and allows for an easier fixing of the problem.

29.5 Process Issues

Figure 250: A bit worn out … (Image Roser)

There may also be issues with the process that may not lead to quality problems, or at least not immediately. In this case, the process should be stopped too. For example, if the machine is overheating, it should be stopped and investigated. Even if the quality of the parts is still good, an overheating machine may eventually lead to defective parts, or to a machine breakdown, or – worst of all – to an injury. In the latter case, you do not get any parts at all, but instead a long delay and a potentially significant repair bill as well as an injured employee.

29.6 Material Supply Issues

Figure 251: Your MRP system told you the parts you need would be there – but sorry, they are not. (Image Roser)

Another common example for a process to stop even though there is no impact on quality is to fill up the material supply for the process or set up a new part. This can also be seen as an abnormality, as the process is not working normally, but rather being prepared. Of course, if you need to stop the process for a set-up, you have to stop it.

29.7 Do It Automatically

Figure 252: Boring Inspection (Image SeventyFour with permission)

The whole "stop the process if there are problems" should happen automatically. Having a human watch over the machine constantly is both demanding and error-prone. For example, if you manually have to inspect every part for even one type of quality defect, your eyes will get blurry rather quickly. It does not help that many defects happen rarely. Even if one out of one hundred parts have this defect, the work would get really boring really quick. And most defect rates are far, far below 1%.

Hence, for jidoka it is very important to have an automatic stop for any kind of abnormality, from quality problems to machine issues to running out of material. If the machine would continue with this abnormality, the costs down the line would multiply. As such, jidoka draws on tools like poka yoke, although poka yoke is more geared toward manual work, and andons. But to me this automatic stop in case of abnormalities is the core of jidoka.

29.8 Fix It!

Stopping the process is the key of jidoka. However, it does not stop there. Naturally, after the process stops, there should be a focus on getting it going again properly. Hence, the problem at hand needs to be resolved. If it is a quality issue, fix it. If the machine has problems, maybe do maintenance. And if the machine stopped due to lack of material, restock the material. This fix does not necessarily have to be permanent.

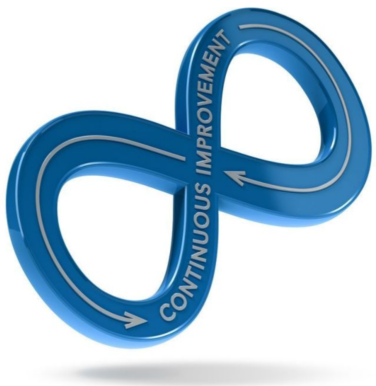


Figure 253: Continuous improvement (Image Olivier Le Moal with permission)

However, if you can get a permanent fix – even better! Depending on the type of stop, you may invest time and effort to not only apply a quick fix, but maybe eliminate the root cause of the stop and prevent it from happening again.

This may not always be possible, but if there is a chance to reduce or eliminate the stop, go for it. Analyze the stop, find the root cause, develop one (or multiple) solutions, and then implement them so the problem will not happen again.

In summary, the main point of jidoka for me is to stop the process if there are abnormalities, and then get your process back under control. Optionally, you may try to prevent the issue from happening ever again if possible. Also note that **the stop is only done to prevent bigger problems downstream and also to highlight the issue, making it more likely to be fixed!**

This all sounds rigorous and daunting. But, in your factory, you may have more problems than what you can fix. Most factories do. In my second post on jidoka, I will talk a bit about the practical approach, and also get a little bit philosophical. Bear with me. **Now, know when to stop your line and how to get it flowing even better, and go out and organize your industry!**

P.S.: This series of blog posts started because Sammy Obara at the very nice Lean Poland Conference mentioned that there is very little information on jidoka available online. Well, challenge accepted ☺.

30 The Philosophy and Practicality of Jidoka

Christoph Roser, July 24, 2018, Original at https://www.allaboutlean.com/jidoka-2/

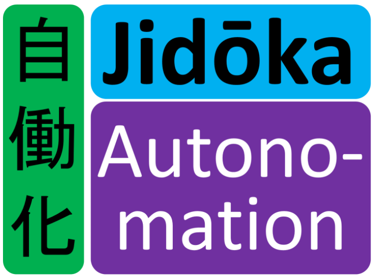


Figure 254: Jidoka is Autonomation (Image Roser)

In my last post I explained what jidoka is (at least in my view). The key part is to stop the line for any irregularity, and resolve the problem. Also try to make sure this irregularity does not happen again. However, this definition is far from universally accepted, and there are many different opinions. Here I will try to show the philosophical idea behind Jidoka as one of the two pillars of the Toyota Production System (the other is JIT).

30.1 A Lot of Different Meanings …

Figure 255: Different Meanings… (Image MicroOne with permission)

Part of this variety of names may be due to the many different meanings that have been attached to jidoka. The source of the list below is the highly recommended book Working with Machines by Michel Baudin.

- At Toyota, jidoka is seen as the ability to **stop a machine or process if there are any problems**. This applies to manual or automatic processes, and these problems may be for example a breakdown or quality issues.
- Jidoka may also refer to **semi-automated machines, where a worker can manage multiple machines at the same time**, for example in a chaku chaku line.
- Some use the original translation and see jidoka as automation, where there is **a gradual increase in automation over time**, and hence people do less and less manual work.
- Another definition, confusingly also from Toyota, sees jidoka as the **automation of dangerous, dirty, or demanding work** (also known as 3K for *kiken* (危険, dangerous), *kitsui* (きつい, difficult), and *kitanai* (汚い, dirty).

As you see, it is all very confusing. Different definitions exist even within Toyota. Which one should it be? All of them involve humans and automation in some aspects. Of course, I have no authority to set the ultimate definition, but I do have an opinion.

30.2 The Toyota House

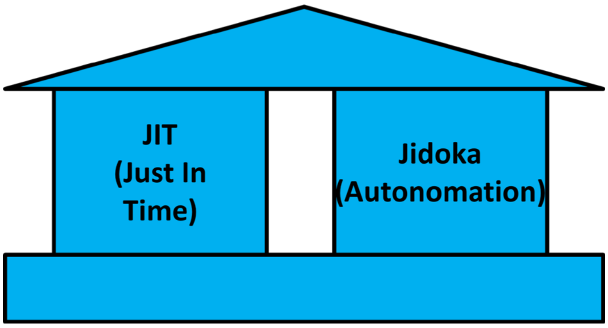


Figure 256: A very simplified Toyota House (Image Roser)

We often like to arrange a set of methods in a methodology in the shape of a house, with a basement, pillars, and a roof. There is also a house for lean manufacturing, called the House of Toyota. While there is no commonly agreed-on House of Toyota, jidoka is commonly seen as one of the two pillars of the Toyota Production System. The other pillar is Just in Time. As for the bottom and the top, there is little agreement beyond stuffing the bottom with lean tools and philosophies and the top with positive outcomes. Hence I left these out from this (simplified) house shown here.

Just in Time **is all about flow**. Parts should arrive just when they are needed, in the amount needed, and in good quality. After processing, the parts continue to arrive just in time downstream at the next processes. If you have JIT everywhere, your parts would be flowing all the time, except for brief stops for processing. Hence, this "flow" is clearly one of the significant underlying philosophies at Toyota.

Now, as for jidoka, which definition could we use to complement this idea of flow? Eliminating dirty, dangerous, and demanding work (#4 from above) is clearly too mundane, as is multi-machine-handling (#2) and some bit of automation (#3).

However, the idea to stop a process if there are any problems (#1) and then make sure that it does not happen again is a very important concept for me. This overlaps a bit with multi-machine-handling (#2) and automation (#3).

Hence, JIT is the goal to establish flow, and jidoka means a process stops automatically if there are any irregularities.

30.3 A Bit of Philosophy

Figure 257: JIT Jidoka Ying Yang (Image Roser)

Diving deep into the Toyota philosophy, you could see this as JIT telling you to let the material flow, and jidoka telling you when to stop the flow. This is a bit like the Chinese philosophical concept of **Ying and Yang, where seemingly opposite or contrary forces may actually be complementary**.

The same applies here. JIT encourages flow, and Jidoka encourages stops, which seems contrary. However, both help to produce more and better parts at a lower cost. Unfortunately, JIT gets much, much more attention as it is the glamorous and positive side, whereas jidoka is often seen as all about problems and stops and other negative aspects. Yet, both are necessary for a good production system.

30.4 Comparison: GM vs. Toyota

Figure 258: Toyota and GM (Image Toyota and GM for editorial use)

As a counter-example, let's take the old Fremont plant of GM (closed in 1982, and later reopened as the Toyota-GM joint venture NUMMI). In Fremont, the philosophy was to never ever stop the assembly line, no matter what. When there were quality problems, they were merely pushed down the line, creating massive problems downstream. Occasionally this even resulted in zombie cars that were half of one model and another half of a different model. Needless to say, the repair and defect costs were enormous. They also did not stop for lack of manpower, and simply hired some people from the bar across the street on the spot and put them on the line – again with devastating results for quality. There are even reports of accidents and injuries where the line was kept running. Yet, despite the "keep it running" vision, the line was stopped frequently. (GM has since then improved, but the idea to keep the line running is still strong).

Toyota, on the other hand, stops the line whenever there are problems, and then tries to find a solution. As a result, newly created assembly lines at Toyota stop very often but, after a few months' ramp-up, run much, much more reliably than other automakers' assembly lines. This results in better quality and less expenses.

30.5 A Practical View

Jidoka works very well because Toyota provides a LOT of manpower to resolve such issues, and you would be flabbergasted to hear how many people a Toyota plant has to help with such problems.

Figure 259: Overworked worker (Image Roser)

Quite possibly, your plant may not have such a luxury of excess manpower to solve problems. Any excess manpower may have long ago been removed to cut cost. Yes, you probably still have a qualified problem solver, someone to take care of problems. However, that person is probably also *responsible for managing 200 people, creating their schedules, taking care of absences, resolving employee disputes, doing data entry into a computer, following up on missing parts, adjusting the production schedule based on changing customer demands, and making sure that the toilets still work, all besides being the first responder for 100+ machines and gazillions of quality problems*.

The point I want to get to is that your highly qualified problem solver simply has no time to solve problems, and because he is so qualified, he is so overloaded that he can barely keep the plant going.

Jidoka is the automatic machine stop in case of abnormalities. Someone has to take care of the problem, and at least add a temporary fix. Not applying a quick fix to get the machine running again will obviously be a problem, because then you produce no more parts. Not stopping the machine in the first place will be even worse, because you create many more issues downstream, eating up even more of the time of your people.

Figure 260: I can't give you what I don't have … (Image 1820796 in public domain)

An optional logical next step is to find the root cause to eliminate the problem for good. However, your people may not have the capacity for a long-term fix. Purists will disagree with me, but **you may have to do with a quick fix**. Yes, the problem will pop up again, and will continue to eat up more manpower. But in this situation you are like a poor person who cannot afford a good car, and the junk he is driving will cost him more in repairs and delays than if he would have bought a better car. Telling the poor guy to just spend more money on a better car does not help here.

Still, try to put in some effort to get at least the worst issues resolved permanently. Out of the many reasons for the stops of the process, prioritize and pick one problem that you want to work on. Try to get this fixed. Once this is done, work on the next problem. Repeat and keep on going until … well … sorry … this will continue as long as you are in this position, and your successor will have to continue after that. Problems in a factory have a tendency to never end.

Also, even Toyota cannot fix all their problems. One key element of jidoka is that if you cannot prevent the mistake, then at least the machine should stop so you can fix it. This automatic stop is also already big step in the right direction.

30.6 Summary

Usually my blog posts are much more into practical advice, but I hope you still enjoyed this excursion into the Toyota philosophy of jidoka and JIT. Or maybe my head is just turning mushy from the heat. In any case, my next post on Jidoka will have some examples. Anyway, **now go out, and organize your industry!**

P.S.: This series of blog posts started because Sammy Obara at the very nice Lean Poland Conference mentioned that there is very little information on jidoka available online. Well, challenge accepted ☺.

31 Examples of Jidoka

Christoph Roser, July 31, 2018, Original at https://www.allaboutlean.com/jidoka-3/

Figure 261: Toyoda Model G Automatic Loom (Image Roser)

In my last two posts I talked a lot about what jidoka is, and the underlying philosophy. Many articles do so. But there are almost no actual examples out there of jidoka. But without examples it is difficult to really understand a concept. A great historic example of this is the Toyoda Model G automatic loom from 1925. This is well known, but here I would like to show you how it connects to jidoka. I will also give you a more modern example of a product that you may even own.

31.1 Toyoda Automatic Loom Type G

Figure 262: Sakichi Toyoda (Image unknown author in public domain)

One famous example of jidoka is the Toyoda Automatic Loom Type G, invented and patented in 1925 by Sakichi Toyoda (1867–1930). This was one of many looms invented by this *King of Inventors*, but it is probably his most famous one.

This loom was able to run almost unsupervised. Routine tasks like restocking yarn could be done while the loom was running, and could be done anytime before the yarn ran out. The loom was also able to detect problems and could shut down. An unskilled worker could easily supervise thirty to fifty looms.

This loom was probably the most advanced loom of its time. The model was so successful that it was also produced by other makers in license from Toyoda. Let me show you what tricks were used in this loom. These are fine examples of the outcome of jidoka: Whenever there is a problem, stop the process immediately, and fix the issue.

31.2 Warp Break Auto Stop

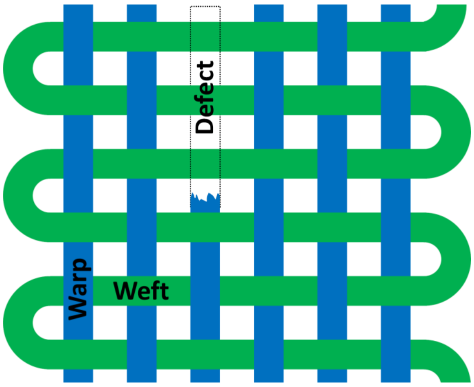


Figure 263: Warp Weft Defect (Image Roser)

One unique feature was the Warp Break Auto Stop. The warp is a set of parallel strings through which another string (the weft) is woven. If the warp breaks, it has to be fixed quickly. The longer an automatic loom produces with a broken string, the more defective cloth is produced.

In olden times, a worker – often a child with lower wages than an adult – had to supervise machines constantly, and if a warp broke, quickly had to tie it back together. Children working with moving machines with little concern for their safety is not a good combination.

The Toyoda Automatic Loom Model G had a novel feature. Every warp had a piece of sheet metal hanging from it. This is shown in the image below. The tension of the warp held the sheet metal up. However, if the warp broke, the sheet metal fell down by a few centimeters. Below the sheet metal was a bar that was connected to the shuttle movement, and hence moved rhythmic back and forth. As long as the warps were intact, there was enough space for this bar to move. However, when a warp broke and fell down, it blocked the movement of the bar. This blockage of the movement immediately stopped the loom and prevented it from producing defective cloth. The shiny metal rods you see in the image below allowed the sheet metal to fall down a fixed distance and also held them in place when the moving bar tried to push them out of the way.

This is a prime example of jidoka. The machine stops automatically if there is an abnormality. The Model G also has a gadget to stop if the weft breaks.

Figure 264: Toyoda Model G Automatic Loom Detail Warp Break Stop (Image Roser)

The following video shows how the system works (the warp break auto stop starting at 3:19).

The Video by Kristianto Jahja is available on YouTube as "Andon&Loom" at https://youtu.be/VkU8DpZu2XY. The warp break mechanism is visible from 3:19 onward

31.3 The Automatic Shuttle-Change

The Model G also had an automatic shuttle change, shown below. The shuttle is a small device containing the weft and is moved back and forth through the weave. In the picture below, these are the stack of wooden "ships" above the center, and an empty shuttle can be seen below in the white box.

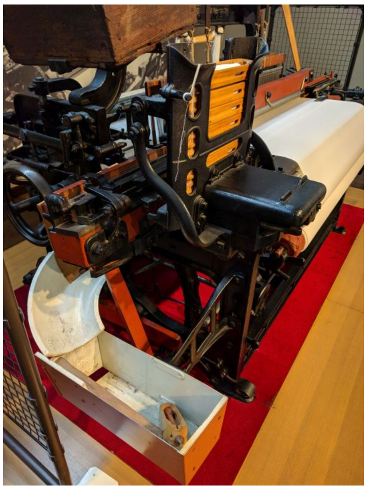


Figure 265: Toyoda Model G Automatic Loom Detail Automatic Shuttle Change (Image Roser)

Previously, if the shuttle was empty, the loom had to be stopped and a new shuttle had to be added. The Model G does this automatically. The operator had to restock a supply of shuttles, but this could be done while the machine was running. Even better, the operator could add seven or eight shuttles at a time, and could refill anytime when it suited the operator's availability. The machine automatically detected if a shuttle was empty and kicked a new shuttle in, which automatically ejected the empty shuttle. The process could continue without interruption, so no immediate attention of the operator was necessary.

This is also an example for jidoka. But now you may be wondering something. Jidoka is about stopping the process automatically in case of abnormalities. But here, this automatic shuttle change is exactly there so as NOT to stop the machine. Here, you have no stops of the machine, how can this be jidoka?

Well, jidoka is about stopping the machine automatically. But an optional next step is to figure out how to prevent this stop from ever happening again. This is what happened here. Predecessors of this machine have been stopped (manual or automatic) millions of times to add a new shuttle. Sakichi Toyoda worked with the problem and resolved it. Now the machine no longer has to stop. Hence, it is the ultimate form of jidoka: Make a machine that can run without stops!

31.4 Example: Laser Printer

Let me show you another example of jidoka, a normal laser printer. Let's start with the automatic stops.

31.5 Empty Toner

Figure 266: Four toner cartridges (Image W.carter under the CC-BY-SA 4.0 license)

Any modern printer stops automatically if the toner (or ink) is low. There is (little) risk of defective prints due to lack of toner. If the printer would not stop automatically, you would waste paper. In a worst case you would print a larger document where the first pages are good but the subsequent pages decrease in quality. If this document goes to your customer or boss, it would make you look unprofessional.

Of course, printer manufacturers err very much on the conservative side, meaning you have to buy more toner or ink. After all, for most small printers you get the printer almost free and pay through the ink. But I digress.

31.6 Paper Jam

Figure 267: Paper Jam (Image AndreyPopov with permission)

Another common example of an automatic stop in a printer are paper jams. If the printer detects that something odd is happening with the paper, it will stop the print and alert you to the issue, often with some indication of which part of the printer is in trouble. After the jam is cleared, the print continues. If the printer would not stop, you would waste time, toner, and paper, and potentially damage your printer.

Both the empty toner automatic stop and the paper jam automatic stop are examples of jidoka. Granted, these are not fancy examples, and you may take them for granted. But just for an instance, imagine the printer would NOT stop. We got used to the comfort, and may complain about the stop, but it is a nice example of jidoka that saves you time and money.

31.7 Paper Feed – Less Changeover

Figure 268: HP LaserJet (Image Joydeep under the CC-BY-SA 3.0 license)

Another example with a printer is the automatic paper feed for blank paper. This is an example where a long (looong) time ago a worker had to feed every page individually into the printer while the printer was stopped. Over time, these stops were resolved, and with the paper tray in a modern printer you can print hundreds of pages before you have to refill the printer. Again, not a fancy example, but one that saves you a lot of time. With lean, you don't need fancy and shiny bells and whistles, as long as it makes your work easier.

Well, here we are with two machines that are the result of a jidoka process. Like many things in lean, this is a never-ending process. For your printer you probably can easily come up with a few problems that still causes stops. Could you reduce the likelihood of a paper jam? Could you reduce the likelihood of warp breaking? Continuous improvement never ends.

Wow, over four thousand words on jidoka across three blog posts. And all of this because Sammy Obara at the Lean Poland Conference mentioned in passing that there is very little information about jidoka online. Well, challenge accepted 🙂. It took me quite a bit longer than usual to write these posts, and I did rewrite quite a bit of it, changing my mind a few times. But now I feel that it is a well-rounded series of posts. I learned a lot, and I hope you learned a lot too. **Now go out, get your machines to stop (automatically!) if there is a problem, and organize your industry!**

32 Lean and Industry 4.0

Christoph Roser, August 07, 2018, Original at https://www.allaboutlean.com/lean-and-industry-4-0/

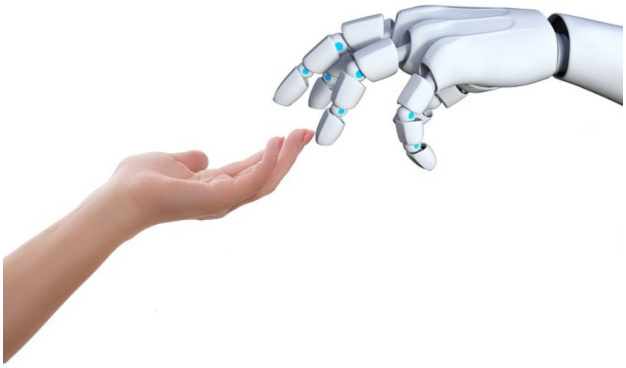


Figure 269: Human and Robot Hand (Image Maxpixel in public domain)

Industry 4.0 is one of the hot topics of modern manufacturing, although some (myself included) say that it is overrated. Lean is one of the older but also still important topics in manufacturing. In this post I would like to compare lean and Industry 4.0. What are the differences, what are the commonalities? Can they complement each other or do they conflict?

This post is based on a presentation I did on June 13, 2018 at the very well-organized and interesting 18th Lean Management Conference for Production and Services in Wroclaw, Poland. They also provide videos of the presentations, hence you can also watch me below 🙂.

The Video by LEI Polska is available on YouTube as "Christoph Roser: Lean and Industry 4.0" at https://youtu.be/qH3Ea0DfXzY

32.1 Introduction

Industry 4.0 is all about using computer technology, artificial intelligence, and especially networks to improve production. To me, it is a bit over-hyped, and there are much more ideas and visions than things that actually work. See my posts A Critical Look at Industry 4.0 for my, well, critical look, and Industry 4.0 – What Works, What Doesn't for, well, what works and what doesn't.

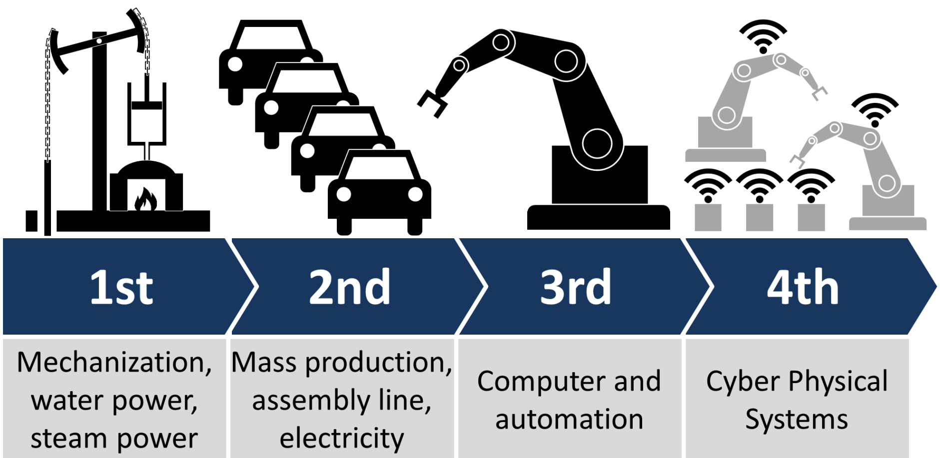


Figure 270: Industry 4.0 (Image Roser)

Overall, it is not very well defined what Industry 4.0 actually is besides a German research program. We are also not sure how it differs from Digital Manufacturing (1970s), Computer Integrated Manufacturing (CIM) (1990s), Digital Factory (2000), Factory 2.0 (from 2005), and the Smart Factory (from 2007), all of which had big promises but few actual results.

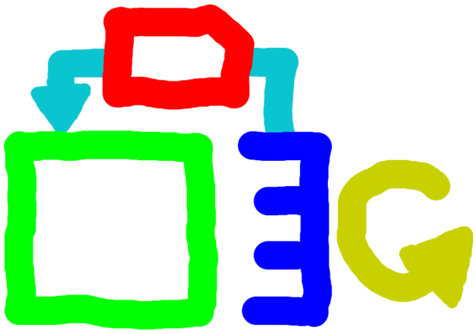


Figure 271: Kanban loops are a basic tool of Lean. (Image Roser)

Lean Production has been around for half a century or more, developed by Toyota from 1950 onward as the Toyota Production System. Like Industry 4.0, lean is also not well defined. It includes Just in Time and Jidoka as well as Muda, Mura, Muri (waste, unevenness, overburden), respect for people, and many other things. I worked for Toyota for five years, and I am a strong fan of lean, hence keep in mind I may be a bit biased. Nevertheless, even in lean a lot of the projects fail or show no significant improvement.

32.2 Similarities between Lean and Industry 4.0

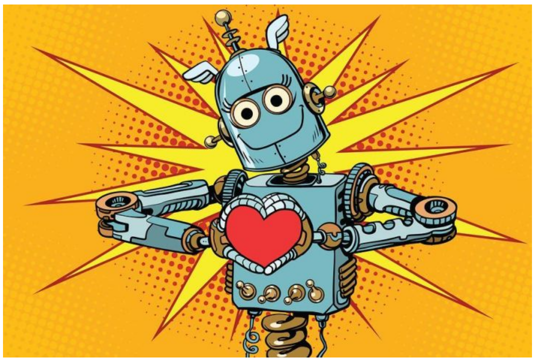


Figure 272: Robot Love (Image studiostoks with permission)

Lean and Industry 4.0 do have a lot of similarities. A good implementation **requires your full attention and support** as well as a lot of time from both you and your people. If you overload your people and start too many projects at once, you will not get them finished, and even if you think they are done, they do not work very well. A key part of lean is to limit the work in progress to make the actual work easier. I strongly believe the same applies to projects.

This cannot be outsourced. If you just hire some people to do the work for you, it will not give you what you want. Even though it may look good, it probably won't work as intended. Don't get me wrong, external people can definitely help, but it is far from a "fire and forget" approach.

No matter if you are doing lean or doing Industry 4.0, PDCA **(Plan, Do, Check, Act) is essential for success**. While anything can look good in a presentation, the important part is if it actually works on the shop floor. Hence especially the Check and Act parts are important for success.

In both lean and Industry 4.0, **most implementations fail due to lack of PDCA**. And the failure rate is drastic. For lean, there are numerous sources stating that 70% to 90% of all lean projects do not bring any measurable benefit, and I believe that number. I have not yet seen similar sources on Industry 4.0, but my own personal experience would put the failure rate of Industry 4.0 projects also between 70% and 90%.

However, if you are one of the lucky 10% to 30% where lean and/or Industry 4.0 works, it **can make a huge difference for your business**. Both lean and Industry 4.0 have the potential to significantly reduce lead time, improve quality, and overall improve the profitability of the operation – if it is done right!

32.3 Differences between Lean and Industry 4.0

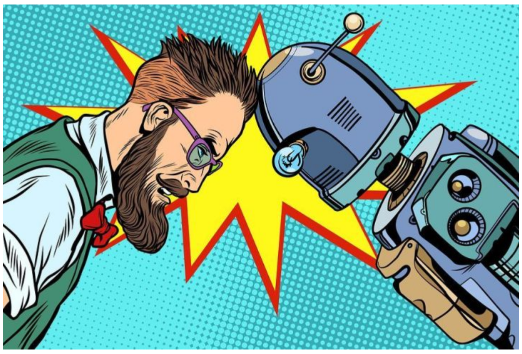


Figure 273: Robot Fight (Image studiostoks with permission)

There are also many differences between lean and Industry 4.0. **Working with People** is an essential part of lean, and lean looks at their needs and how they interact with each other. Industry 4.0, however, focuses on computers, automation, and robotics. The ultimate goal of Industry 4.0 is the lights-out factory, where there are no people left. Of course, there are also papers that claim that the workers are essential to Industry 4.0, but to me this feels fake. Something like "You are important, so shut up and do your work until you are replaced by a robot."

As for **the use of computers**, lean is not hostile to computers. If the best solution includes a computer, then lean will happily use computers, automation, networks, and any other computer-related aspects too. Industry 4.0, however, pretty much has to pick the computer solution over the conventional one. Computers and computer-free solutions both have benefits and disadvantages. My gut feeling is, however, that in most industries, the advantages of the computers are overestimated, and the problems overlooked.

Another difference is the **speed of the change**. Lean often has easy and quick-fix solutions as for example Karakuri Kaizen. Especially in Japan they often prefer the quick and dirty solution over an expensive and cumbersome one. As long as it works, it is good. Industry 4.0 on the other hand is hardware- and software-heavy. Any change requires a programmer and technicians, which are usually in short supply. Therefore, an Industry 4.0 implementation will take much more time, whereas a lean implementation can (not always but often) be faster.

Another related difference is **flexibility**. Industry 4.0 often does not have much flexibility. Of course, the goal is to flexibly produce any part you want anytime. But if you need to change the actual production system, Industry 4.0 takes much more time and money. In terms of complexity, this rivals an ERP change. If you work with ERP systems, think back to the last software update, version change, or – shudder – a complete change to a different ERP software vendor. It probably was very expensive and messy. The same applies to Industry 4.0. In my view, Industry 4.0 actually reduces flexibility. Lean, on the other hand, prefers to make many small steps over big leaps, as this will help your learning curve and give you more time to correct mistakes. It also encourages fast and flexible changes to improve quicker.

Figure 274: Can you move them three meters to the left? (Image Ricardo Liberato under the CC-BY-SA 2.0 license)

Finally, there is the topic of **continuous improvement**. The idea of always improving is one of the cornerstones of lean manufacturing. However, due to the slower speed of changes and implementations in Industry 4.0, most Industry 4.0 applications are what I would call "monuments." Very expensive, and once they are there, they are difficult to change. Hence, Industry 4.0 is often a one-shot approach that may (or may not) work.

32.4 A Quick Survey

During my presentation at the Lean Management Conference in Poland, I presented the audience with different Venn diagrams on how lean and Industry 4.0 interact, and also asked for their opinion in which one they believe most.

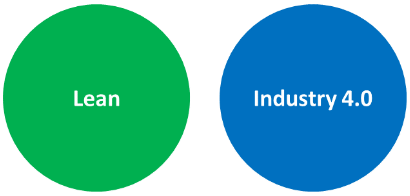


Figure 275: Lean and Industry 4.0 Separate (Image Roser)

The first option was a complete separation of Industry 4.0 and lean; they have nothing to do with each other. Around seven or eight people in the audience believed this to be the most likely scenario.

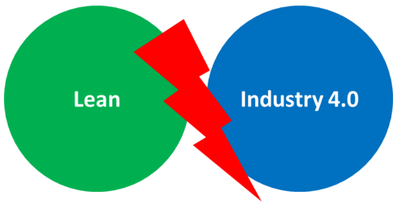


Figure 276: Lean and Industry 4.0 Conflict (Image Roser)

The second option was that lean and Industry 4.0 are actually in conflict with each other and actively fight for dominance or importance on the shop floor. In other words, it would be either lean or Industry 4.0, but a combination is not possible. Also around seven or eight people in the audience preferred this scenario, similar to the "completely separate" approach above.

Figure 277: Lean includes Industry 4.0 (Image Roser)

The third option showed Industry 4.0 as a subset of lean. Everything Industry 4.0 does can be seen as part of the lean methodology. Of course, for me as a lean guy, I see everything through lean glasses, so … *take that, you scummy digital wannabe pretender* … ahem … sorry. To be honest, this would not have been my preferred Venn diagram. However, a large group of the audience saw it this way – although with this being a **Lean** Management Conference, people may also have been biased in favor of lean.

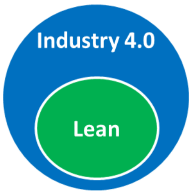


Figure 278: Lean as part of Industry 4.0 (Image Roser)

The next scenario was the other way round, with lean being a subset of Industry 4.0, and anything lean does is included within Industry 4.0. (*What?!?!? Come here, you buggy pile of transistors. I'll show you how manufacturing works!*). Surprisingly, this was the most likely scenario for one person in the audience. He said that this may be the most realistic scenario.

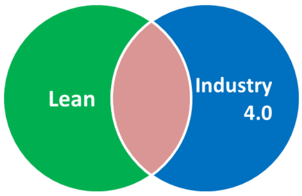


Figure 279: Lean and Industry 4.0 Overlap (Image Roser)

Another scenario is that there is an overlap between lean and Industry 4.0. They share ideas and visions and have to work together, but there are also a lot of distinct parts. This was also the preference for a significant group of the audience, and this would also be my preferred view of the world.

Figure 280: Lean equals Industry 4.0 (Image Roser)

Finally, the last scenario sees lean and Industry 4.0 as identical. There is no difference between lean and Industry 4.0; it is all the same thing. A few people also believed this to be the most likely scenario.

The surprise for me was that for every one of these scenarios above, at least one person voted it to be the most likely one. There was not even a clear winner, with both the scenario of Industry 4.0 being a subset of lean and the scenario with an overlap having a similar number of votes. Quite surprising. Anyway, as always, I hope this post was insightful to you. **Now, go out, and no matter if you do lean or industry 4.0 or both, organize your industry!**

33 What Is POLCA?

Christoph Roser, August 14, 2018, Original at https://www.allaboutlean.com/what-is-polca/

Figure 281: Polka Dot Girl (Image PXHere in public domain)

POLCA stands for **Paired-Cell Overlapping Loops of Cards with Authorization** and was developed by [Rajan Suri]() around 1990. It is sometimes mentioned alongside kanban and CONWIP as a production control system. Let me explain to you how POLCA works. In my next post I look at the pros and cons of POLCA. In my last post of this mini-series, I will show you the calculation for the number of POLCA cards, including some critical comments.

The similar-sounding word *Polka* is also a Czech dance music and textile pattern, hence the colorful illustration of the polka dots on the left (don't worry, more technical diagrams will follow below).

33.1 How It Works

POLCA is designed for job shops, systems of work centers, or systems of cellular manufacturing of high-mix low-volume or customized parts. The jobs may move differently from machine or cell to another machine or cell. Between each possible pair of machines or cells, POLCA establishes a loop similar to a kanban loop. However, instead of kanban or CONWIP, these cards are called **POLCA cards**. As the name implies, these loops are overlapping. You also need to calculate the **order release dates for the different jobs at each cell or machine**.

33.2 The Overlap

A simple example is shown below. A product came from machine M1 to M2, and will go to M3 next. Coming from M1 to M2 the product had the M1-M2 POLCA card attached to it. Continuing to M3 it will receive the M2-M3 POLCA card from the subsequent loop. **The product will be processed at machine 2 only if a) there is a M2-M3 POLCA card available and b) the order release date for this product on M2 has passed**. If either the product order is not yet released for M2 or there is no M2-M3 POLCA card, the order will not start at M2.

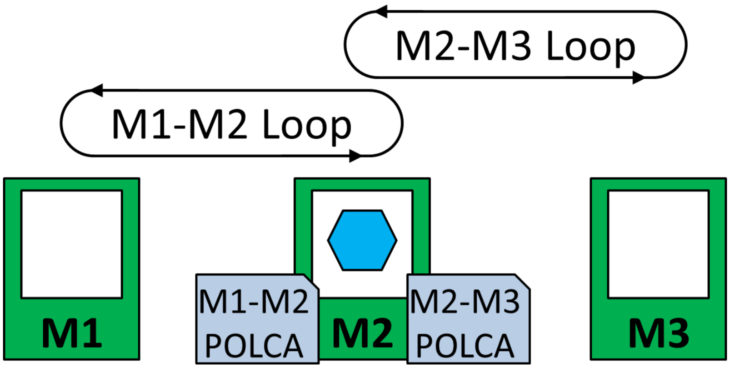


Figure 282: POLCA Overlap (Image Roser)

Once the product at M2 is completed, the M1-M2 POLCA card goes back to M1 to permit the processing of the next product at M1 (a loop can have multiple POLCA cards). Hence there is a pair of loops with POLCA cards that overlap at every machine or cell, hence **Paired-Cell Overlapping Loops of Cards**.

33.3 Elements of POLCA

A system using POLCA needs three elements for control:

- At the beginning of a larger system is a **list of open orders** that are released for the first production step.
- Between each pair of machines or cells, there is a **loop with POLCA cards**. Each POLCA card is assigned to one and only one loop, but it is not assigned to a certain product (unlike kanban).
- You need to calculate the **order release time** for each order in the list of open orders and each machine that it will pass though. For example, order 4711 can be started at the earliest at the first machine on Monday 11:00, the second machine Monday 14:00, and the third machine Tuesday 8:00. This is often done through an overarching ERP system.

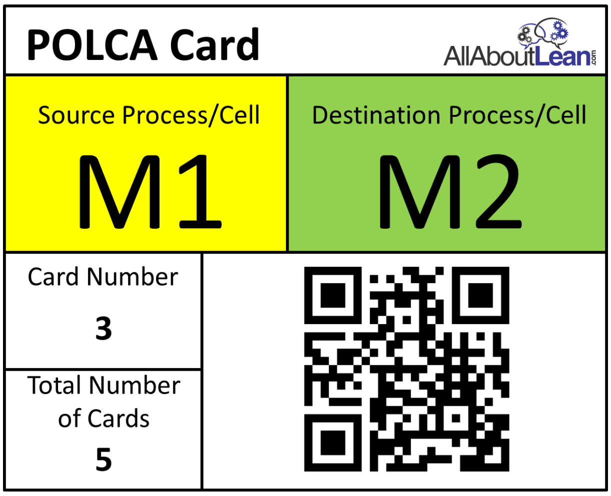


Figure 283: POLCA Card Example (Image Roser)

There is little information needed on a POLCA card. Most important are the **source process** and the **destination process**. For management it is also helpful to know the **index number of the card** in the loop, and the **total number of cards** in the loop. A **barcode** can also help.

Please note that this card does not necessarily have to represent only one item. A POLCA card can also be used for batches of material. If your batches get too large, however, you may consider using multiple POLCA cards for large batches.

For larger systems it may be better to implement these cards virtually in an ERP or similar computer system, where a computer keeps track of the cards as well as the release dates.

33.4 Rules of POLCA

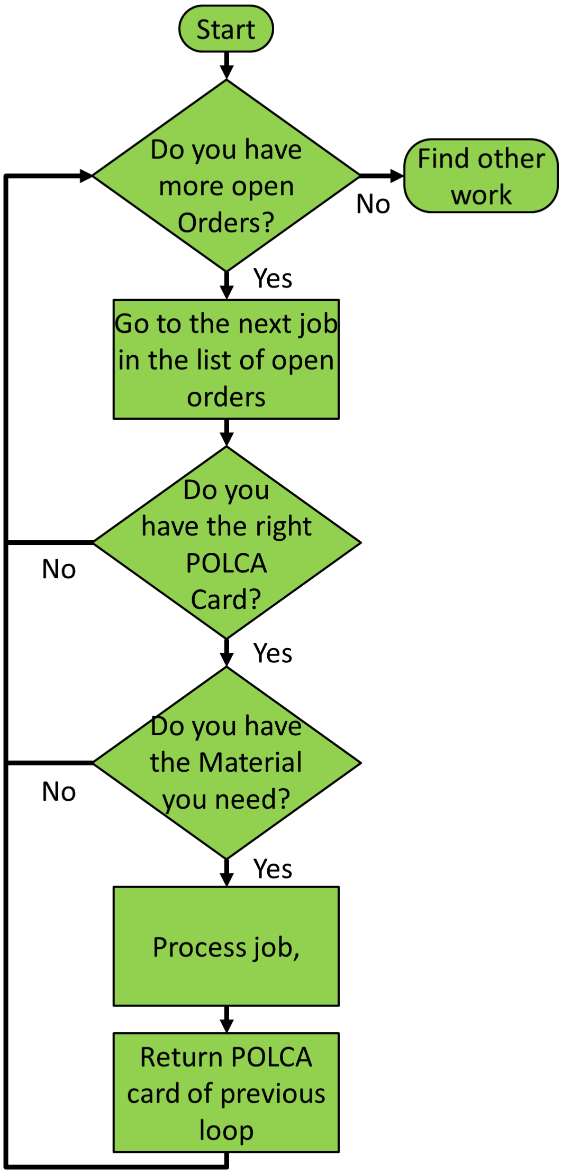


Figure 284: POLCA Sequence (Image Roser)

The operator has to follow a few simple rules in using POLCA. Suri calls this the "Decision Time." These rules are also shown in the flowchart.

- At the beginning, the operator should check if there are any **available open orders** in the list of open jobs for his cell or machine where the **order release time has passed**. If there are no open orders left that he can do, he should find work at another process or cell. This may involve a supervisor assigning him to a new task.
- The operator takes the next **available and released** job.
- The operator checks if he **has the right POLCA** card available from the subsequent process that allows him to start the job. If not, he repeats the process with the next open order (except for the last process in the POLCA system, which has no subsequent process).
- The operator checks if he **has all the material needed** to start the job. If not, he repeats the process with the next open order
- After these checks the operator **processes the job**.
- Afterwards the operator **returns the POLCA card of previous loop** to the previous process to release more jobs.

33.5 A Few More Details

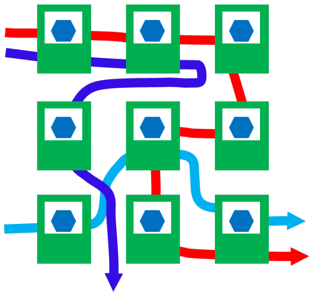


Figure 285: A job shop (Image Roser)

In the original literature on POLCA (sources below), it supposedly works only with manufacturing cells (although it is not defined what exactly the author sees as cells). However, as described in more recent literature, it would work also for any general job shop with multiple machines or processes. It would even work for a larger system where different sub-units are merged together. It is not suitable for flow shops. It is also not really helpful for mass production.

POLCA is sometimes called a push-pull hybrid. While the author uses an, in my opinion, incorrect definition of pull in his book (see my post The (True) Difference Between Push and Pull), the result is correct. The number of POLCA cards limit the inventory to a hard upper limit between two processes. The multitude of possible process loops does water it down a bit, but this is still pull. The order release time calculated by an ERP system, however, is definitely a push aspect of production. If it would only be the order release time, it would be easy to overstuff the system with jobs. However, since both the order release time and the POLCA card are needed for processing, it is in the end still a pull system.

So, after explaining to you the basics of POLCA, in my next post I will do a bit of a review of the advantages and limitations. Overall it is a feasible method. In my last post I will talk about the way to calculate the number of POLCA cards, where I may be a bit more critical. Overall it is up to you to decide if this method will work for you or not. Nevertheless, I hope this is insightful to you. **Now, go out, and organize you industry!**

33.6 Sources

The original book by Suri is *Suri, Rajan.* Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times. *Portland, Or: Taylor & Francis Inc, 1998.*

Suri just published another book: *Suri, Rajan.* The Practitioner's Guide to POLCA: The Production Control System for High-Mix, Low-Volume and Custom Products. *Productivity Press, 2018.*

While doing my research I also found the book by Hermann Lödding helpful, although to my knowledge it is available only in German: *Lödding, Hermann.* Verfahren der Fertigungssteuerung: Grundlagen, Beschreibung, Konfiguration. *3. Aufl. 2016. Berlin Heidelberg: Springer Vieweg, 2016.*

P.S.: This series of blog posts is based on a question by Vyacheslav Goncharenko.

P.S.S.: I would like to thank Rajan Suri for his input and his patience.

34 Advantages and Disadvantages of POLCA

Christoph Roser, August 21, 2018, Original at https://www.allaboutlean.com/polca-pros-and-cons/

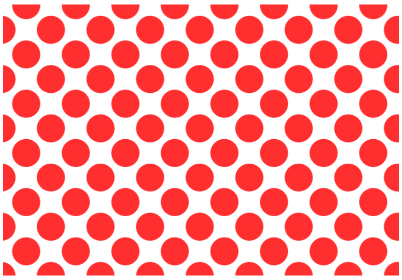


Figure 286: Polka Dots (Image Roser)

In my previous post I described how POLCA (Paired-Cell Overlapping Loops of Cards) is supposed to work. Now let me look at the advantages and disadvantages of the method. Overall POLCA is a valid method of managing job shops. If it is the right one for you depends very much on your production system.

34.1 Benefits of POLCA

34.2 Limits Inventory

Figure 287: Warehouse worker checking the inventory (Image WavebreakMediaMicro with permission)

POLCA is good at controlling the inventory. Since all processes (cells, machines, etc.) are connected using loops with a limited number of POLCA cards, they can prevent excessive inventory between two cells. Hence, if a process is blocked in one direction due to the lack of POLCA cards, it can use the available capacity to make products for another subsequent process that has free POLCA cards available. This allows for a better and also more timely use of the utilization of the different processes. The reduction in inventory also reduces the overall throughput time.

CONWIP systems could be set up across the entire job shop. In this case, it is still possible to accumulate inventory in some parts while others run dry. A POLCA system defines the inventory along every possible step in the value stream, and hence allows for a finer tuning of the inventory (although you could similarly also set up multiple CONWIP loops).

34.3 Avoids Blocks toward Upstream

You could also limit the inventory at a process with a simple FIFO in front of the processes. However, in this case a very busy upstream process may block other less busy upstream processes by filling up the FIFO and prohibiting other processes from getting their turn. With the individual loops for each two connected processes, every upstream process gets its shot. In other words, every upstream process has a chance to deliver its goods downstream.

34.4 Minor Issues with POLCA

There are a few issues with POLCA. **None of them is a deal breaker**, at least not for all production systems. And many of these issues are shared with other ways to manage job shops.

34.5 A Bit of Complexity

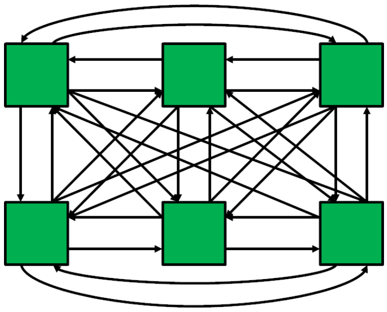


Figure 288: POLCA loops for 6 processes (Image Roser)

The method with its multiple overlapping loops of POLCA cards can be complex. The POLCA loops have to cover every possible path that a product can take. If it goes from one machine to another, you need a loop. If it goes back, you need a second loop. In its extreme, it would need two loops between every possible machine combination.

However, in actual application this seems to be manageable, and real-life systems have much fewer loops than the maximum possible. There are numerous reports from the shop floor that it works.

34.6 What's With the Overlap?

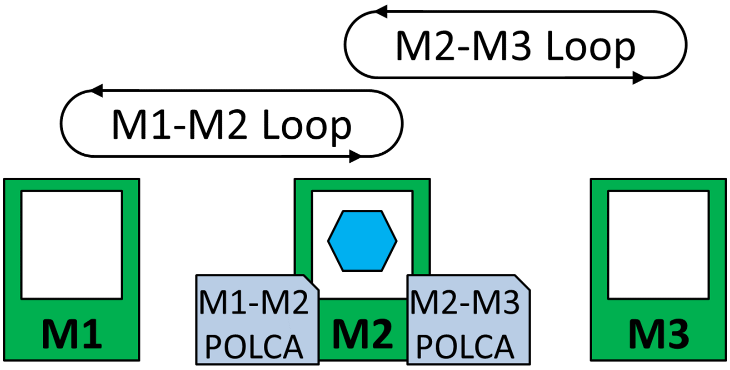


Figure 289: POLCA Overlap (Image Roser)

By definition, POLCA loops overlap. Whenever a part is processed in a machine or cell, there should be two POLCA cards attached to it (except for the first and last cell in the value stream).

Why is that? Suri told me that this helps with positive interactions between the workers of different processes, and avoids the "throw it over the wall" effect.

This effect is believable, but I would prefer no overlap. I worry that having sometimes two cards (during processing) and sometimes one card (whenever not processing) attached to the part may be a bit more confusing. My preference would be without overlap. But I also agree that this is not a strong argument. I guess either way is possible.

34.7 Accuracy of the Order Release Time

Figure 290: Time Spiral (Image mipan with permission)

One requirement of POLCA is that every order has an order release date for every machine that it has to be processed on (and more, if it visits a machine twice).

This will be very difficult to calculate. I have worked with job shops before, and it is quite difficult to determine the order release date for the first process, much less for every process along the line. Job shops are notoriously difficult to plan, and suffer from the *butterfly effect* (a small difference between assumption and reality can have a big effect). On the other hand, all control systems have similar problems in job shops, so this is also not a big handicap. It depends how much effort you need to determine these times and to get them to the people that need to know them.

34.8 Possible Deadlocks

A POLCA system can in some rare cases cause a deadlock, where a combination of orders and POLCA cards can cause processes to block each other. Below is a simplified example, where M1 cannot continue without a M1-M2 POLCA card. All M1-M2 POLCA cards, however, are at M2, which cannot continue without a M2-M1 POLCA card. However, these cards are all at M1. A deadlock ensues, and neither process can continue.

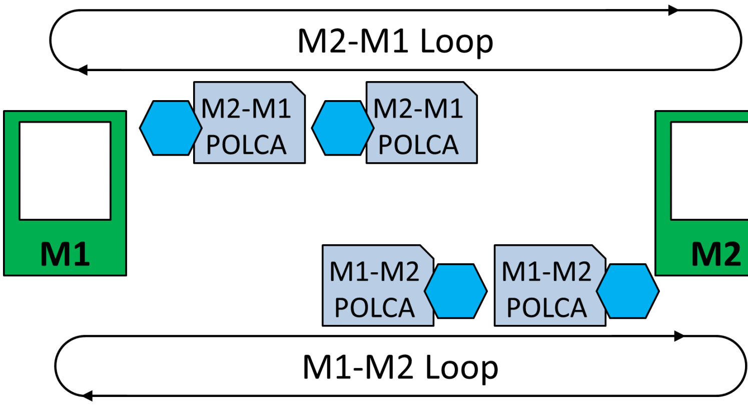


Figure 291: POLCA Deadlock (Image Roser)

It seems, however, that this happens very, very seldom. It can happen only if the POLCA loops form a circle (i.e., following the loops you may eventually come back to the starting process, as in the image above from M1 to M2 and back to M1). According to Suri, **this has happened only in simulations, but not yet in reality**. Suri also developed a solution using a "cycle card." This is not a regular POLCA card that goes back and forth, but a card that always goes forward along the processes in the loop. Details are in the chapter 6 *Preventing Gridlock When Loops Form Cycles* in The Practitioner's Guide to POLCA.

34.9 Overloading or Low Utilization

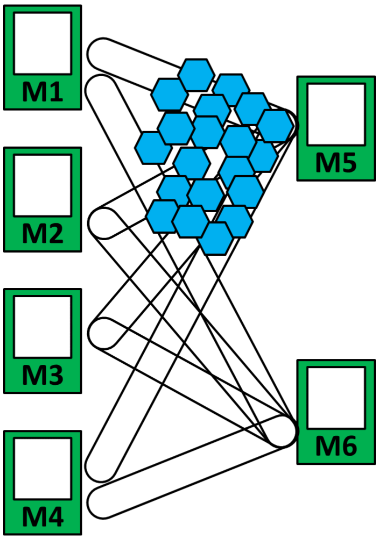


Figure 292: POLCA Overload (Image Roser)

POLCA tries to balance the workload in the production system and tries to prevent overloading of a process – which is a worthy goal. However, it is easy to imagine situations where this breaks down. Take the example here. Four machines (M1-M4) feed two other machines (M5 and M6). Hence both M5 and M6 can receive work from multiple machines.

It is possible that there is a lot of work for M5 and none for M6. Hence, M5 would be overloaded, and M6 would be idle. The actual maximum inventory in each loop would be limited by the POLCA card, but multiple loops with a number of POLCA cards each can add up to a lot of material. In the example there are four loops arriving at M5, each with 5 POLCA cards, putting a whopping twenty products at M5 for production. At the same time, M6 would be starving for work.

While this is an extreme example, similar situations can happen. But then, they can also happen with other job shop control systems. Any kind of planning in a job shop is difficult and failure-prone.

34.10 Reduced Flexibility

Figure 293: Is it Flexible? (Image Kennguru under the CC-BY 3.0 license)

POLCA requires an order release date for every process the part has to go through. This usually means that the production sequence has to be fixed beforehand. This reduces flexibility.

In my experience, many job shops do have alternative processes available. A part could be processed on machine 1 OR machine 2. I also have experienced rerouting in job shops if one machine is overloaded and another one is available. While not ideal, in a chaotic job shop it sometimes does make sense. For POLCA, however, it would require quite a bit of recalculation and rearrangement. Have a look at the overloading example from above again. Must all parts go through M5? Or did a system quirk merely schedule all parts for M5 and none for M6?

34.11 Summary

There is simply no good solution for job shops, but CONWIP and POLCA are often good enough. It depends very much on the specifics of your system to decide if POLCA or CONWIP is better, and even that is difficult to determine beforehand. Hence, POLCA is a valid option to control job shops.

Please believe me, I did not come to this conclusion lightly. In fact, I wrote this post twice. The first time I nitpicked everything apart (a bad habit of mine sometimes). Yet, Rajan Suri was very patient and provided me with lots of information and details on POLCA. It does not happen often, but he changed my mind, and I now believe that POLCA can work. If you go the POLCA route, I recommend his 2018 book The Practitioner's Guide to POLCA. It contains more information and updates compared to his 1998 book. It also contains details on steps for designing and implementing a POLCA system.

But make up your own mind and choose the method that works best for you! In my next post I will talk about the method to calculate the number of POLCA cards. Until then, I hope this post was of interest to you. **Now go out and organize your industry!**

34.12 Sources

The original book by Suri is *Suri, Rajan.* Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times*. Portland, Or: Taylor & Francis Inc, 1998.*

Suri just published another book: *Suri, Rajan.* The Practitioner's Guide to POLCA: The Production Control System for High-Mix, Low-Volume and Custom Products*. Productivity Press, 2018.*

While doing my research I also found the book by Hermann Lödding helpful, although to my knowledge it is available only in German: *Lödding, Hermann.* Verfahren der Fertigungssteuerung: Grundlagen, Beschreibung, Konfiguration*. 3. Aufl. 2016. Berlin Heidelberg: Springer Vieweg, 2016.*

P.S.: This series of blog posts is based on a question by Vyacheslav Goncharenko.

P.S.: I would like to thank Rajan Suri for his input and his patience.

35 Calculating the Number of POLCA Cards

Christoph Roser, August 28, 2018, Original at https://www.allaboutlean.com/polca-calculation/

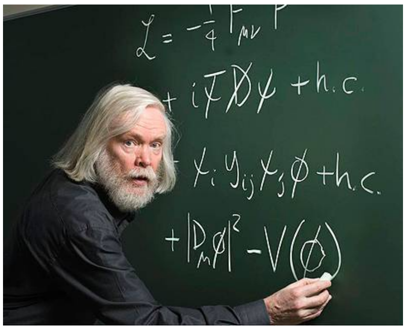


Figure 294: Scientist on Blackboard (Image Open Knowledge Foundation under the CC-BY 2.0 license)

In my previous posts I explained how POLCA works and discussed the pros and cons of POLCA. In this post I will explain how to calculate the number of POLCA cards. While POLCA is overall a feasible method, I do have some critical comments on the method to calculate the number of POLCA cards.

35.1 How to Calculate the Number of POLCA Cards

The equation used by Suri to calculate the number of POLCA cards has evolved over time. The latest book The Practitioner's Guide to POLCA gives a calculation of the number of POLCA cards as follows:

$$No. of\ AB\ Cards = \frac{(LT(A) + MT(AB) + LT(B) + RT(BA)) \cdot NUM(A,B)}{D} \cdot (1 + S)$$

The symbols stand for:

- **No. of AB Cards**: The number of POLCA cards for the loop between Process A and B, rounded up to the next integer.
- **LT(A)**: Lead time at process A. This includes authorized jobs waiting for processing at process A (in days).
- **MT(AB)**: Movement time from A to B (in days).
- **LT(B)**: Lead time at process B: This includes authorized jobs waiting for processing at process B (in days).
- **RT(BA)**: The time needed to return the POLCA card from B to A (in days)
- **S**: The safety margin (where, e.g., 0.1 would be 10%).
- **NUM(A,B)**: Number of jobs or parts passing though the A-B loop within a given time period (which he called the planning horizon). Or, to be more precise, this would be the number of POLCA cards passing through the system, because if you make batches, a part may not represent a POLCA card.
- **D**: Number of days in the planning horizon (in days).

In his book, Suri also gives an example that moves a total of 128 cards [**NUM(A,B)**] within the planning period of 63 days [**D**]. The lead times are 3 days for process A [**LT(A)**] and 1 day for process B [**LT(B)**]. It takes 0.25 days to move from A to B [**MT(AB)**], and 0.25 days to move the POLCA card back [**RT(BA)**]. With a safety margin [**S**] of 0.1, the equation gives 10.1 POLCA cards, which is then rounded up to 11 cards.

$$10.1 = \frac{(3 + 0.25 + 1 + 0.25) \cdot 128}{63} \cdot (1 + 0.1)$$

35.2 How Important Is This Equation?

Maybe now you are thinking about how to calculate this for your case. Don't worry too much about it. While I think the equation is not wrong, I also believe it is not very relevant either.

35.3 What Do We Want to Achieve?

Figure 295: Running to Goal (Image Roser)

Let's think about it. The number of POLCA cards influences different aspects of your production system. Probably most important to you are the **lead time** (how long until the job is completed), the **throughput** (how many jobs can I complete in a certain time), and the **utilization** (are my people actually working or just waiting for work?). Getting all of these right gives you happy customers and hopefully a good profit.

Throughput and utilization are usually closely related. If you increase your utilization, it tends to increase your throughput. (Although this is a big simplification, and you can also push your utilization up while reducing output and creating waste. High utilization on its own is usually not a good goal.)

35.4 The Trade-Off

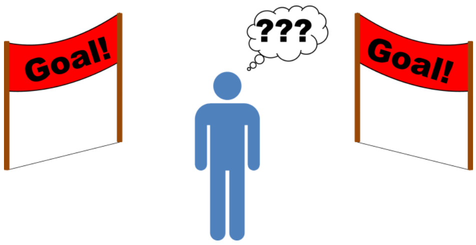


Figure 296: Conflicting Goals (Image Roser)

Lead time, however, usually has a conflicting relationship with throughput and utilization. If you want to have the fastest possible lead time, you release one job into the system and then wait until this job is done before releasing the next one. Lead time will be great (the sum of all processing and transport time, without any waiting times), but your throughput will be very low, as will probably be your utilization.

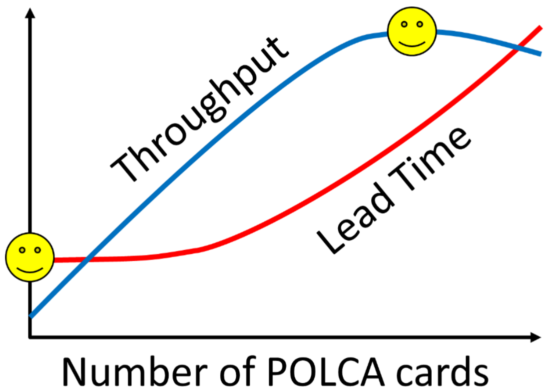


Figure 297: Throughput vs Lead Time (Image Roser)

On the other hand, if you have a lot of WIP, your throughput and utilization will be larger (up to a certain point where the handling of the WIP will take up too much effort). Both are influenced by the number of POLCA cards. The relation will look something like the graph shown here (of course, influenced also by many other factors like fluctuations, management actions, etc.).

For the best lead time, you should set the number of POLCA cards in all loops to one. For the best throughput, they may be significantly more than one. Hence you need to adjust the number of POLCA cards to get a trade-off between lead time and throughput. And that is very difficult to calculate. Rajan Suri knows much more about queuing theory than I do, but we agree that neither queuing theory nor simulations are a practical approach.

35.5 It Is a Circular Equation

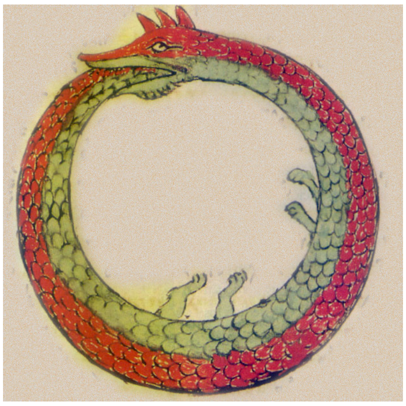


Figure 298: Biting its own Tail (Image anonymous in public domain)

The equation at the top of this post does not really address this trade-off (at least not very well). The equation is not so much about what we would like to calculate (the trade off), but more about what we can calculate (the relation between lead time and inventory [or POLCA cards] using Little's law).

The equation uses Little's law starting with the lead time to determine the number of POLCA cards. However, to determine the lead time you would need Little's law starting with the WIP. Hence, the number of POLCA cards is nothing more than a representation of the WIP plus a little bit for transport and safety. It is not a trade-off between throughput and lead time, but merely a back and forth of the WIP using Little's law.

35.6 Why the Equation Is Not Overly Wrong

The equation is based on the current lead times. The underlying assumption is that the current system is – while maybe not as good as you want it – at least a functional system. Hence, if you base your calculations on a functional system, you get a functional number of POLCA cards. A trade-off between lead time and throughput happened probably somewhat automatically by your people trying to make the system work. Therefore the POLCA calculation is probably not worse than what you have currently anyway. And Rajan Suri makes it very clear (and I agree) that this calculation is only an initial number that has to be refined by looking at how the system actually works.

35.7 Alternative Approach: Estimate!

As explained above, the calculation at the top of this post takes the WIP, converts it to a lead time, and converts it back to the number of POLCA cards (a representation of WIP), plus some safety and transport factors. An alternative and less mathematical approach is to **simply look at the current WIP in the loop, and transform it into a number of POLCA cards** (i.e., if one POLCA card represents one product, then you have one POLCA card per product).

Feel free to adjust if the number makes you (or someone familiar with the shop floor) feel uncomfortable. In case of doubt, go with the lower number, as the instinct on the shop floor is to seek safety in large WIPs, ignoring the damaging effect of this on the lead time. And lean manufacturing always tries to nudge you toward less inventory and faster lead times. Additionally, the case studies on POLCA implementation show that it helps to get rid of some of the dysfunctional operations on the shop floor, which also contribute to the current WIP.

35.8 Adjust as the System Is Running

Figure 299: Fixing a running system… (Image U.S. Department of Defense in public domain)

Rajan Suri strongly recommends (and I totally agree) reviewing the number of cards regularly. First of all, the system and the load on different loops will change over time. Secondly, the initial calculation (or estimate) is merely a starting point. Hence the need to adjust.

This does not mean recalculating the number of cards, but looking at the cards in the system (Rajan calls this an audit). For each loop, determine how many cards (absolute and percentage of total) you find at which location. These locations could be

- Waiting at first process
- In first process
- Moving
- Waiting at second process
- In second process
- Missing

If, for example, there are a lot of cards "moving," then your moving process may be too slow. If you have few or no cards waiting at the first process, then you may have too few cards. Similarly, if there are a lot of cards waiting, you may have too many. Feel free to adjust the number of cards accordingly, but avoid radical changes. Due to the random nature of job shops, a small (or large) number of cards may be a random quirk, and may change again soon. If you have a digital POLCA system, you may collect more statistics to see if there are often too few (or too many) cards.

In summary, don't worry too much about the exact number of POLCA cards. Rather, try it out and adjust. Anyway, this is the conclusion of my mini-series on POLCA. Now, use this knowledge to go **out and organize your industry!**

35.9 Sources

The original book by Suri is *Suri, Rajan.* Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times. *Portland, Or: Taylor & Francis Inc, 1998.*

Suri just published another book: *Suri, Rajan.* The Practitioner's Guide to POLCA: The Production Control System for High-Mix, Low-Volume and Custom Products. *Productivity Press, 2018.*

While doing my research, I also found a book by Hermann Lödding helpful, although to my knowledge it is available only in German: *Lödding, Hermann.* Verfahren der Fertigungssteuerung: Grundlagen, Beschreibung, Konfiguration*. 3. Aufl. 2016. Berlin Heidelberg: Springer Vieweg, 2016*.

P.S.: This series of blog posts is based on a question by Vyacheslav Goncharenko.

P.S.S.: I would like to thank Rajan Suri for his input and his patience.

36 Happy 5th Birthday AllAboutLean.com

Christoph Roser, September 01, 2018, Original at https://www.allaboutlean.com/5th-birthday/

Figure 300: 5th Birthday Cake (Image Revi under the CC-BY 2.0 Korea license)

Wow, it is now five years already and 265 posts since I started this blog! I am amazed (a bit) that I managed to publish one blog post with at least 1,000 words every week. I am also among the top 400,000 websites in the United States and the world! Thanks to all for your interest in my work! Time to celebrate (again).

36.1 Most Popular Posts

Figure 301: Top 10 (Image Roser)

Here are the ten most-clicked posts in the last twelve months. All of them describe elements from the lean toolbox that help you improve your production system.

- 10.Overview of Value Stream Mapping Symbols
- 9.The Seven Types of Waste (Muda) – Now with 24 More Types of Waste Absolutely Free!
- 8.All About Swim Lane Diagrams
- 7.Line Layout Strategies – Part 2: I-, U-, S-, and L-Lines
- 6.Visual Management
- 5.The Key to Lean – Plan, Do, Check, Act!
- 4.How Many Kanbans? – The Kanban Formula
- 3.How to Measure Cycle Times
- 2.What Is Your Production Capacity?
- 1. The (True) Difference Between Push and Pull

36.2 Recognition

I also got quite a bit of praise. Probably the nicest was from Ian Kano at Scmopex via LinkedIn:

Spotlight on Prof. Christoph Roser: Every now and then a hidden gem appears, and amongst all the sediment of everyday life appears a shining light that helps others reach clarity with their focus and dedication to purpose. One such light is Prof. Roser, whose clarity of vision and dedication to lean manufacturing and organizational restructuring is proof that no matter how much you think you are optimized, there is always more optimization to gain.

But I also got praise here on my blog. Here's just a small selection:

Great insight into improving the usefulness of a classic tool.(by Andy Moysenko for my post on 5 Why)

Very Great Explanation, Thank you for sharing this information. (by Agus Santoso on my post on Jidoka)

Good content in an article that is not too large. I like it very much! Thanks a lot! (by Timo Gruß on my post on Toyota Standard Work)

A great blog. And I read your book. What a great history of manufacturing!!! (by Kurt also on my post on Toyota Standard Work)

Also, my worldwide popularity has been steadily increasing. Both worldwide and within the USA, I am among the top 400,000 websites according to Alexa. That may not sound like much, but I think it is quite an achievement for a one-man blog where pretty much every word is written by me (and of course spell checked by someone else, to make me look a bit more cultured ☺)

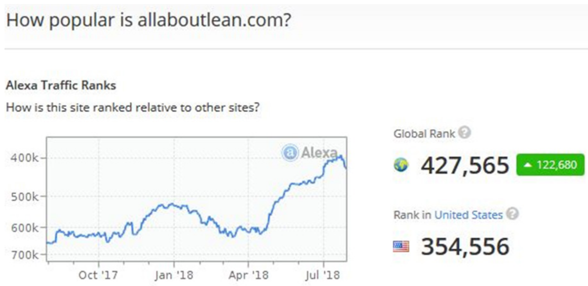


Figure 302: 2018.08 AllAboutLean.com ALEXA Rank (Image Alexa for editorial use)

Figure 303: Curious Cat (Image Curious Cat for editorial use)

Also, the influential Curious Cat blog by John Hunter lists me as the third-best blog on management improvement, behind the Lean Blog by Mark Grabam and the Curious Cat Management Improvement Blog itself. Quite a jump up from #10 last year (with a bit of up and down in between).

36.3 GDPR

Figure 304: GDPR as part of Europe (Image Roser)

One of the larger changes this year is the European GDPR (General Data Protection Regulation), which puts Europe at the forefront of protecting the data of its citizens. If you are online, you must have gotten at least some emails about this privacy law implemented in Europe. This law also applies to my blog. Hence, I made quite some changes in the background. Overall, it took me a week to do so, but I happily did it since I support the GDPR.

In the spirit of the GDPR, I have no interest in your data. If you leave a comment, the comment and contact is stored on the blog. If you subscribe to my email update, I need your email. Otherwise I have no interest in storing and maintaining your data, and I'm definitely not into selling it. I would like to know how many visitors I have for my statistics, but I am not interested in the details of an individual visitor. I also weeded out third-party plug-ins that may be more data hungry. Some of the changes I did to comply with the GDPR:

Wrote a data protection and privacy policy page. This is now the second-longest page, with 19,000 words, after my glossary (23,000 words). It is a mix of legalese and plain text, both in English and also in German (since I am not sure which language would apply to an English blog located in Germany). If you are into dry, boring legal texts, go for it. Otherwise it is not recommended reading. Please don't sue me!

Figure 305: Not on my site! (Image Roser)

I removed advertising. For a long time, I had Google ads on my site. However, this was always focused on user friendliness. No annoying pop-ups! The only thing that pops up is the mandatory GDPR info at the bottom, but hopefully this is not in-your-face annoying. Also, I am perfectly fine if you use an ad blocker. On average, I made about €1 per day in advertising, and figured that is just not worth the potential risk to your privacy. Hence, no more advertising.

I **removed the sharing buttons** at the bottom of the post. I started with removing the Pinterest button (since I don't like Pinterest), but then just took all of them out. It probably did not add much value to most visitors, but it was a potential back door for potential data-hungry companies to learn more about YOU.

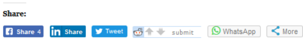


Figure 306: Sharing Buttons (Image unknown author for editorial use)

I **weeded out different plug-ins**. I had *Google Analytics for WordPress by MonsterInsights*, but they provided GDPR options only in the paid version, so I showed it the door. I manually added the Google tracking cookie, but set it to anonymous, so it should not get your full IP address. I still use *Jetpack*, but disabled a lot of the features that may intrude your privacy. Some other plug-ins also went out. I replaced *Askimet* with the GDPR conform *AntiSpam Bee*.

I **removed YouTube tracking cookies**. Embedded YouTube videos are now set up in a way that does not use YouTube tracking cookies. I also reduced the number of Amazon image links.

Hence, I put in quite some effort to protect your privacy. The website speed also improved slightly. Above all, **please don't sue me!**

36.4 Brand

Figure 307: All About Lean Logo (Image Roser)

I also finally registered my brand with the *Deutsches Patent- und Markenamt (DPMA)*. Now the logo and text can be used only by me (at least in Germany).

You may not have noticed it, but I also slightly updated the logo. In the old logo, the gear would not have worked, because all the teeth (cogs) are of different size. Easy for the design, but just not accurate. In the new logo, the gears within the brain are now technically correct fully working gears. The central hole is also the same size. Not a big thing, but as a German engineer I strive for perfection. Also, I want to emphasize that at no point ever did I have three gears interlocking with each other as in the image on the right. While you see this frequently in other logos, these gears cannot move since they block themselves. I know, I am a nerd.

Figure 308: AllAboutLean Logo Old and New Gears (Image Roser)

Overall, it was an exciting year, and I would like to thank all of you for reading my work, and I hope that it helps you with your job to organize your industry. In the next year I plan to publish a new book on how to create pull systems. While it is based on a lot of blog posts, it is much more organized and structured than a random set of blog posts. I also write a lot to fill the gaps and to make it a coherent structure. I will definitely let you know on my blog when it comes out 🙂. Until then, keep on reading, and **above all go out and organize your industry!**

37 Toyota Kata

Christoph Roser, September 11, 2018, Original at https://www.allaboutlean.com/toyota-kata/

Figure 309: Climber on Summit (Image Max Pixel in public domain)

There is one word that currently takes the lean world by storm: **kata**, or more properly **Toyota Kata**, a method developed by Mike Rother. The idea behind it is not only a bunch of buzzwords (like all too often) but actually goes in the right direction. Overall, I like the concept, although the attention it gets sometimes feels overdone. Let me give you the gist of kata.

37.1 Linguistics

Figure 310: Karate students doing Kata (Image Airman 1st Class Jonathan Fowler in public domain)

Kata (型 or 形) is a Japanese word that literally means form, model, pattern, type, style, or mold. It is most often used in the context of Japanese martial arts (judo, kendo, aikido, and karate), but also in Japanese theater and tea ceremony.

In karate it is one of the three basic exercise types. The first one being **Kihon** (基本 or きほん for foundation or basics), for basic ways how to stand. The second being **Kata**, a choreographed set of movements that are repeated over and over again. This will improve muscle memory. Finally, **Kumite** (組手) is free sparring with an opponent. As such, kata is a very good name, since the method proposes regular repetition of the same five questions. Below is a video of the 2016 World Karate Championship male team kata competition.

The Video by the World Karate Federationis available on YouTube as "Karate FINAL. Male Team Kata JAPAN. Kata Anan. 2016 World Karate Championships" at https://youtu.be/W-Ejm78jJz4

Hence, Mike Rother used the word *kata* for his approach. Since it is modeled somewhat based on Toyota, it is usually called Toyota Kata, to distinguish it from the martial arts kata. However, the term itself is to my knowledge not used in that form at Toyota.

37.2 What Problem Does Kata Try to Solve

Figure 311: Surely going somewhere … (Image Jeroen Komen under the CC-BY-SA 2.0 license)

Most lean methods and tools aim to improve individual aspects of manufacturing (and other) systems. Kata is an overarching approach that helps keep track of the overarching goal and work toward achieving it.

In my view, this is often a significant issue, and one of the major reasons why so many lean implementations fail (the other being a lack of PDCA, especially the C&A part). Lean projects are often started for reasons like

- they can be done
- it has a nice buzzword
- it was in the last book I read on management
- someone else is doing it
- etc.

All of these are not really good reasons. They lead to meandering your way with aimless improvement. You improve something (assuming you get the PDCA part right), but it may or may not contribute to your overarching goal, or in worst case even be detrimental to the overall goal. You may not even have an overall goal. And, as Yogi Berra said, "If you don't know where you are going, you might wind up someplace else."

Figure 312: True North (Image Hike The Monicas under the CC-BY-SA 4.0 license)

Toyota Kata tries to help you determine the **ultimate goal**, sometimes called **true north** or **vision** (although it is also said that if you have visions, you should see an eye doctor).

As such, I see this as an approach that addresses one of the most significant issues in lean (or in manufacturing in general).

37.3 Improvement Kata

There are actually two separate kata. One is for individuals who want to improve the current situation, the **Improvement Kata**. Another one is for other individuals who want to coach and teach others in the way of kata, the **Coaching Kata**. Let's start with improvement kata.

The improvement kata helps you get from your current state into the direction of the vision (or true north) through many different small steps. Below is a visualization of the improvement kata, based on Mike Rother's book.

Figure 313: Improvement Kata (Image Roser)

37.4 Steps of the Improvement Kata

Actually, kata starts out by defining the **vision**. This is the direction where you ultimately want to go. You may or may not actually reach this vision, but it is necessary to clarify the main direction. For Toyota, Mike Rother interprets these visions as follows (source at the end of the post):

- **One-piece flow**: I totally agree. See also my post Toyota's and Denso's Relentless Quest for Lot Size One.
- **100% value add**: Good vision.
- **Security for people**: A bit too vague for me. I would replace this with **Respect for humanity.**
- **Zero defects**: Okay-ish as a vision, just don't use it as a target.

Next you need to understand your **current condition**, where are you now.

The third step is to develop the **target condition** based on the current condition and the vision. These target conditions should be not too easy to do, but still feasible within a time frame of a few weeks or months. The (currently) impossible part is the vision, and through many small steps we move toward the vision. Mike Rother distinguishes between target condition and target. A target is an outcome (e.g,. x pieces per hour, defect rate below y%, etc.). A target condition is a description of a process or system. How should the future system function and operate.

Finally, in the last step you can work on finding a way from your current condition to the target condition, overcoming the **problems and obstacles** in between. This includes a whole lot of problem-solving approaches, and may include some of the more familiar lean tools like kanban or SMED. Here you should also definitely use PDCA!

37.5 The Five Improvement Kata Questions

Mike Rother summarizes the improvement kata in five questions, which you should repeat regularly during your improvement process (again, source below). The repetition of these questions is the actual kata in the Japanese sense of the word. The vision is not questioned repeatedly, but changed very rarely once established (think decades).

- What is the target condition?
- What is the actual condition now?
- What obstacles prevent you from reaching the target condition? Which ones are you addressing now?
- What is your next step (your next PDCA cycle)?
- Where can we go and see what we have learned from taking that step?

Please note that these improvement kata questions are usually called "coaching kata" questions. They will be used again for the coaching kata:

37.6 Coaching Kata

Figure 314: Coaching (Image unknown author in public domain)

While the improvement kata is about how to improve your production system, the coaching kata is about how to teach others to improve their system.

The improvement at Toyota is done by the operators themselves, and by their supervisors and managers. The operator improve lots of little things, but the bigger potential is from the supervisors and managers (raising 90% of the productivity improvement according to a paper by Koichi Shimizu, source below). They do improvements and also teach and coach others.

The coaching is (unfortunately but definitely) not a group activity. Rather, it is one mentor and one (or very few) mentee(s) who are coached individually one-on-one. So don't even think about a mass "kataing" of your people in a few classroom lectures.

The goal of a coach is also not to simply give the answers. This way the student would not learn, and also the improvement would be limited to the ideas of the coach. In many cases the coach does not even know the answers.

The coaching is done in regular intervals (maybe weekly) with a duration of around twenty minutes (or as needed). These meetings are also based on the five kata questions from above. Basically the coach goes through the five questions, listens to the answers, and gives his input. An A3 sheet can also help with the meeting, as well as doing it right where the issue is (on the "gemba").

37.7 Too Much Kata…

Figure 315: Sneaky Consultant advertising Kata (Image bramgino with permission)

Overall, I think Mike Rother's Toyota Kata is valid and goes in the correct direction. It may be a bit overly formalistic, but this can help newer coaches on learning how to coach.

One thing I definitely don't like is that it is turning into a new "religion" within lean. There are about 17 million results on Google for Toyota Kata, of which 1.3 million offer or mention a

Toyota Kata training. Books promise you "Superior Results in 20 Minutes a Day." Overall, kata has turned into a big business.

Figure 316: Just completed his online course … (Image Roger Rössing & Renate Rössing under the CC-BY-SA 3.0 Germany license)

While I understand that *ringing the bells* is necessary to sell your idea, I am not overly fond of it. I also worry that the promotion and training of kata has overtaken the actual improvement process. I am not sure if a ~3-hour *online Toyota Kata course* really prepares someone to be a coach, and I doubt the credentials of the *10-hour kata certificate* (links intentionally omitted).

These trainings are fine, as long as you understand that these are only a bare-bones starting point, and true skill comes only from practice. And again, the overall concept behind kata is sound and valid. If you want to continue with kata, I can recommend Mike Rothers book Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results. Now, **go out, coach your people using these five questions (or along the line of that), and organize your industry!**

37.8 Sources

The Bible of kata is the book by Mike Rother. This is an overall sensibly written book, and I like a lot of the ideas in it. If you want to do more with kata, this is the book you should get:

Mike Rother: Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results, McGraw-Hill, 2009.

Shimizu, Koichi 2004: Reorienting Kaizen Activities at Toyota : Kaizen, Production Efficiency, and Humanization of Work. 岡山大学経済学会雑誌.

38 Just in Time at Hyundai Mobis in Korea

Christoph Roser, September 18, 2018, Original at https://www.allaboutlean.com/jit-hyundai-mobis/

Figure 317: Hyundai Mobis Asan Entrance (Image Roser)

As part of the APMS Conference 2018, we visited the Hyundai Mobis Asan plant in South Korea. They are a good example of supplying parts just in time to the nearby Hyundai plant. The site also had some other nice features. Let me show you the details:

38.1 About Hyundai Mobis

HYUNDAI MOBIS

Figure 318: Hyundai Mobis Logo (Image Hyundai Mobis for editorial use)

Hyundai Mobis was founded in 1977 and is a major parts supplier for Hyundai, Genesis, and Kia. It belongs to the Hyundai Group and is one of the largest automotive suppliers worldwide (#6 in 2015) with 25,000 employees. The *Mobis* stands for mobile systems. Its production base is mostly in South Korea, but they also have plants in China, North America, and Europe.

38.2 Some Statistics

Our visit was to the Asan factory located some 80 km south of Seoul. There are 332 employees in the Asan plant. The plant works sixteen hours per day in two shifts, producing chassis modules (front and rear, shown in the top row below), front end modules (bottom left), and cockpits (bottom right) for Hyundai Motor. These are produced with a large number of variants matching the exact demand and its sequence from the Hyundai main plant.

Figure 319: Hyundai Mobis Portfolio (Image Roser)

38.3 Just in Time and Just in Sequence (JIT and JIS)

Hyundai Mobis had a very tightly integrated Just in Time and Just in Sequence system. This stretches from their suppliers through the entire plant to the customer, the Hyundai Motor Asan plant.

38.4 Supplier Integration

The suppliers of Mobis were closely connected. The table below shows the number of suppliers and components as well as the annual production quantity.

Module	Suppliers	Components	Annual Quantity
Chassis Modules	45	57	250,000
Front End	23	28	(forgot to write down)
Cockpit	30	44	252,500

I checked the dates on the paper accompanying thirty different materials, and on average they were one day old. Some material was delivered on the same day. No material that I saw was older than two days. Compare this with your plant! However, to be fair they do some repacking of the suppliers, in a warehouse, to optimize efficiency (more below). Hence, the zero to two days may be only from the warehouse. Even so, this is a pretty tightly run ship. The material from the suppliers is delivered by milk run, and they have a two-hour inventory on site, similar to Toyota.

38.5 In-House Material Flow

The in-house material supply was mostly by automated guided vehicles (AGV), although there also was some overhead and below-ground transport of material and empty workpiece carriers. The AGV are custom commercial AGV rather than the converted golf carts that you may see in Japan. As such, it came with a substantial price tag of around 300,000 € for the entire system. At the assembly lines themselves, critical material was handled using pick-by-light. The material inventories all looked small to me, similar to Toyota. As it is common sense in lean, expensive materials were tightly controlled. Inexpensive bulk material like screws, on the other hand, were plentiful. You do not want to turn off your plant for the lack of a twelve-cent screw!

38.6 The Loading Dock

One particular feature was the loading dock, which uses an approach that I have never seen before. The parts come from the assembly line just in time and just in sequence, automatically move into a small buffer, still in sequence, and then automatically are loaded into the trucks. No human hand touches the material or even the workpiece carriers.

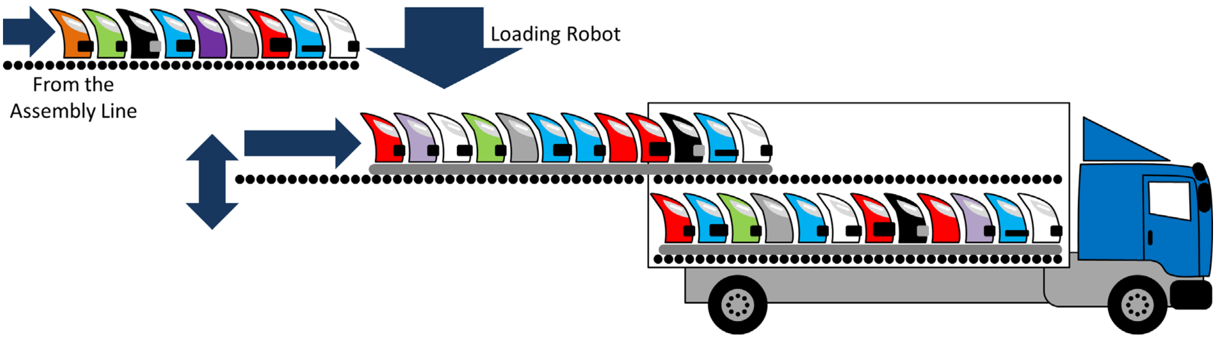


Figure 320: Hyundai Mobis Truck Loading (Image Roser)

The material arrives just in sequence from the assembly line (overhead to cross an AGV and pedestrian path in the plant). A loading robot moves the material on a customized workpiece carrier. The image shows the example for the front end modules, but I have also seen a second dock for the cockpits, and I believe there is a third for the chassis modules. Whenever the customized workpiece carrier is full (twelve front ends or seven chassis), it moves up/down to align with the truck and is pushed into the truck. The truck has capacity for two layers of modules.

Once the truck is full, it departs immediately. The driver does not even go out to close the doors – this is done by two assistants outside, and is also the only manual part of the loading process. There are twenty-four trucks for chassis and front ends each per shift. While we were not allowed to take pictures in the plant (and I always respect these wishes of my hosts), we could take pictures outside. Below is the truck with the doors already closed and departing. Please also note that this is not a huge truck, but only a medium-sized vehicle. In the spirit of lean, Hyundai prefers more smaller trucks rather than fewer big ones.

Figure 321: Hyundai Mobis Loading Dock (Image Roser)

38.7 On the Way to Hyundai

All products of Hyundai Mobis go to the Hyundai Asan plant. This plant is 12 km away from Hyundai Mobis, which is typically a twenty-four minute drive. They have a primary route that they use, but depending on traffic conditions they have two alternative routes to bypass possible congestion (on a side note, Google Maps legally cannot give driving directions in South Korea, which is my preferred way to avoid congestion).

Figure 322: Hyundai Mobis Asan JIT Supply Route and Alternatives (Map OpenStreetMap under the CC-BY-SA 2.0 license)

The table below shows the statistics on the approximate production and delivery time and WIP inventory as well as the safety buffer (also in time and inventory). Hence, Mobis seems to be indeed tightly integrated with the main plant. Especially for cockpits, the time buffer is quite tight.

Module	Production & Delivery	Safety Buffer
Chassis Modules	97 min / 89 Pieces	45 min / 41 Pieces
Front End	81 min / 74 Pieces	122 min / 112 Pieces
Cockpit	85 min / 78 Pieces	16 min / 15 Pieces

38.8 Other Observations

Figure 323: Fitness Gym similar to the one at Hyundai (Image Getmotivatedfitnes under the CC-BY-SA 4.0 license)

Overall, the plant was very clean (almost too clean), and everything was marked nicely in the spirit of 5S. The equipment also looked very new, or at least well maintained. A lot of andon showed information about the status of the line and the processes, and work instructions were displayed on monitors at the stations. One andon was even in the office.

Two surprising features were a gym for the employees and the large number of plants in the factory (the in-plant plants 🙂). And I am not talking a measly small daisy in an egg cup, but multiple rather large flowerbeds up to the size of twin mattresses next to each line. And almost all of the plants were even real, only a few plastic ones. Of course, all were properly marked with 5S lines on the floor. Most of them were close to the break areas, of which there were also multiple tables per line.

One interesting trick was their customized material containers. While many plants use custom containers and boxes, Hyundai Mobis used a movable cart with a tilting shelf system. While this is also not absolutely unique, it is rare enough to warrant a small explanation as in the image below. When moving, the shelves are flipped down. Any parts in the shelf are secured through some rubber foam that pushes down on the parts. When the cart arrives at the destination, the top is flipped up, giving access to the first layer of parts. When this layer is consumed, the shelf is flipped up, giving access to the second layer, and so on. I found this quite a nice solution. Hyundai Mobis used this for smaller complex parts like the brake pad assemblies.

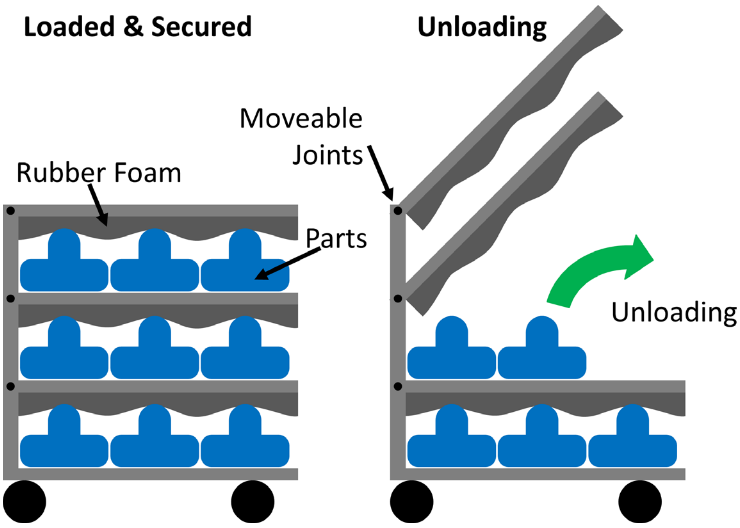


Figure 324: Hyundai Mobis Secured Transport Cart (Image Roser)

I also looked at their assembly line efficiency, similar to what I did during my Grand Tour of Japanese Automotive. Here, it was not overly spectacular, with the workers at the chassis modules adding value 52% of their time, and 53% at the cockpit line. Nevertheless, ergonomics at the line was good, and many tools and devices assisted the workers in their task.

Overall, I liked the plant and its approaches to their problems. The JIT and JIS seemed to be working well (which cannot be said of all plants that *claim* to do JIT and JIS). It was the first time that I have seen their approach at the loading dock – although this is useful only if you make lots of almost-identical parts for the same customer.

I hope this report from the shop floor was interesting to you, and maybe gave you some inspiration for your own plant. Now, **go out, get your material flow structured, and organize your industry!**

39 Introduction to Milk Runs

Christoph Roser, September 25, 2018, Original at https://www.allaboutlean.com/milk-run-intro/

Figure 325: Milk Splash (Image NellyGraceNG in public domain)

Milk runs are a popular concept for material delivery within a plant and even across multiple plants. It is very much based on the philosophy of pull, keeping inventories down, and making material supply easier.

However, it is only suitable for mass-produced goods, or more precisely for identical components and identical parts, even if they go into different product variants. Additionally it can also be used with kitting. This post starts a series on the topic of milk run with an introduction to the topic.

39.1 The Original Milk Run

Figure 326: Milk Run in England (Image Ministry of Information in public domain)

Milk runs were originally just what the name implies, a person delivering milk to different households along a route. This was a common approach in the United States, Great Britain, the Netherlands, India, and other places to distribute milk. However, due to the nature of the product, this type of delivery differed significantly from, for example, the delivery of mail or other goods.

Fresh milk is a product that perishes quickly. With modern refrigeration it can last a bit longer. Pasteurized milk (common in Germany, for example) can even be kept for months without refrigeration. However, nowadays raw milk still is the biggest cause of hospitalization due to foodborne diseases. The short shelf life of milk was an even bigger problem before modern refrigeration and pasteurization. It was difficult to have a stockpile of milk, and milk had to be consumed quickly before it spoiled.

Figure 327: Milk Delivery in the Netherlands (Image Nationaal Archief in the Netherlands in public domain)

Therefore the milk men and women used a few simple tricks to help their customer. Along their route, they simply replaced empty milk bottles with full bottles. If the customer put one empty bottle out for the milk man in the morning, he got one full bottle. If the customer put out two empty bottles, he got two full bottles back (and so on). Hence, this empty bottle was not only for reuse and recycling, but also contained a signal to replenish the consumed milk. In modern lean lingo, **this milk bottle would be a kanban!** More precisely it would be a transport kanban, since the milk man did not produce the milk but merely transported it from a storage facility. Such "box" kanban are also common nowadays.

Through this simple approach, the milk run created a stable supply of milk to the household. Of course, things still could go wrong, and the milk could spoil if the customer was away, or the customer could run out of milk if he needed more than average. But for most days the basic supply was provided with a minimum amount of fuss and hassle.

Update: Actually, Michel Baudin says the milk run comes from combat pilot slang for an easy trip (see comment below). Juan Carlos Viela on the other hand says the milk run was the truck that collected the milk from the different farms and brought it to the processing facilities. Hence, the actual source of the name is a but fuzzy, but the milk men example above is a good example of the in house milk run, whereas the collecting truck is a good example of the external milk run which I will discuss in a later post.

39.2 The Modern In-House Logistics Milk Run

Figure 328: Electric Tractor Train (Image Still under the CC-BY-SA 3.0 license)

The modern logistic milk run is pretty much the same as the old milk run (except for the milk, I guess). It is a way to provide material from a central warehouse to the assembly and manufacturing lines. Like the original milk run, **it replenishes consumed material on a regular schedule**. Hence, it is used only for products where there is a constant need for the same material over and over again (although it can be used in connection with kitting; more on that below). There are a couple of requirements that make a logistics process into a milk run:

- It has a **fixed route with multiple stops**. The milk run originates typically in a warehouse or kitting area, moves along a fixed route with multiple stops, and at the end returns to the starting point. There are no branches or doubling back. There is a fixed number of stops along the line where the milk run removes empty boxes and provides new boxes with full material.
- The milk run **runs on a fixed schedule**. For example, while the plant is running, the milk run starts every hour at fifteen minutes past the hour.
- The milk run **replenishes only consumed material**. If there is an empty box or container, the milk run takes it away and on the next visit brings a full box of the same material. Of course, it is possible to also tag along some on-demand material that is needed only once, but this is best avoided. The normal replenishment of consumed material is easiest, and the more exceptions and additional tasks you add, the more likely something is going to get messed up eventually. Do this only if you see no other way of avoiding it.

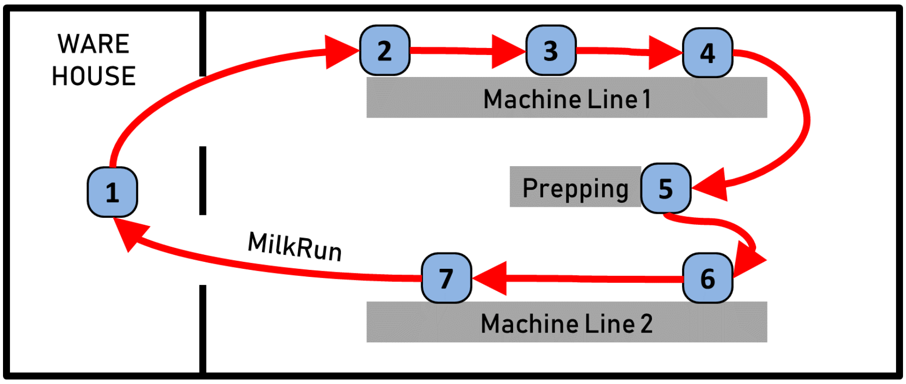


Figure 329: Milk Run Route Example (Image Roser)

The picture above shows an example of an in-plant milk run with a total of seven stops (including the warehouse at the beginning). These milk runs can be within the plant (in-house logistics) or on public roads connecting multiple plants or suppliers (external logistics).

39.3 Benefit of the Milk Run

Figure 330: Smiley and Frowney Percent (Image Roser)

The milk run gives a few benefits and follows the philosophy of lean.

- It makes an often somewhat random job ("hey, we need more stuff over here…") into a **standardized and cyclic work**. The milk run follows a single, reasonable simple standard that repeats almost identically over and over again, a big improvement over the random calls for material (either by humans or by ERP systems) that are still common in many plants.
- Since it is a repetitive standard, you can have a **more efficient use of your manpower**. The milk-run worker will provide material to the line or remove empty boxes most of the time, whereas a traditional forklift frequently runs empty and hence wastes time and energy.
- As it is a repetitive standard, it is **much easier to optimize and improve**. As we will see in subsequent posts, the capacity of the milk run and its usage can be calculated reasonably well, which is harder to do for a "random" forklift.
- The milk run is **part of a** pull production. The boxes are the kanban that get restocked as they are consumed. There is no accumulation of inventory. There can never be more inventory than the number of boxes assigned to the system.
- This pull production will also help you to **get the signal upstream** to your suppliers. If the consumption is higher, the system will pull more. If the consumption is slower, the system will pull less. While you still may have to arrange with your supplier the average quantities, smaller fluctuations are easier to handle.
- Due to the milk run being a pull production, it will have **less inventory** than a comparable performing push system.
- This reduced inventory leads to a **reduced use of space around your assembly line**. And the assembly line is the spot where space is most valuable. Saving space at the assembly line is probably even more valuable to the system than simply reducing inventory. See also my post on Twelve Ways to Create Space around Your Assembly.
- Another side effect of the pull system is that **the inventory – more or less – manages itself.** You do not need to track when to send what to where, as this happens automatically with the milk run.
- As a final side effect, since the pull system happens more or less automatically, there is less chance for human (or computer) error, and in a properly defined system you are **less likely to have stock-outs**.

39.4 Drawback of the Milk Run

Figure 331: Identical and Non-Identical Screws (Source images Haragayato under the CC-BY-SA 2.5 license and Ssawka at under the CC-BY-SA 3.0 license)

The milk run has one major limitation: It works only for mass-consumed parts that are in stock at the assembly line. If your assembly line needs lots of customized items, the milk run may not be the right thing for you.

One possibility of using the milk run with customized items is by kitting, where the milk run delivers kits. However, in this case, a just in sequence approach is needed. More on this later.

The next post has much more on organizational details, before I go into the calculation and set-up of the milk run. **Go out, get your material flowing like the milk of the milk men, and organize your industry!**

40 Milk Run Basics

Christoph Roser, October 02, 2018, Original at https://www.allaboutlean.com/milk-run-basics/

Figure 332: Pouring Milk (Image Martin Vorel in public domain)

In this second post on the topic of milk runs, I will look at the organizational issues around the milk run: what kind of transport can you use, and what should the source warehouse be like. I will also talk about optional extras like repacking or kitting. Let's start.

40.1 Type of Transport

There are a few organizational issues for a milk run to work. The first one is the type of transport. For external logistics this would be a type of truck. A human could push along a cart, but more commonly I have seen small trains where a tractive unit pulls a number of carts.

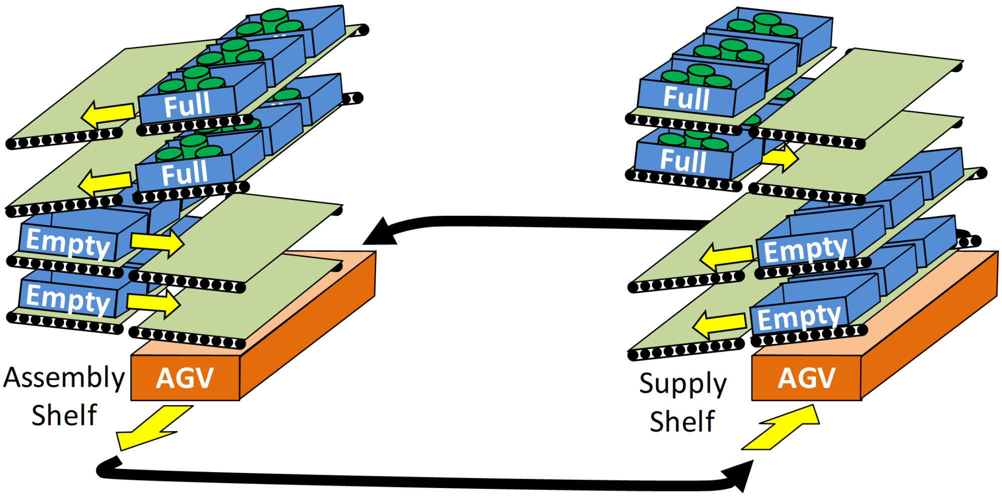


Figure 333: BMW South Africa Karakuri (Image Roser)

Automated guided vehicles (AGV) that deliver goods driver-less are also possible, although here you need to ensure that there is a person or process for unloading the goods and loading the empty boxes. See my post on [Karakuri Kaizen Examples](#) for inspiration. For a milk run you would need these carts and tractors, and your plant should have drive paths and corners that they can pass through safely.

Figure 334: Electric Tractor Train (Image Still under the CC-BY-SA 3.0 license)

Electric tractors commonly pull a number of carts. These may have shelves for smaller boxes, or carts that have stacks of boxes, or even carts that can fit an entire pallet. They could have a roof and even a tarpaulin if the train has to cross into different buildings exposed to the elements.

Often the materials have assigned spots on the different carts. Material A goes on cart 1 shelf 2, material B on cart 2 shelf 1, and so on. If possible, put all material for one destination close to each other so that the driver does not have to walk to different carts. Hip-height material is most ergonomic, so you could opt to put heavier or more commonly needed materials there.

In any case, if it is unloaded manually, the driver should have easy access to the required material, and should not have to handle multiple boxes to get to the material he wants. The boxes should be of a weight or size so that they can be unloaded easily by hand. If the boxes are larger or heavier, or if the train also contains pallets, you may have to provide handling equipment like a small forklift or crane.

There are even some nice gizmos that can make loading and unloading easier. Since the driver will be doing a lot of loading and unloading, any small help can make him more efficient. See for example the short video below:

The Video by LogismarketDE is available on YouTube as "Milkrun train - LEAN Manufacturing" at https://youtu.be/JOAp9tQS3VU

40.2 Source Warehouse

Figure 335: Supermarket with Beverages (Image Roser)

The source warehouse also needs to be easily accessed for the milk run. The material has to be readily available, without lengthy delays due to a material request into the warehouse management system. Naturally, you should not run out of stock at the source warehouse. I have seen systems where the material was provided on pallets on the floor or on shelves that are easily accessible for the drivers. It looks just like a supermarket with shelves and pallets.

For very advanced plants this can also be used with Ship-to-Line, where the goods are unloaded from a truck into a small buffer stock (ca. two hours) for the milk run, after which the milk run delivers the goods to the line. However, this is quite advanced, and if you don't have it yet I recommend starting with a milk run (easier) before attempting Ship-to-Line.

40.3 Optional: Repacking

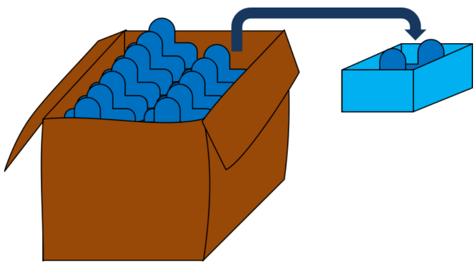


Figure 336: Repacking (Image Roser)

Often the source warehouse is also used for repacking. If the material arrives in containers that are too big, made from cardboard, or otherwise not suitable for delivery to the line, there is the option to take the material out of the packaging and put it into smaller boxes that are then brought to the assembly by the milk run. The advantages are smaller quantities and hence leaner material supply, avoidance of cardboard and other trash at the line, and customized containers that are easy to use at the assembly location. On the other hand, you need someone (often the driver) to do the repacking.

40.4 Optional: Kitting

Finally, there is the option of kitting, where a person (again, often the driver) selects different parts into a kit. These kits could be the same set for every part (i.e., always the same four parts in a box). Although, in this case, it would be easier to just have a separate box for every part type. The advantage of kitting is in providing custom parts just as they are needed at the assembly line.

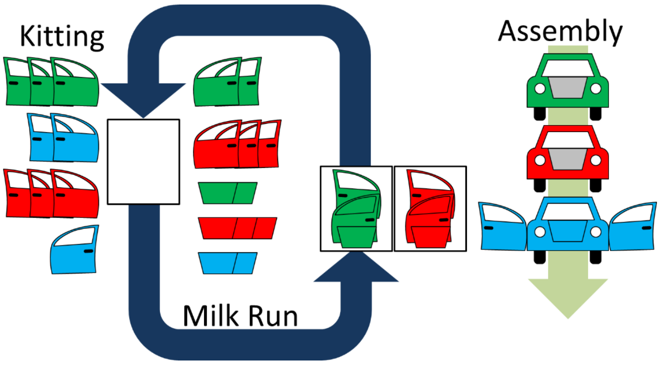


Figure 337: Kitting Assembly Milk Run (Image Roser)

The big challenge here is to make sure the driver knows what to pick! Any mix-ups may lead to parts being out of sequence or a mismatch at the assembly line, resulting in a stop of the line or costly rework. If you go this route, make sure you put a LOT of effort into the right sequence. Pick-by-Light can help, although you have to make sure that the computer accurately knows which part to pick, and that there is no foul-up on the way to the line or within the line. A lot of things can go wrong with such a Just in Sequence approach.

40.5 Destination Stops

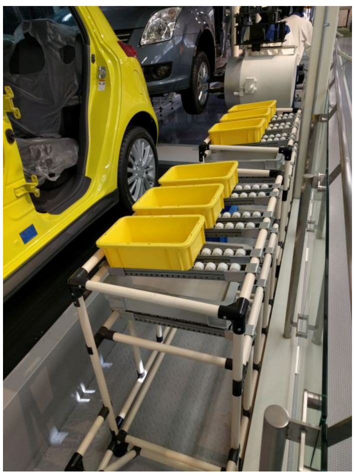


Figure 338: Small Supermarket at Assembly (Image Roser)

At the destination, you need a small supermarket inventory. Often this is done using rolling lanes or sliding chutes, as seen in the image here. The image is from the Suzuki museum in Hamamatsu; in reality the rolling lanes are a big longer and – most importantly – the boxes are

NOT empty. The driver of the milk run drops the full boxes into the matching chutes of the small supermarket, and removes empty boxes from return chutes.

The chutes for the full material have to be assigned to one material only. A certain type of material goes in only one chute and no other. If you have a lot of material of one type, you may use more than one chute, but this is sub-optimal. Try to fit all material of one type in a single lane.

The return chute with the empty boxes, however, is rarely assigned to empty boxes of one material type. Usually, such supermarkets have much more material than empty boxes, since the material demand is steady, but the milk run just takes away all empty boxes that he can find. Hence, you can save a lot of space by not assigning return chutes to apart type, but allowing any empty box in a return chute (that matches the box size if you use different sized boxes). Often such return chutes are on the very top of the shelf, since empty boxes are light, and – to save space – you can also stack the boxes sideways or on top of each other. Whatever saves you precious space at the assembly line!

In the next post I will start with the numerical side of the milk run. How often should it run, how much space is needed at the line and on the milk run, etc. So stay tuned. Until then, **go out and organize your industry!**

41 Calculating the Material for Your Milk Run

Christoph Roser, October 09, 2018, Original at https://www.allaboutlean.com/milk-run-calculations/

Figure 339: Milk and Cookies (Image Carsten Schertzer under the CC-BY 2.0 license)

After all the theory on how a milk run works, it is finally time to calculate the quantitative details of the milk run. Since this takes a bit longer, I have split the calculations into two separate posts. Well, here we go!

41.1 Frequency and Capacity

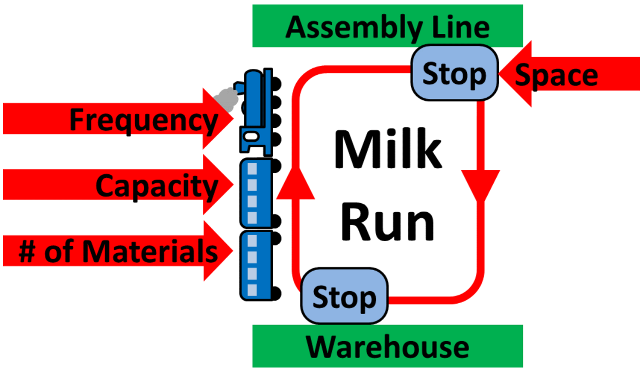


Figure 340: Milk Run Factors (Image Roser)

There are a few things on a milk run that influence or depend on each other. The capacity of the train, the frequency of the train, the number of materials supplied, and the space at the assembly line. In theory, a cost-benefit analysis would guide you toward the optimal solution. Unfortunately, in real life you do not have the costs and the values associated with these effects, and I believe a reasonable cost-benefit is not possible.

Instead, I would suggest starting at one end and working your way toward the dependent variables. Out of all these factors, the space at the assembly line is the most critical one. Hence, your milk run should be set up to minimize the use of this space. You probably have to repeat the calculations below a few times iteratively to come to a suitable solution.

41.2 You Need Two Cycles' Worth of Material Plus One Box in the Loop

So let's start with the space at the assembly line. We want to figure out how much material we need at the line. You always want to have at least one box of material there all the time. Let's look at one box in more detail. If you have just emptied the box, the milk run would pick it up on its next visit, and bring it back full on the second visit after that. In the best case, your box would be empty just when the milk run arrives, and you would have to wait one milk run cycle to get a new box (i.e., if the milk run comes every hour, you would get a full box back in one hour). This is illustrated below on a timeline where the red line represents the milk run traveling from the warehouse to the assembly line stop and back.

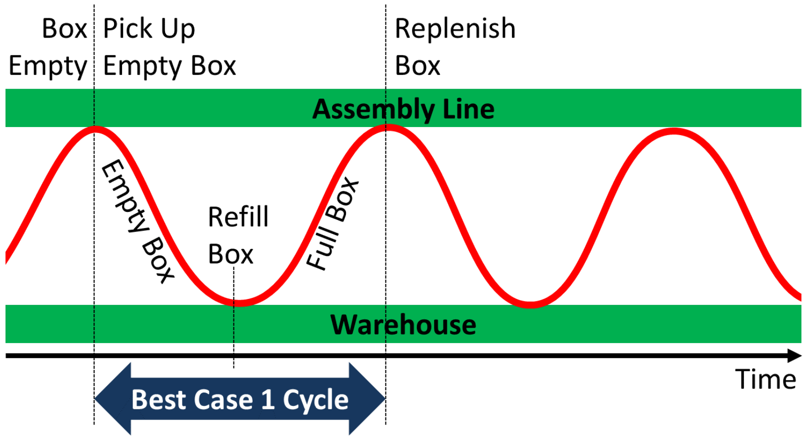


Figure 341: Milk Run Loop Best Case (Image Roser)

In the worst case, however, your box becomes empty just when the milk run left, and you would have to wait a maximum of two cycles. If the milk run visits every hour, you would have to wait one hour for the milk run to pick up the empty box, and another hour to bring you the box back full. Hence the total replenishment time is two milk run cycles, or in our example two hours. This is also illustrated below.

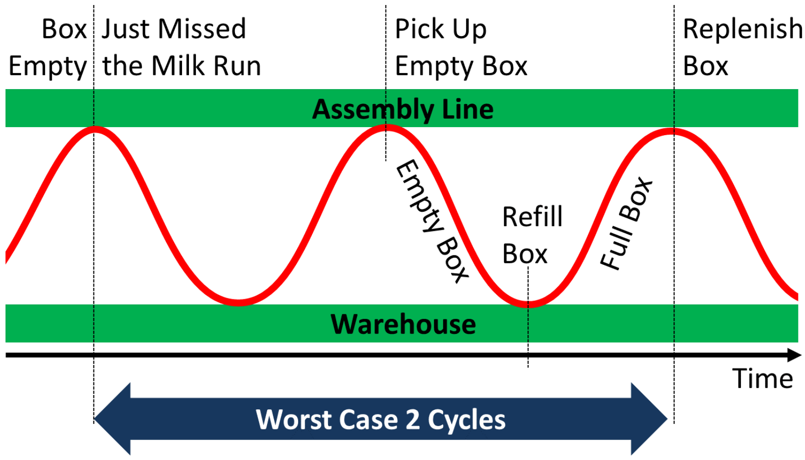


Figure 342: Milk Run Loop Worst Case (Image Roser)

Both the best case and the worst case are possible. Hence, we have to set up the milk run to handle the worst-case scenario. Since this worst case won't happen all the time, this assumption also gives us some safety buffer for the "not-the-worst" cases. Therefore we need enough space at the line to store material worth for two cycles duration **plus one box**! We need this extra box of material in case all other boxes are empty or refilled and just on the way back from the warehouse. You can add some additional safety buffer if you feel uncomfortable with the number.

In regular operation, half of the inventory (plus safety buffer) would be at the assembly line, whereas the other half would be on the milk run (either empty to the warehouse or full returning from the warehouse). You may get away for regular operations with space at the assembly line for material for only one cycle (plus safety), while the material for the other cycle (plus safety) is on the milk run. However, in this case material may back up in the milk run if the demand is unusually low.

In any case, when the milk run is operating, check the status of the supermarket at the line. If there are occasional stock-outs despite material in the warehouse, you may want to increase the number of boxes. If there is always more than one box in the supermarket, you may want to reduce the number of boxes.

41.3 Estimate the Milk-Run Cycle Time

Next, we would need to make an initial estimate on what our milk-run cycle can be. This, of course, will be revised later iteratively to find a good solution.

So how often does your milk run run? Do you have one every two hours, one every hour, one every thirty minutes, or even one every fifteen minutes? The shorter the cycle, the less material you need at the assembly line. However, the shorter the cycle the more milk runs you may need.

You may have noticed above that I used nice, round numbers for the duration. You could of course determine that you want a milk run every twenty-three minutes and fifteen seconds. This would work, but it would drive your people crazy. Your driver would have to check every time when his next round is due. However, if your cycle is somewhat regular (hour-sided intervals, or an even division of the hour (thirty minutes, twenty minutes, fifteen minutes or so), the driver and also the customer can remember it much easier and will notice much faster if something is out of whack. For an automated transport system, you could in theory also use odd numbers, but even then the customer may wonder when his next vehicle would arrive.

41.4 How Much Is Two Cycles Plus One Box?

Okay, let's figure out how much material you need to cover two cycle times plus one box. Determine what material types you need at the assembly line, what their consumption rate (or consumption takt) is, and how many of them you want to put in a box. For example, assume you need on average one piece of type A every 50 seconds (the consumption takt). If your box fits 12 pieces, then one box will be enough for 10 minutes of consumption (12 times 50 seconds equals 600 seconds or 10 minutes).

Hence, if your cycle is (for example) 1 hour, then you would need 6 boxes to cover the one hour, plus one (i.e., a total of 7 boxes of this particular material type).

In this example I had nice round numbers. Chances are that you may end up with a non-integer number of boxes (i.e., 7.3 boxes to cover the two cycle). **In this case, always round up!** Strictly speaking you may not need the additional +1 box in this case, but whenever possible I prefer to add this +1 anyway to be on the safe side.

Hence, the calculation of the total number of boxes in the loop is as follows:

$$\text{No. of Boxes} = \text{RoundUp}\left(\frac{2 \cdot \text{Milk Run Cycle Time}}{\text{Consumption Takt} \cdot \text{Pieces per Box}}\right)$$

where the consumption takt is as follows:

$$\text{Consumption Takt} = \frac{\text{Time Interval}}{\text{Demand during Interval}}$$

This calculation has to be repeated for every material that you want to provide by milk run. The consumption rate may change depending on the part (i.e., one product may require four screws and one flange per piece, hence the hourly demand or the time between pieces may differ). The number of parts in a box or container may also differ depending on the part number. But overall you now have the number of boxes that you need to fit at the milk-run stop supermarket. This has to be done at every station for all the material that goes on the milk run.

In the next post I will continue these calculations with discussion of the milk run layout. Until then stay tuned, and **go out and organize your industry!**

42 Milk Run Layout

Christoph Roser, October 16, 2018, Original at https://www.allaboutlean.com/milk-run-layout/

Figure 343: Milk on Spoon (Image PXHere in public domain)

In this post I will discuss the layout of the milk run as well as the space on the milk-run train, and other topics. It is a continuation of the previous post on the milk-run calculation. Let's continue.

42.1 Space on the Train

Figure 344: Crowded Train (Image Chris 73 under the CC-BY-SA 3.0 license)

After calculating the required inventory that has to cycle around in the milk run, we next need to consider the space needed on the train. For each part you have to bring full boxes and return empty boxes. However, you have to consider only one or the other. If you are bringing full boxes of a part, you won't have empty boxes for this part yet, since you pick them up only after delivery of the full boxes. If you are returning empty boxes, you have already dropped off the full boxes. Hence, you need to consider only the empty or the full boxes. I would recommend the full boxes, since empty boxes are easier to handle and may stack inside each other. In any case, the number is pretty much the same.

So how much material does the milk run have to carry on its route in the worst case? This is simple to answer: it is one cycle's worth of material consumption. Hence, the milk run has to have enough space for one cycle's worth of boxes of all the materials that are delivered, plus some safety buffer to account for fluctuations in the consumption rate at the assembly location.

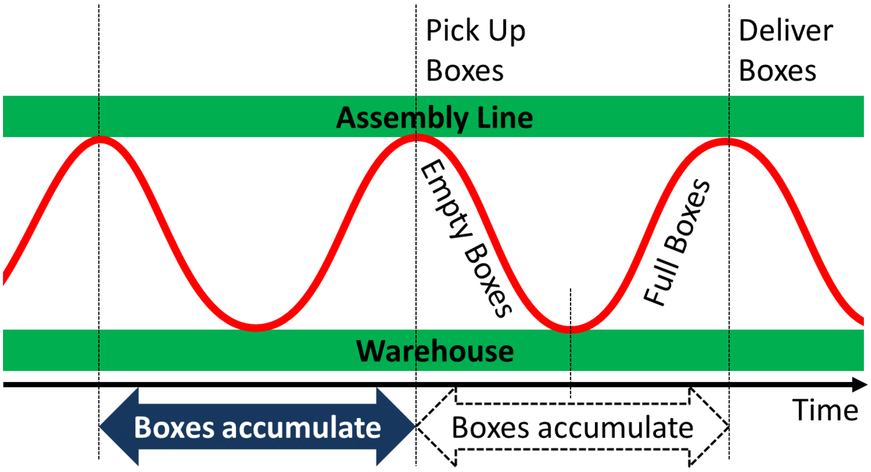


Figure 345: Milk Run Boxes accumulate (Image Roser)

Hence, similar to the calculations in the previous post, the calculation of the total number of boxes of one part on the milk run is as follows:

Das verknüpfte Bild kann nicht angezeigt werden. Möglicherweise wurde die Datei verschoben, umbenannt oder gelöscht. Stellen Sie sicher, dass die Verknüpfung auf die korrekte Datei und den korrekten Speicherort zeigt.

Again, you may end up with a non-integer number of boxes (e.g., 4.2 boxes of part A). In the previous equation, we rounded it up since the line absolutely needs this part. Here, the milk run only needs to have enough space for the box. If one material type has one box more, another material type may have one less. Hence, I would not strictly round these numbers up all the time. If I have 3.1 boxes, I would go with 3; if I get 3.5 boxes, I would go with 4. It all depends on how much risk you are willing to take, but here it is not quite as critical.

42.2 Milk-Run Loop Layout

42.3 Milk-Run Stops

So far the design of the milk run was a pretty much straightforward calculation. Now comes the more artistic part. How do you design the loops for the milk run? First, you need to figure out where you want to have your stops. You definitely need one at the warehouse were you get the material. Ideally the warehouse can handle multiple milk runs simultaneously if you have different routes.

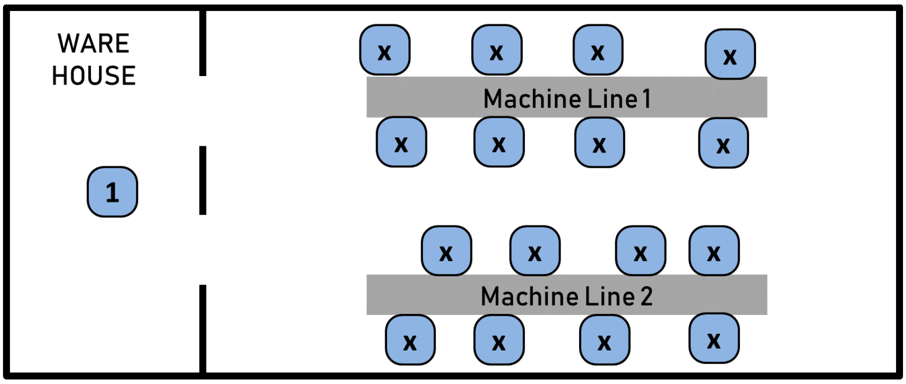


Figure 346: Milk Run Stops (Image Roser)

For the assembly lines or cells, you would have to consider where you want your stops. You best take a A3 print of the layout and go through the shop floor, thinking about where you need material. This can also depend on other logistic elements. For example, if you have a point-of-use provider (also known as water spider or, in Japanese, *misuzumashi*) that brings material from a small supermarket near the line to the actual machines and assembly locations, you may need only one stop with a supermarket for one line. If, however, the milk run is the last logistic step before the part is assembled, then you need probably multiple stops along the cell or line.

At the end you should have a list of stops where the milk run is supposed to deliver material. It also helps to determine which material has to be delivered at which spot.

42.4 Milk Run Route

Next, you have to determine the route of your milk run. This is done by connecting the desired stops in a logical fashion.

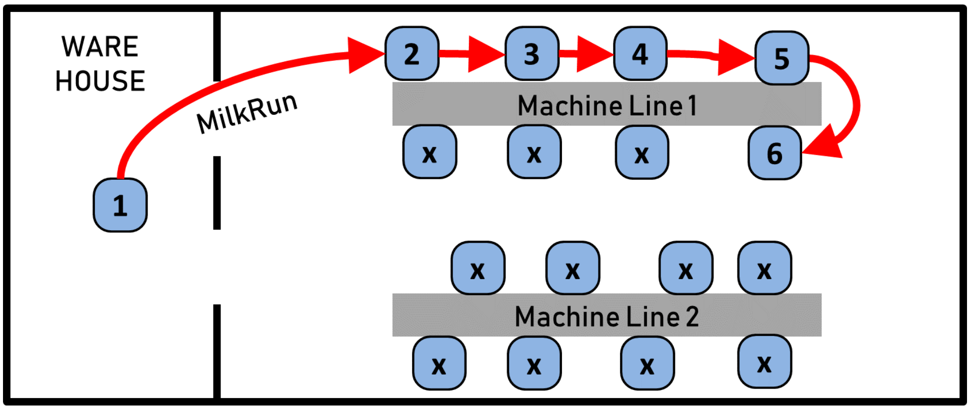


Figure 347: Milk Run Route Development (Image Roser)

There are two things that limit your milk-run length: the time needed to do the milk run has to be less than the milk-run cycle time we used for our calculations above, and all the material has to fit onto the train.

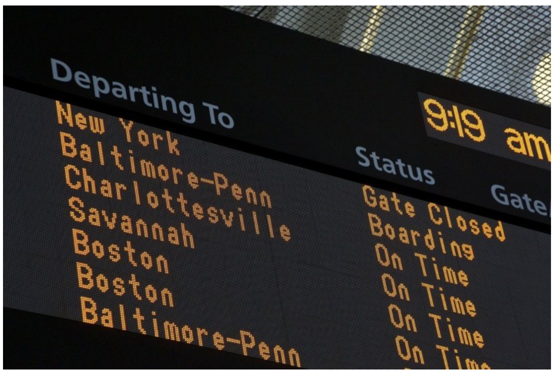


Figure 348: Train schedule display (Image Pexels in public domain)

As for the time, you should put as much logistics in the cycle as you can. If your milk run takes one hour, then try to put almost one hour's worth of work in it. However, do keep some safety time buffer too. If your milk run falls behind, your whole assembly line may be slowed down. The calculations below assume a human driver, but similar calculations can be done for automated guided vehicles too.

There are a couple of things that go into the calculation of the loop. You have the **time needed to drive** the distance. Depending on your vehicle and regulations, this speed may be somewhere between one and two meters per second, not including acceleration and deceleration.

You also need **time at a stop to load material and pick up empty boxes**. This is best simply tested, and may end up with a few seconds per box handled, plus possible walking distance for the operator.

You also need **time to restock the milk run in the warehouse**. How many empty boxes have to be refilled? This may take more time than the drop-off at the assembly line, especially if you need **time for additional repacking or kitting work**.

Often, the time is the bigger constraint, but **occasionally check if your stuff still fits on the train**. Most trains have from three to five wagons, but this depends on your type of vehicle. Overall the train should be able to safely and easily navigate your shop floor.

I find it best to simply start at the warehouse, and add stops (including the driving time, time at each stop, and time to refill at the warehouse at each stop). I follow a logical sequence of stops along the line. Whenever I reach my time (or space on the train) limit, I finish one loop and start the next. Do not forget the return trip, hence loops are better than in-and-out trips. Also, try not to have all milk runs depart from the warehouse at the same time, or you will create a rush hour that slows things down.

42.5 Iterations

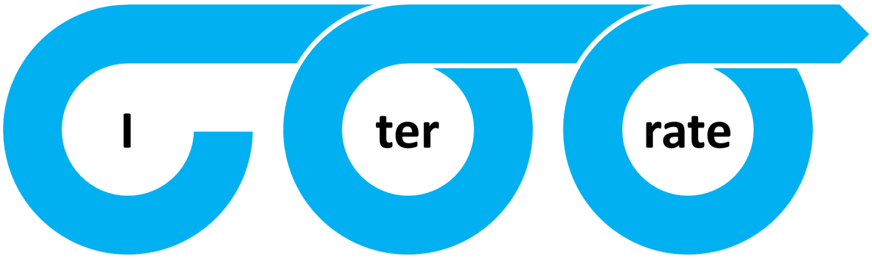


Figure 349: Iterate your Solutions! (Image Roser)

Chances are that while doing the calculations, you may run into a constraint. You run out of space at the line (common), your train will be too long, etc. If so, you may want to adjust the above assumption of the milk-run cycle time and redo the calculations. Excel is a great help here. Over time you (hopefully) will get a workable solution. You may also choose to deliver the bulkiest parts by forklift rather than milk run, although this is not really a good lean style. Overall, multiple smaller milk runs are often better, with lower inventory, and more flexible than one big run.

To be honest, this iterative process can result in a lot of fiddling. The goal here is not to achieve the best possible solution, especially if this is your first milk run, but something that works reasonably well. When the actual milk run starts, you will in all likelihood find many things that you overlooked or that behave different than expected. It is easier to improve a running system (more below); you just have to find a system than does not crash your shop floor.

At the end you may have created a number of different milk runs that all should be comfortably below the cycle time and should able to fit all the material needed for one cycle.

42.6 Refinement

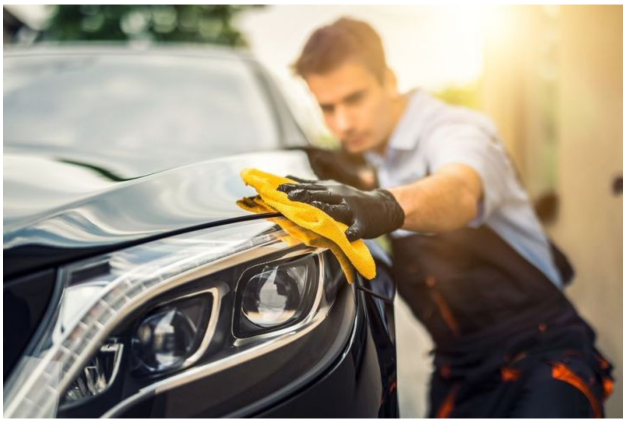


Figure 350: Refine your Solutions! (Image REDPIXEL.PL with permission)

You gave it your best effort, did the calculations diligently, carefully checked all numbers, and then set up the milk runs. Nevertheless, chances are some things may not work out as well in reality as in theory. That is life. By nature of the calculations, you made assumptions, some of which may turn out to be not good enough.

When creating a new milk run, definitely keep a close eye on it for the next few days or weeks, and consult with the drivers and assembly-line workers about their problems. Follow up these problems and refine the milk run as needed. You may have additional stops, increase delivery frequency, use smaller boxes, or do other things to tweak the performance. Such projects (like most lean projects) are not fire-and-forget projects, but something that needs work and care, especially if they are new or if the system (products, machines) change.

So, this is the gist of milk runs. However, there is much more. In the next post I will discuss a few frequently asked questions on milk runs, and then also discuss external milk runs. Now, **go out, get your material flowing (cyclically), and organize your industry!**

43 Frequently Asked Questions for Milk Runs

Christoph Roser, October 23, 2018, Original at https://www.allaboutlean.com/milk-run-faq/

Figure 351: Milk Splash in Glass (Image unknown author in public domain)

After discussing a lot about the milk run, its use, and its calculations, here is a post on a number of remaining frequently asked questions. Many of them are pitfalls, where it is easy to make a quick wrong guess (e.g., two milk runs on the same route will not halve your inventory at the assembly locations). Let's get into more details.

43.1 What About Using a Part at Multiple Locations?

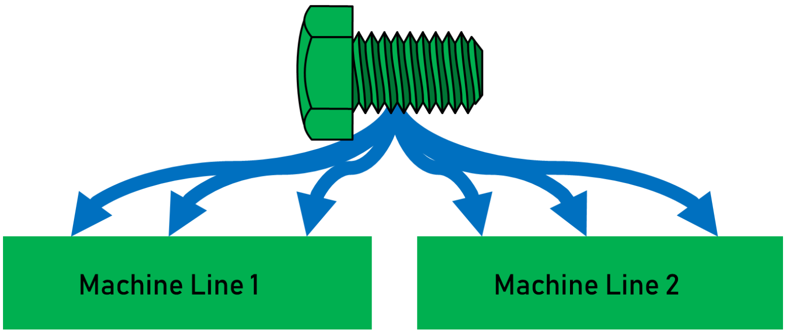


Figure 352: Multiple Points of Consumption (Image Roser)

You may have identical parts that go to different stops (e.g., screws that are used at different locations). In this case you must consider all of these different destinations separately. Hence, for the same screw you need to calculate a demand at stop A, demand at stop B, and so on for every stop where the screw is used. You cannot use a joint demand!

The reason is that the milk run needs to know where it needs to drop off the parts. If you use identically labeled boxes of screws for all stations, then the milk run does not know where to put them. The driver will probably try to fit as many boxes as possible at the first station, oversupplying the first station and causing all other stations to run out of screws. Hence: **Do use separate labels and make separate calculations for every milk-run stop, even if the parts are identical!**

43.2 I Don't Have Enough Space!

You may do the calculations and then mentally place the boxes at your station, only to find out that you do not have enough space! Well, welcome to the club! This happens to everybody. You can look at my post on [Twelve Ways to Create Space around Your Assembly]() for some suggestions, but one way to resolve this problem is an increased delivery frequency (i.e., a shorter milk-run cycle).

It turns out that you may have problems only with a few bulkier parts, and everything else is fine. Unfortunately, since they are all on the same milk run, they all run on the same schedule.

Hence, a more frequent delivery for the bulky parts means a more frequent delivery for all parts on the same vehicle.

However, it is unlikely that you will service your entire plant with the same milk run. In all likelihood you may have multiple milk runs for different areas. In this case, you can opt to have different milk run cycles for different areas.

43.3 How About Multiple Trains on the Same Loop? – Don't!

You may have a genius idea: You just use two trains, and the inventory needed to cover the loop would shrink to half of the inventory. Or even three trains and you would need only one-third of the inventory. Wrong! By using multiple trains, you would indeed reduce the time needed to cover in the worst case, but much less.

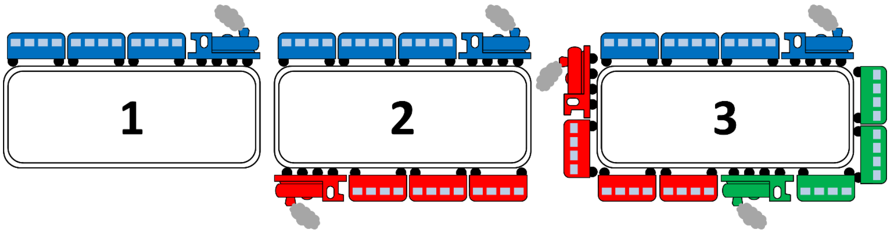


Figure 353: Milk Run Multiple Trains (Image Roser)

Let's assume an example with two milk runs on the same loop. Assume the first milk run (the red line) just missed the box. Instead of waiting one cycle for the red milk run, the empty box has to wait only for half a cycle to be picked up by the blue milk run. Hence the overall worst case to cover is 1.5 cycles.

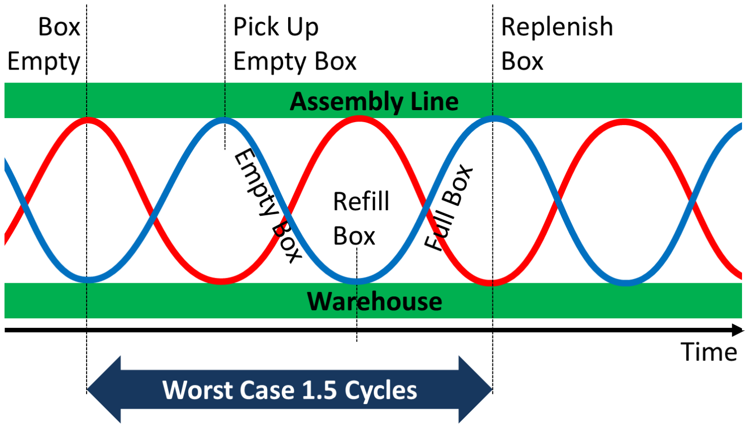


Figure 354: Milk Run Loop Worst Case Two Trains (Image Roser)

Here is the example with three milk runs on the same loop. The "just missed" empty box would be picked up one-third of a cycle later, giving you a worst case of 1.33 cycles.

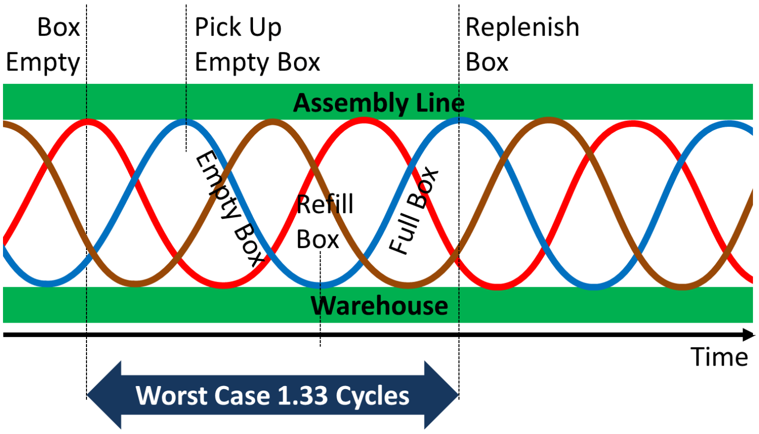


Figure 355: Milk Run Loop Worst Case Three Trains (Image Roser)

Overall, I believe the benefit in reduced inventory at the assembly line is small, and may not worth be the effort. It definitely won't cut the required inventory in half for two milk runs or even one-third for three milk runs. You also may run into problems if a milk run catches up with the other one. The only more substantial benefit would be that the milk run would carry only half (or one-third) of the material of a single milk run.

Frankly, while possible, I have never seen such a solution, and would strongly advise against it. **Rather than making two (or more) trains on the same loop, split the big loop into two (or more) separate loops!**

43.4 Milk Run During Breaks?

The milk run must run on a regular schedule. This schedule ensures that there is a milk run visiting to pick up empty boxes and return full boxes every fixed time interval. If the milk run does not come, the line will run out of material very soon. Hence, the milk run MUST visit every cycle.

However, this is only valid while the lines and stations are actually running. If the assembly is idle, the milk run can idle too. Hence, during breaks at the line, the milk run can take a break too. Obviously, if the line is stopped completely (holidays, off-shifts, etc.), the milk run does not have to run either.

43.5 Different Break Times?

Can the milk run have different break times than the line? In other words, if there is a break, could the milk run just continue its route while the rest of the plant takes a break, and then take the milk-run break once he has arrived in the warehouse?

In short: No! Do not use different breaks for the milk run and the assembly locations! You will mess up the delivery cycle.

In more detail, let's first look at the situation without a break. In the example below, we look at one station of a milk run. A part is consumed per minute (or ten every ten minutes), represented by the green boxes with a "10" in them. The milk run stops by every thirty minutes (the blue arrows), picking up empty boxes for thirty parts and delivering boxes with thirty new parts (the arrows with the 30 in it).

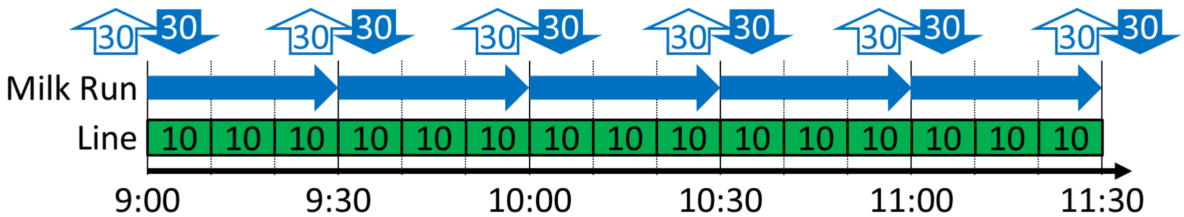


Figure 356: Milk Run without Breaks (Image Roser)

If the milk run and the assembly take a break at the same time, nothing changes. The milk run still picks up boxes for thirty parts and delivers thirty parts every time it stops by. One stop will be twenty minutes later due to the break, but the line also had a break, hence the consumption is the same thirty parts.

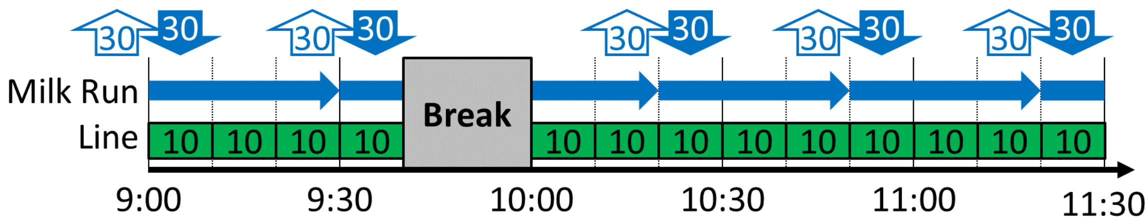


Figure 357: Milk Run with the same breaks as the line. (Image Roser)

However, if the milk run takes its break early, the line will run out of parts. The milk run will return after fifty minutes, but during this time the line consumed forty parts, running out of their thirty-part inventory. Depending on the safety buffer, the milk run would have to pick up forty parts. After the break when the milk run returns at 10:20, the line worked consumed only twenty parts. This will be a problem later when the milk run brings only twenty parts, but the line would need thirty to cover the time till the next milk run. In sum: It is a mess!

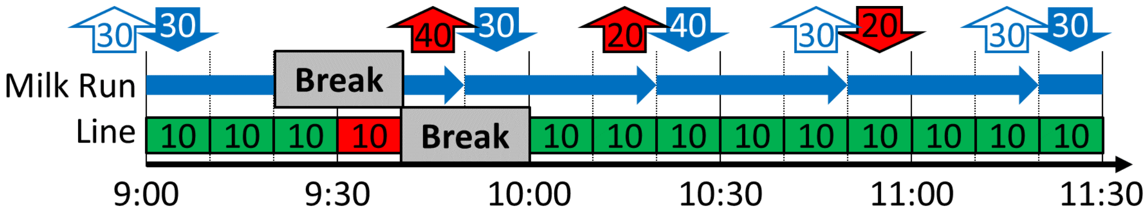


Figure 358: Milk Run with an early break. (Image Roser)

A similar situation applies if you have your break late. At 10:00 the milk run picks up only ten parts. The line will run out of parts afterward, since there would be a need for fifty parts until the milk run returns. Even when the milk run returns, it will bring only a measly ten parts. Again, we have a mess.

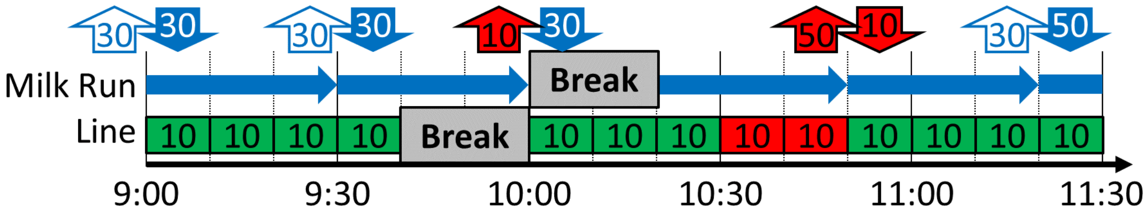


Figure 359: Milk Run with a late break. (Image Roser)

Hence, keep your break times for the milk run and the lines the same. There is a tiny bit of wiggle room, as the milk run can take a break the scheduled last station before the line break and the scheduled first station after the line break. However, this usually amounts only to less than five minutes depending on your schedule. If you REALLY need different breaks, your lines need more inventory or you need to have a special process supplying the lines during the overlapping break. Again, don't do it.

43.6 My Milk Run Supplies Two Lines. If Only One Is Running, Do I Need Fewer Milk Runs?

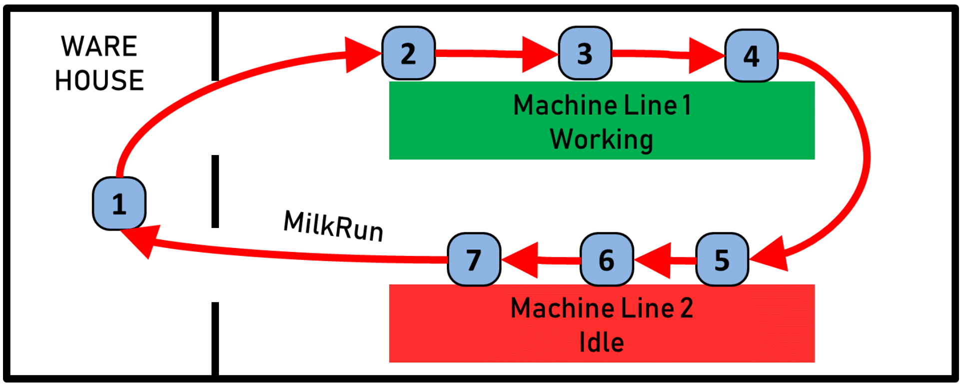


Figure 360: Milk Run on Idle and Working Line (Image Roser)

No. The milk run replenishes the consumed parts at each station within the milk-run cycle time. If only one line is running, the milk run still has to supply the other line every milk-run cycle, hence you cannot reduce the number of milk runs. The only difference for the milk run is that it will carry less material and can make the stops at the idle line slightly faster.

If your lines have sometimes-different schedules, it may be useful to have separate milk runs for separate lines. This way you could turn off the line-specific milk run along with the line without worrying about the other still-working line.

43.7 I Have a Great Idea of Putting On-Demand Goods Also on a Milk Run …

So you want to have the milk run also bring parts that are needed only once or twice, but not regularly like the other milk-run goods? Don't! The more you create exceptions from a standard approach, the more you will be messing up the standard. Mistakes and errors will increase. The same also applies if you want to "flexibly change the routes" depending on demand or other shenanigans. Of course, they can all be done. I just don't recommend it. It will be a lot of trouble to create such a mixed standard, and even more trouble to maintain it. In the end, you may be better off just having a guy bring the rarely used parts separately from the milk run.

So here you have it. A few pointers and tips on how to do milk runs. However, this series is not yet done. So far I looked primarily at internal milk runs. However, it is also possible to do milk runs externally. While most of the previous concepts still apply, there are some additional things to consider. More on this in my next post. Now **go out, establish a cyclic material supply throughout your plant, and organize your industry!**

44 External Milk Runs

Christoph Roser, October 30, 2018, Original at https://www.allaboutlean.com/external-milk-runs/

Figure 361: Milk Run Truck (Image MaryArVeil in public domain)

In my previous posts I talked a lot about internal milk runs. However, you can also have milk runs externally across multiple suppliers and plants. There are a few things to consider that are different from the internal milk runs. Let me elaborate …

44.1 Introduction

Figure 362: Traffic conditions may vary … (Image mploscar in public domain)

External milk runs transport goods from different suppliers or warehouses to the destination. They use trucks and drive on regular public roads. Hence the main difference is that they are subject to traffic conditions.

In fine weather during off-peak hours, the truck may be able to do the cycle in two hours. However, during rush hour in a snowstorm, the time can easily multiply. Therefore, two major differences between in-house and external milk runs are weather and traffic conditions.

Figure 363: Pushing Car in Snowstorm (Image U.S. Air Force photo in public domain)

Your milk-run cycle calculations should not be based on ideal conditions. Rush hours are jammed and weather may change, yet you still want your plant to be up and running. Hence you should do the calculations with a sufficient safety buffer by assuming some congestion or bad weather for your milk-run cycle time. On the other hand, if you plan your milk run to work even during the *snowstorm of the century*, you may be overdoing it with your safety.

Another difference is that internal milk runs usually pick up material at one site and drop it off at multiple locations within the plant. For external milk runs it is usually just the opposite. The truck picks up material at different locations (warehouses or plants) and brings it to one central location (also a plant or a warehouse).

44.2 Basics

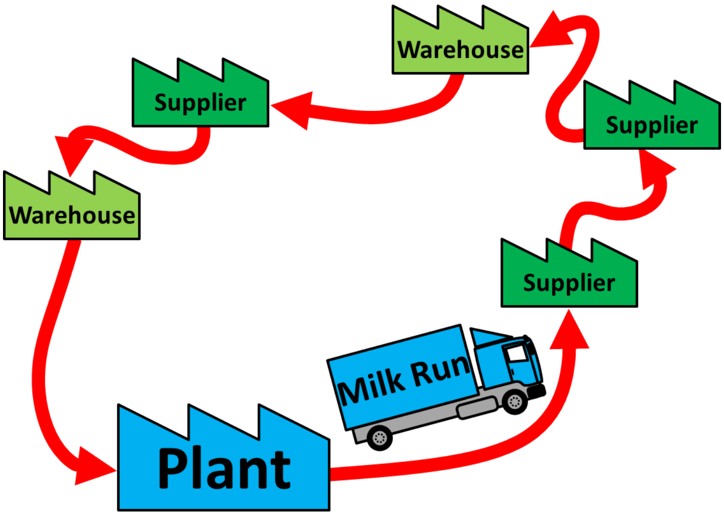


Figure 364: Basic External Milk Run (Image Roser)

An external milk run works best if all the stops for picking up material are near the destination. As a rule of thumb, it is recommended that the milk run should be able to do its route in less than two or three hours. Hence, they cannot make too many stops, and another rule of thumb recommends no more than five stops to pick up material.

44.3 Calculation Difference to Internal Milk Runs

The calculation for external milk runs can be done quite similar to the calculation of internal milk runs. You need enough material to cover the duration until the milk run returns. There is, however, one major difference: In internal milk runs, the signal to replenish is an empty box arriving at the warehouse. In external milk runs, it is very common to create a digital signal (e.g. through your ERP system). The replenishment time does no longer include the time for the truck to drive out, but hopefully the much faster time of collecting the data and sending the digital information.

While the digital data travels at near-light-speed, do not neglect the time to collect and process the data. However, it is likely to be faster than a truck driving out. Hence the time that needs to be covered with material in the milk run consists of the items below. This is also visualized in the diagram below.

- The time for the data signal of an empty box to arrive at the supplier warehouse
- The maximum time the supplier has to wait for the next milk run truck to arrive at the supplier (including loading of the material)
- The time for the milk run to drive back from the supplier to the destination (including unloading and bringing it to the destination supermarket).

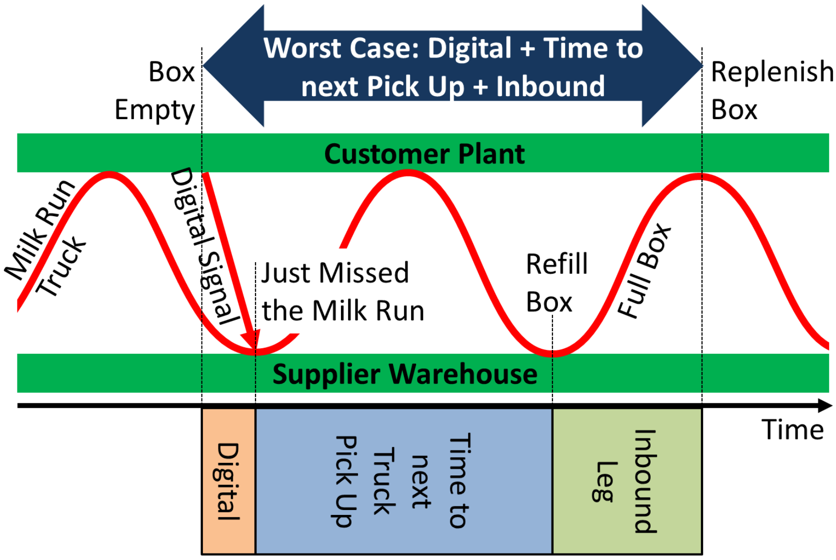


Figure 365: Worst Case External Milk Run (Image Roser)

44.4 Truck Types

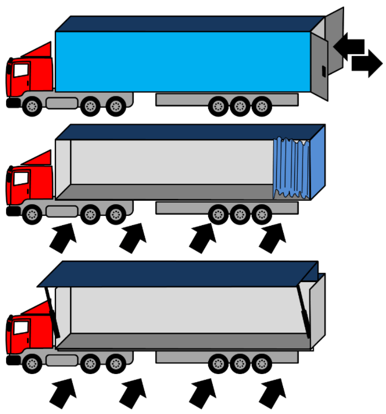


Figure 366: Different Truck types (Image Roser)

The most common type of trucks have a door at the rear. This is easiest to build, but allows loading and unloading only through a small area in the back. If you need to get a certain material (or in our case, more likely an empty box or pallet for refilling), you may have to remove everything else from the truck.

Hence, for milk runs it may be better to have trucks than can be loaded from the side. This could be by sliding back a plane, or by flipping the entire side of the truck up for easy access. These "gullwing trucks" are very common in Japan, but I have been told that European regulations for securing loads handicaps their use in Europe.

Figure 367: Gullwing truck with one wing open (Image Roser)

Having access from the side allows a more selective unloading. For the typical milk run, this makes it easier to return custom containers to the plant or warehouse where they are refilled. It also makes it much easier to maintain Just in Sequence deliveries.

The size of the truck is also relevant. A common habit of logistics is to get the biggest truck and fill it up to the max so the transport costs are reduced. However, this would increase the required buffer inventories, and smaller trucks that run more frequently may be better overall.

44.5 Long-Distance Suppliers

There may be situations where the material is coming from a long-distance source. In this case you have two options (based on Lean Logistics: The Nuts and Bolts of Delivering Materials and Goods by Michel Baudin).

44.6 Remote Suppliers to Local Warehouse

The sources farther away could deliver to a warehouse closer to the destination. Regular trucking brings material from far-away suppliers or warehouses to a local warehouse. The local warehouse contains a buffer stock (based on the replenishment time from the far away suppliers). The milk run simply picks up the material from the warehouse buffer. However, you can also consider having the long-distance trucks deliver directly to your plant warehouse, and you in-house milk run takes over the rest.

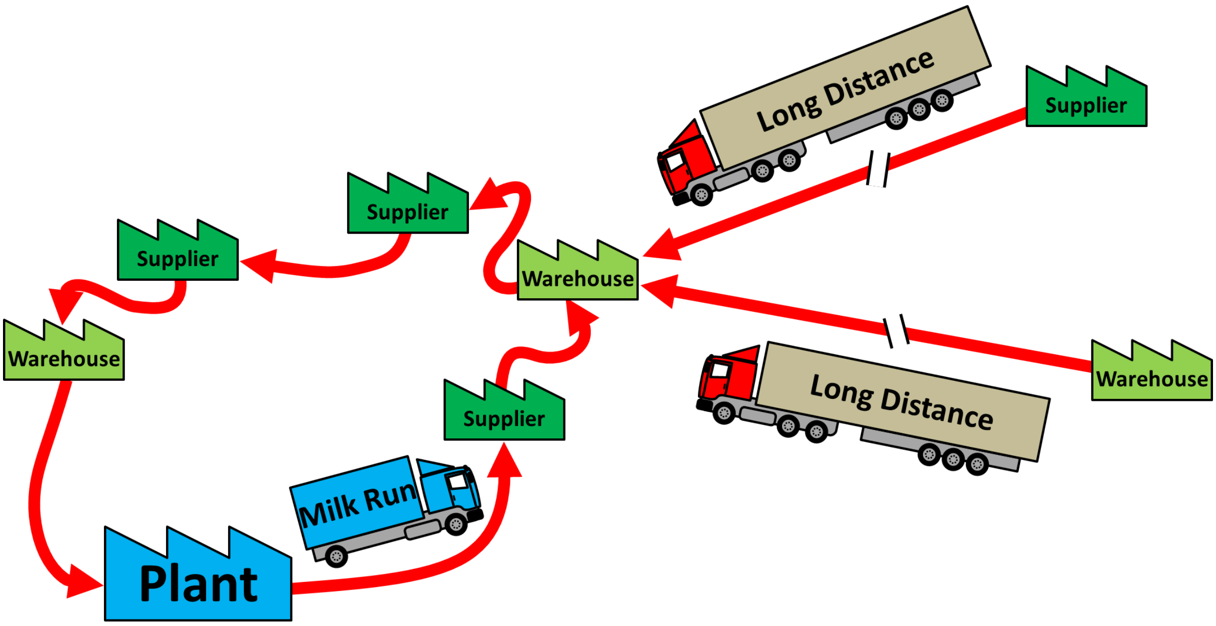


Figure 368: External Milk Run combined with a Long Distance Haul (Image Roser)

44.7 Remote Supplier Cluster

If there are multiple suppliers together in a remote cluster, you can also have a milk run into a warehouse (or cross dock) at the supplier cluster, and then haul the goods from the warehouse to your plant using long distance trucking.

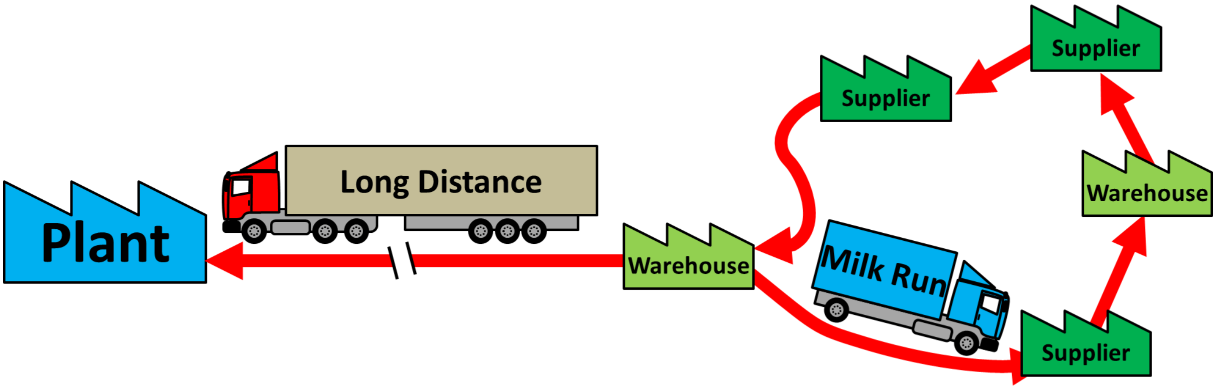


Figure 369: Long Distance Milk Run with a Cluster (Image Roser)

44.8 Long-Distance Milk Run

Finally, you can also have a long-distance milk run, stopping at different suppliers and warehouses. However, the longer the milk run, the longer the milk-run cycle. And, as we have seen in my previous posts Calculating the Material for your Milk Run, the milk-run cycle is one of the key factors determining the required material buffers. A milk-run cycle that takes, for example, two days instead of two hours does need twenty-four times the buffer inventory for twenty-four-hour round-the-clock assembly, or eight times if you work only one shift per day.

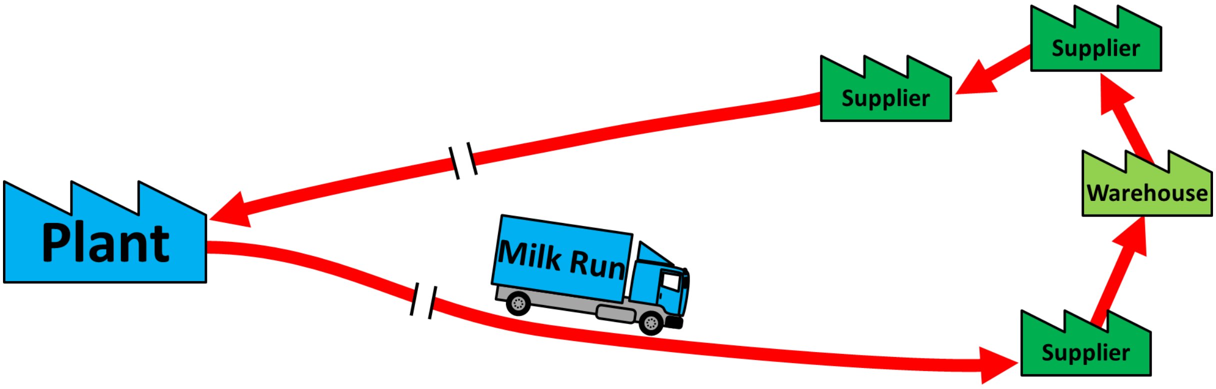


Figure 370: Long Distance Milk Run (Image Roser)

You could use multiple trucks on the same loop, but they will not proportionally reduce the inventory. Multiple trucks reduce the time the information has to wait until the next truck as described in the diagram above at "Calculation Differences". See also my post on Frequently Asked Questions for Milk Runs for details.

Another issue to worry about with long driving distances is the required rest periods for the drivers. If your travel time alone takes twenty hours, the driver will need a ten-plus-hour rest in between (depending on the laws in your location).

If your suppliers and customers are close to each other, you could even combine inbound milk runs with outbound milk runs. Just make sure that if you return empty packaging to your suppliers or customers there is still enough space for the actual goods.

These are a few options for long-distance milk runs. There are more variations possible. You have to find out what works best for your plant.

44.9 The Traveling Salesman

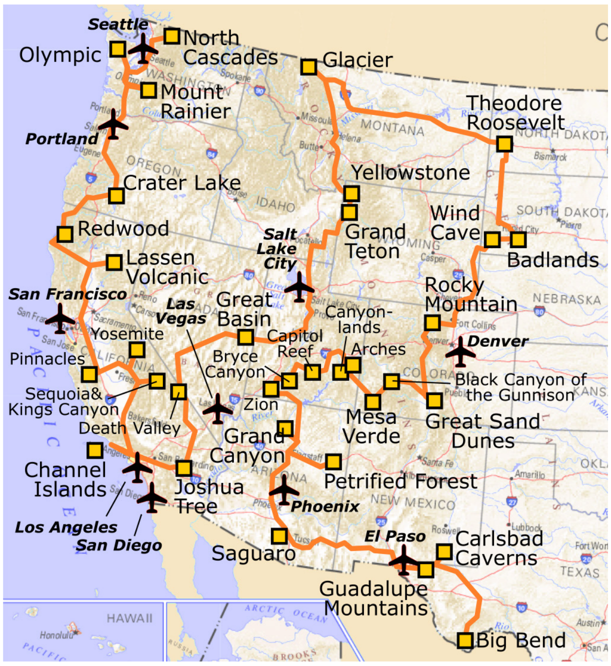


Figure 371: Traveling Salesman Example (Image Stilfehler under the CC-BY-SA 4.0 license)

If you have multiple stops on your milk-run route, there are a number of different sequences in which you can visit them. This is commonly known as the traveling salesman problem, an exciting mathematical problem.

Mathematically optimal solutions are available for routes exceeding 1,000 stops, and if your milk run has 1,000+ stops, then you are doing something else wrong! Hence for your typical milk run with five stops or less, the problem can be solved reasonably easy.

There is only one thing to consider: Do you **optimize for shortest travel distance or shortest travel time?** I strongly recommend travel time, since in your plant time is much more valuable than a truck driving thirty miles more.

So this is an introduction into external milk runs, supplying material from other plants or warehouses. Keep in mind, however, that milk runs make sense only for parts that you consume regularly in larger quantities, and that you have a buffer stock. If it is an on-off part, a milk run is the wrong tool. Similarly, if you consume so much of it that the milk run is almost always full with parts from only one supplier, a direct haulage may be better. You could see this as a milk run with only one stop (on top of your own plant). Now, **go out, get your material flowing, and organize your industry!**

44.10 Selected Sources

A good book discussing external milk run (and other things) is by Michel Baudin (and all of his writing is worth reading): Baudin, Michel. 2005. Lean Logistics: The Nuts and Bolts of Delivering Materials and Goods. New York, NY: Taylor & Francis Inc.

45 A Good Standard Needs No Explanation

Christoph Roser, November 06, 2018, Original at https://www.allaboutlean.com/good-standard/

Figure 372: Standard Illustration (Image Mazirama with permission)

Standards are one of the backbones of lean manufacturing. For a standard to be good and used consistently, it should be self-explanatory. Additionally, you should understand it well enough to easily recognize deviations from the standard. I would like to give you an example of how my thought process works when exploring a standard.

45.1 Introduction

As part of my job I frequently visit different plants and other locations. These tours often come with a lot of explanations by the guide. However, to be totally honest, a lot of these explanations are a bit distracting to me. I'd rather watch the progress in action and focus on what I see rather than focusing on listening to someone. Figuring out how it works somehow gives me a personal satisfaction.

CONSORCI SANITARI Garraf

Figure 373: Consorci Sanitari Garraf Logo (Image Consorci Sanitari Garraf hospital for editorial use)

As part of the recent Lean Global Network (LGN) annual meeting in Barcelona and Tenerife, I was able to visit the Consorci Sanitari del Garraf hospital near Barcelona. We were a bigger group, and the explanations were translated from Catalan into English, hence it was a perfect opportunity for me to focus on what I see.

Before I start, I would like to point out that this approach does not work in all plants. If there are no standards visible or followed, then you can't really understand the standard, much less see deviations from it. However, recognizing no standard already tells you a lot about the plant.

In this particular hospital, we were told that it is just starting out on its journey, and that we (a bunch of hardcore lean experts) should be gentle with our feedback. However, this request would not have been necessary, as I indeed quite liked what I saw. The hospital was doing lean quite nicely.

45.2 The Medicine Cabinet

After the obligatory introduction, our tour started in the surgery ward. While they explained their scheduling board, I got interested in their medicine cabinet. No, I did not stock up on everybody's favorite drug, OxyContin (DON'T DO IT!!!), but I was interested in their material supply system. At first glance it looked structured, and all boxes were properly labeled. So far, so good.

Figure 374: Hospital Supermarket (Image Roser)

45.3 Kanban Boxes

I took a closer look at the boxes. They seemed to usually have three almost identical labels. The box itself was labeled, and split with a divider (except for larger items where they had two boxes next to each other). The divider and the back had a removable label each with a barcode. The rear label also was colored signal red.

Figure 375: Medicine Boxes Close Up (Image Roser)

This looks very much like a variant of the two-box kanban system: if one box is empty, it is refilled. While it is being refilled, the other box is used. One box hence needs to last at least long enough while the other is refilled.

Except in this case it is only one box, and the box itself does not move, only the kanban cards. I assumed that when the front half of the box is empty, the kanban card is sent for a refill, and the second half of the box is moved forward to maintain FIFO. Time to check this hypothesis.

45.4 Kanban Standard

I found a couple of boxes where the front part was empty. In some of these boxes, the front kanban was removed and only the rear kanban was still there. However, other boxes were also empty in the front half, but still had their kanban. Below are two such examples where the front half in both boxes is empty, but one still has a kanban.

Figure 376: Half Empty Boxes (Image Roser)

This is now a bit unclear. If the card is a kanban, when should it go back? Toyota sends the kanban back when the first part of a box is removed. Here this would be not ideal, since the material would return while both halves of the box are still full, leading to problems with maintaining FIFO and potentially expired medicine.

But, with waiting until the box is empty, do they send the kanban back when the last part is taken (right example above), or when the first person finds a (half) empty box (the left example above)? My preference would be to send the kanban back when the last part is removed. Anyway, this is now not obvious, and this ambiguity may indicate a deviation from the standard.

Hence, now I had to ask. It turned out that the kanban should be sent back when removing the last part in the box, and hence a few workers did not quite follow the standard as well as they should have. However, getting workers to consistently follow the standard is often an uphill struggle. Yet it is a good standard since I noticed the deviation without any explanation.

45.5 Kanban Post

Anyway, in the back of a room I noticed some magnets with kanban stuck to them. This is the kanban post (or kanban box) where the kanbans for empty boxes are collected to be refilled. A closer inspection of a sample empty box indeed showed the kanban at the wall (here, the *Mercromina* from the photo above with the kanban below).

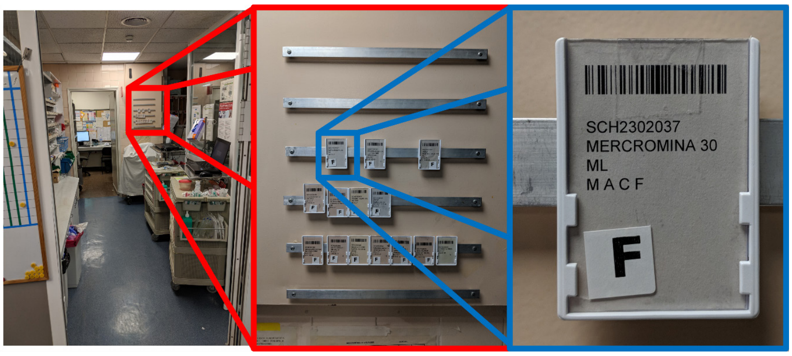


Figure 377: Kanban post overview (Image Roser)

It is also clearly visible that there are no red kanban on the kanban post. The red color was used only for the second box, hence it seems to be a visual indicator (visual management) that they now really ran out of parts! No red cards means everything is A-OK.

At another location, the kanban post did have some red kanban attached. This means that they'd run out of material since they removed the kanban with the last part. This is a problem. The good thing is I was able to recognize this right away due to the good visual management.

Figure 378: Kanban Post Detail (Image Roser)

45.6 Where to Put What?

I think I now understood the flow of the kanban back to the central warehouse. However, how does the person who refills the inventory know where to put what? I found a list attached close to the inventory, and was able to match material in the supermarket to the list. The left number was the material number, but the right one was unclear, hence I had to ask again. Indeed the right number was an indicator of the location, in this case room 1 shelf 07 level 02 and 01 for front part. This location code was also on this kanban. However, the image of the other kanban above seems to have a different code (*Mercromina* was *M A C F*), and I did not figure that code out.

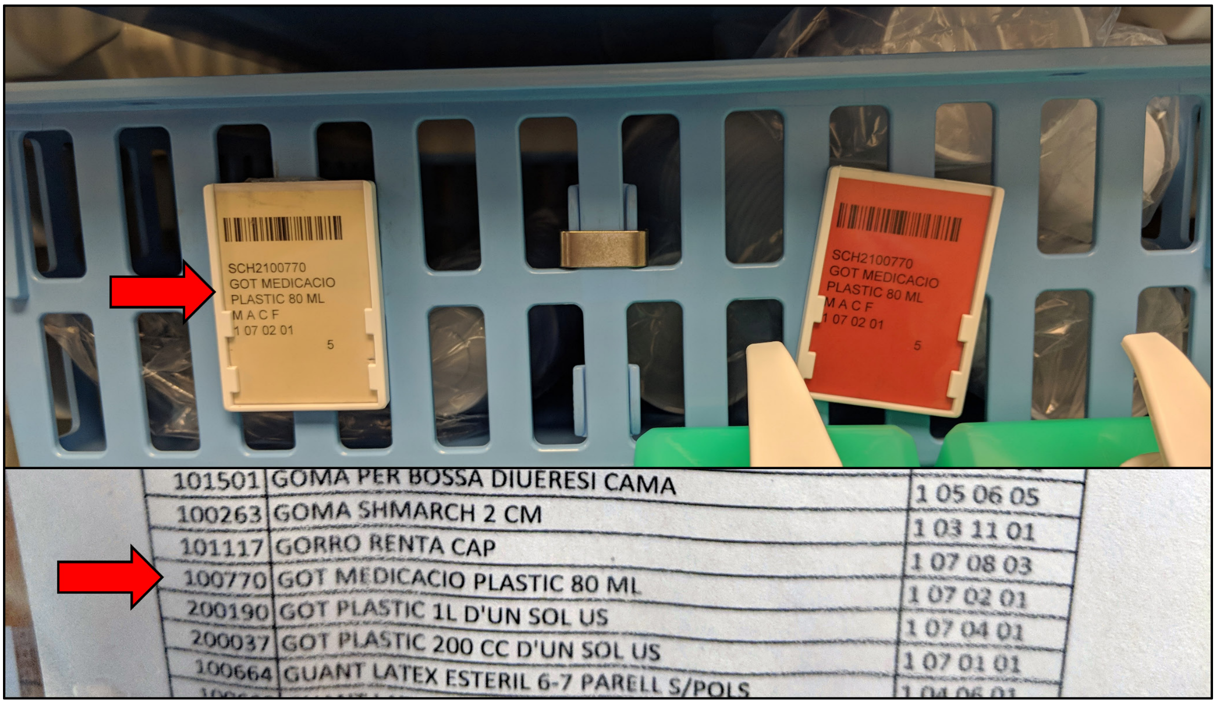


Figure 379: Medicine Locations (Image Roser)

45.7 All Material Kanbanized?

Throughout the plant, almost all material flow was structured using the same kanban system. Below is another storage cabinet with supplies using the same two-box kanban system. Here, too, the kanban post in the back shows no red cards.

Figure 380: Hospital Material Supermarket (Image Roser)

However, there were a few instances of materials without kanban. There was some medicines that had no kanban but only a date on them. These may be materials that are infrequently used and were a special order.

Figure 381: Non-Kanban Medicine (Image Roser)

Another location, however, had frequently used material like blood tubes and bed sheets outside of the kanban system. As there was no standard visible, I had to ask again. They said that these "*were different suppliers and hence no kanban were necessary.*" Since I am a strong believer in kanban for frequently used inventories, I interpreted this as "*they did not yet get around to doing it.*"

Figure 382: Non Kanban Blood Tubes (Image Roser)

Overall, I think I understood the standard and its deviations rather well. The only thing that I did not figure out is how often the materials are delivered and how often the kanban are picked up. But otherwise, I liked the standard, it was reasonably easy to understand, and I could recognize deviations and problems in the standard even without (much) explanation.

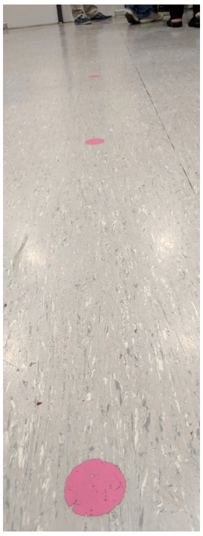


Figure 383: Pink Maternity Line (Image Roser)

There were many more nice lean things to see in the hospital, such as how they organized their beds, how the emergency trauma center was set up, and – my personal favorite – a pink dotted line for expectant mothers leading straight to the maternity ward 🙂.

Overall, I hope this blog post helped you to understand how I try to analyze standards. Another example is written work instructions with photos at Toyota. However, these are not necessarily hung up in a way easy to see for the operator – he should know the standards by heart. Instead, they are displayed for the external observer so that he can see if the worker follows the standard or not. Now, **go out, create standards on your own shop floor that I can understand without explanation, and organize your industry!**

P.S.: Many thanks to Oriol and his team at the Lean Institute Spain for organizing the event and the tours, and also helping the hospital with their lean journey in the first place! Many thanks also for the Consorci Sanitari del Garraf hospital offering the tour.

46 Example of Problem Solving – Japanese Men's Relay Team Rio 2016

Christoph Roser, November 13, 2018, Original at https://www.allaboutlean.com/japan-relay-2016/

Figure 384: 2016 Rio Men Relay Race (Image Fernando Frazão/Agência Brasil under the CC-BY 3.0 Brazil license)

Good problem solving can seriously help you with the performance in your plant. John Shook recently pointed out another nice example to me: the Japanese Men's 4x100m relay team during the 2016 Olympics in Rio. They were the underdogs, with none of their team having ever run 100m in under 10 seconds. Yet they stunningly won the silver medal! They achieved this through good problem solving. Let me show you the details:

By the way, this is a cross-post, with the same article appearing on Planet Lean almost simultaneously.

46.1 Introduction

First of all, let me point out that I was a swimmer, but never a runner. In fact, I run more like a three-legged cow that is tied to a post. And this is even without carrying a stick … I mean a BATON … of course I know it is called a baton … never mind, back to the topic, please!

Figure 385: The Japanese Team: Ryota Yamagata (24), Shota Iizuka (25), Yoshihide Kiryu (21), and Aska Cambridge (23) (Images Dmitry Rozhkov and Barcex under the CC-BY-SA 3.0 license, and Fernando Frazão/Agencia Brasil under the CC-BY 3.0 Brazil license)

Anyway, during the 2016 Rio Olympic Games, the Japanese team was quite the underdog. No runner on their team ran 100m faster than 10 seconds, whereas all other teams in the final (except Brazil) had at least one runner faster than 10 seconds over 100m. In fact, all runners on the US team and the Jamaican team could run 100m in less than 10 seconds, including the world record holder, Usain Bolt on the Jamaican team, with 9.58 seconds.

Below is the overview of the sum of the personal records of the runners of each team in seconds. Jamaica had Usain Bolt and other excellent runners, and the sum of their personal records comes to 38.89 seconds. Japan is the second-slowest team in the finals, after Brazil, summing up to 40.38 seconds.

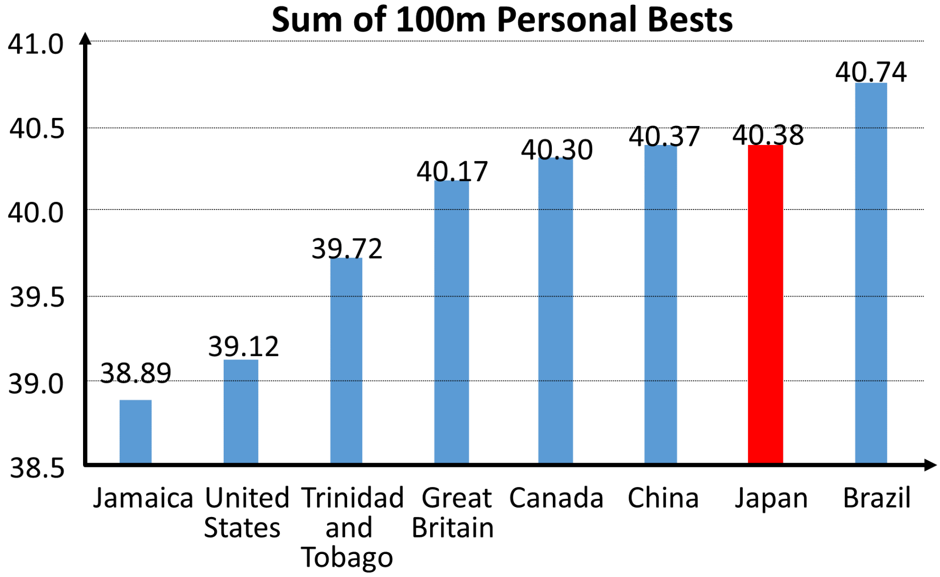


Figure 386: 2016 Rio Relay Sum of Bests (Image Roser)

Looking purely at these numbers, Japan should have had no chance on any medal. Instead, Jamaica, the US, and Trinidad would be on the podium. Yet Japan made second place, after Jamaica! Below is how many seconds the relay time of each team was faster than their personal bests. Relays are usually faster than the individual times, since three of the four runners have a running start. Here, Japan outscored all the other teams. Through their superior baton handovers, **they gained over one second on Jamaica and the USA**, which had the sloppiest handovers (and the USA also got disqualified for handing over outside of the zone). A one-second advantage is huge in Olympic 4x100m relay races.

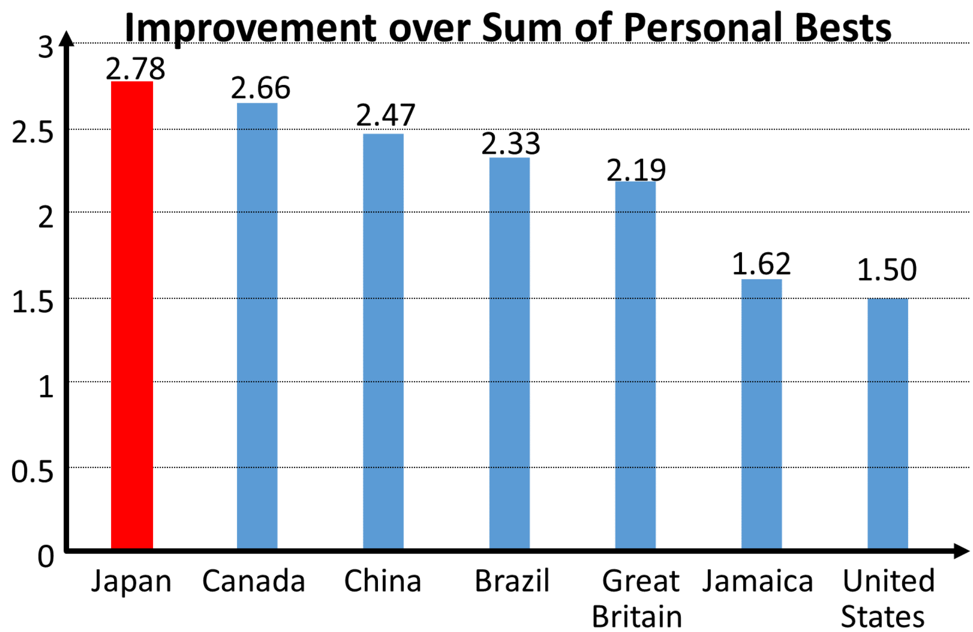


Figure 387: 2016 Rio Relay Improvement over Sum of Bests (Image Roser)

This is due to their superior problem solving, use of standards, and outstanding performance with the baton handover. Let's look at the details.

46.2 General Handover

Figure 388: Relay Race Hand Over (Image tableatny under the CC-BY-SA 2.0 license)

The 4×100 m relay race has four runners over 100m each. They carry a baton (never a stick!), and hence three times they have to give the baton to the next runner. This handoff has to happen in a changeover box. If they miss this zone, they are disqualified (which happened to the US team in the finals, but they were still behind Japan).

The speed and quality of the handover is crucial for winning, and hence this is a much-researched topic in sports. Many teams fail because they mess up the handover or even drop the baton altogether. Having to hold your hand in position for the baton handover reduces your running speed. Usually, the next runner just holds his hand in place without looking, and the previous runner places the baton in the hand. Some verbal shouts can help with the timing of the process.

46.3 Where to Hold the Baton?

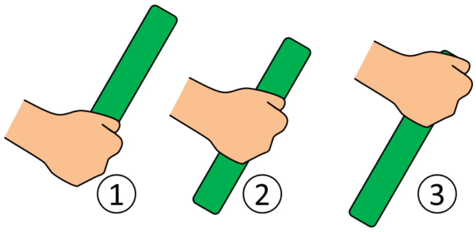


Figure 389: Baton Position (Image Roser)

There are different possibilities for how you could hold the baton, but it seems most athletes like to hold the baton at the bottom (number 1 in the image). This seems to make running easier. (I actually tried this out, and it is indeed easier – but then, I can't really run).

46.4 The Problem with the Handover Position

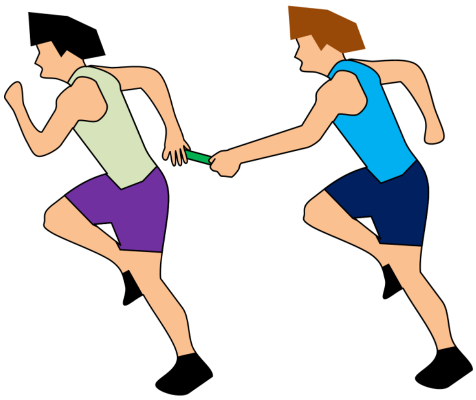


Figure 390: Baton Hand Over Hip (Image Roser)

This now creates a problem for the handover process. The easiest way to hand over the baton would be an upsweep roughly at hip height as shown in the image here. The baton would be roughly horizontal.

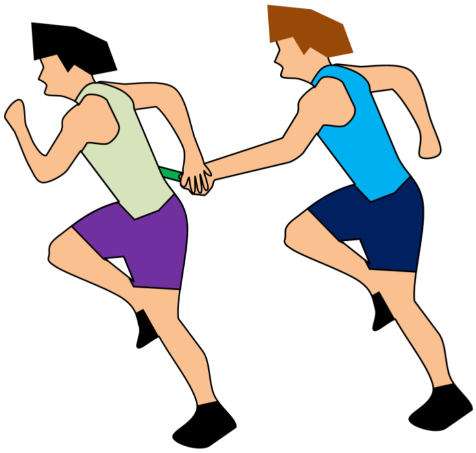


Figure 391: Baton Hand Over Japan (Image Roser)

However, this upsweep creates the problem that the next runner holds the baton in the wrong spot (number 3 or number 2 of the baton positions above). The runner would either have to run with an odd baton position, switch hands, or have to adjust the baton, which requires two hands or increases the risk of dropping it. All of these options will slow him down.

If the subsequent runner wants to grab the baton in an upsweep position, that is good for him; he would find the hand of his teammate already there. Hence, the hand of the previous runner is completely in the way for the next runner.

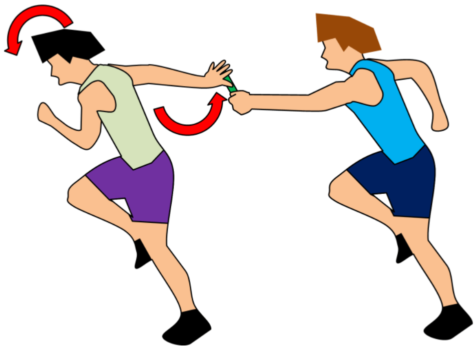


Figure 392: Baton Hand Over High (Image Roser)

The normally used alternative involves literally quite a bit of arm-twisting. The next runner twists his arm and hand upward so that he can grab the baton from below. This way the baton will be in a good position for the next leg to run (number 1 from the baton positions above). The baton is almost vertical during the handover.

Figure 393: Relay Hand Over with a high grip (Image tockphotoVideo with permission)

Unfortunately, this twisting comes at a cost. The hand and arm has to be very high, tilting the upper body of the runner forward. Overall, this makes it harder to run.

Here is a picture of such a handover from a real race (World Youth Championships 2013, Team USA). Notice the high hand position. Looking over your shoulder is also time consuming and not advised, but happens even in Olympic races.

46.5 Japanese Problem Solving

Japanese people seem to have excellent skill in problem solving. Enter Shunji Karube (苅部 俊二), a former runner specializing in 400m, and now a professor for sports at the Hosei University, Tokyo (his blog in Japanese). He has been researching running and relays for a long time. Since 2014 he has worked for the JAAF (Japan Association of Athletics Federations) on improving and researching the relay race.

Figure 394: Prof. Karube (center) and his winning team. (Image Prof. Karube with permission)

My experience with Japanese problem solving is that they look at many, many different solutions and try out a lot. While I don't know in detail how Karube progressed, at one point he questioned the problem of putting the hand on top of the other. He probably also involved many other runners and experts to tackle the problem. And he found a solution.

Japanese athletes do indeed put their hands pretty much on top of each other. It does not look easy, but they manage it effortlessly. It reminds me a little bit of how to hold a Japanese sword (of which I know a little bit more. I proudly hold the 6th kyu in Kendo … although if you know Japanese martial arts, you know that this is the level of six-year-old children in Japan … never mind, just trying to impress you with fancy Japanese words … after all that what lean is all about … or maybe not?)

Figure 395: Japan Baton Hand Over Detail (Image Roser)

Anyway, the above sketch merely gives a glance at the detail of the standard, and there is much more (that I don't know about). The receiver spreads his hand wide, and the previous runner slides it forward right in the web of the thumb very close to his hand. The receiver grabs it and the previous runner pulls his hand out from underneath the next runner's hand. (The French do something similar, but with an upward sweep)

There are definitely verbal clues so the next runner doesn't have to look behind his shoulder. I could imagine synchronizing the steps may be significant. It is already common knowledge to always hand left to right or right to left hand, and that the last runner should be the fastest, although I am sure Karube looked into this too. They also considered the reliability of the handover. Baton passes are notoriously tricky, and many teams in world-class races fail or disqualify themselves due to a faulty pass.

They also tweaked the technique to improve the distance between runners during hand over. The further apart the runners are, the less they have to actually run. Compared to 2008 they improved by almost 1 meter per hand over, turning a 4x100m relay into a 100+3x99m race. Here the previous runner does most of the reaching out. Naturally, they also optimized the time for the hand over, requiring much less fiddling than other teams.

The shoulder position was also optimized. Previously the shoulders of the next runner tilted to the right by about 15° when receiving in the left hand. Now, the shoulders are almost level. They also researched other things like the optimal handover point (middle of the zone, except for the first runner, where it is the last third), adjusting the trigger point signaling the next runner to start, and many other things with the help of three high-speed cameras.

46.6 Standardization

Next is getting the standard to the people. Unfortunately, the team is set up only shortly before the Olympics. However, Karube worked with the potential candidates six months in advance to extensively train his guys on the handover. In contrast, the Jamaican team practiced only a few times before the actual race.

46.7 Continuous Improvement

There is no standard that cannot be improved, and Karube has his sights already set on more details and improvements to make the Japanese team even faster. After all, the 2020 Olympics are on their home turf in Tokyo, Japan, and they surely would like a gold medal there 🙂.

46.8 Videos

The video of the final is on the Olympic website here. Due to copyrights (the Olympics is all about money, after all), it is not on YouTube. However, the Japanese broadcast ended up on Twitter. Note how low the batonhand over is of the Japanese team compared to the others.

The Video by ひぞっこ is available on Twitter at
https://twitter.com/musicapiccolino/status/766819799968079872

Here's a video of the handover from Twitter. Notice how low the handover is, and that the two hands are almost on top of each other.

The Video by 山縣 亮太 is available on Twitter at
https://twitter.com/V7Jqq/status/758604371605065729

Finally, here are two YouTube videos with two different angles of a demonstration the team did during a press conference:

The Video by PanOrientNews TVis available on YouTube as "Rio Olympics' 400m Relay Silver Medalists Demonstrate Baton Pass バトンパスの実演" at https://youtu.be/Y5KSyhtgmak

The Video by The Japan Times is available on YouTube as "Baton-passing demo of Japan's 4×100-meter relay team [RAW VIDEO]" at https://youtu.be/wmqZZ-I5SG0

So this post was something outside of lean for a change, but still interesting (I hope) to lean practitioners. Now, **go out, make sure your guys don't drop the baton, and organize your industry!**

46.9 Selected Sources

Japan's Secret To Relay Success; Spikes, January 12 2017

P.S.: Many thanks to John Shook for giving me the idea on this topic during the Lean Global Network meeting in Barcelona and Tenerife.

P.S.2: Many thanks to Prof. Shunji Karube for his input and the permission to use his photo.

47 Lean Construction

Christoph Roser, November 20, 2018, Original at https://www.allaboutlean.com/lean-construction/

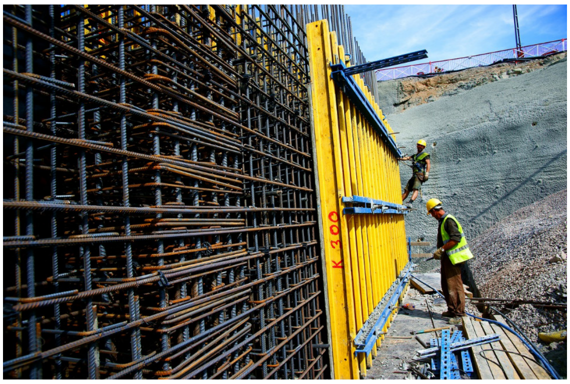


Figure 396: Construction Workers (Image Engin_Akyurt in public domain)

The methods of lean have been adapted to a wide variety of industries, from military to healthcare, from government to banking. One of these industries is lean construction, where it's applied to the construction industry. In this post I would like to give you an overview of the similarities and differences, and how to adapt lean methods for construction.

47.1 Introduction

Figure 397: Skyline with Cranes (Image unknown author in public domain)

Construction is a big business. If you drive to work, you probably come across some roadwork, unfortunately often combined with a traffic jam. If you live in a city and look out your window, it's likely that you'll see a crane. I just counted eighteen cranes while looking out my window. Since there is always improvement potential wherever something is happening, construction can also benefit from improvement.

In the automotive industry, a nearly identical car comes down the line every minute, and the worker just needs to reach behind him to grab the part he needs. His work is very standardized and highly regulated. Construction, however, is not like automotive, and there are some major differences.

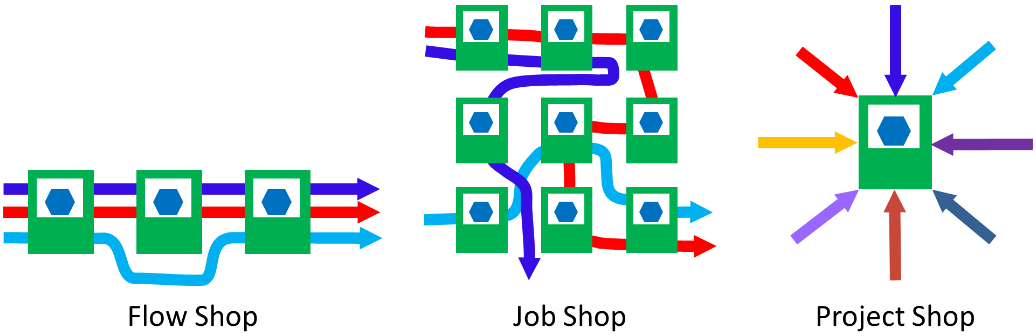


Figure 398: Flow Shop Job Shop Project Shop (Image Roser)

- First of all, while “normal” industry uses flow shops or job shops, construction usually uses **project shops**. Rather than the product coming to the machines and parts, the machines and parts come to the product(ion site).
- Additionally, your project is usually not at home, but **at the location of the customer**. If it would be your own home turf where similar projects happen over and over again, you could optimize your site to your needs. This is done, for example, in ship building, which also uses a large project shop. However, in construction you need to go to the site of the customer, which may be different every time. As a side effect, it may be possible that one aspect is completed before the preceding aspect is finished (like a road that is freshly paved and then dug open again to install pipes).
- Your **lot size is small**. Rather than making thousands of identical items, in construction you usually work on a unique project every time. In larger projects you may build multiple identical houses, but even then your lot size rarely exceeds a few dozen.
- While your lot size is small, your **cycle time is very long**. Rather than completing a car every minute, even larger companies rarely complete more than one project per week. Similarly, your **lead time is also very long**. A car takes a few weeks between start of production and its completion, whereas buildings often take months or even years to complete (or in the case of the infamous new Berlin airport that was supposed to open 2011, apparently never?).
- Overall, these long lead times, cycle times, small lot sizes, and locations at the customer make it **more difficult to standardize and optimize** the process. Since the projects rarely repeat, and if they do they repeat with a long delay, it is difficult to define the processes clearly.
- On top of that there are often many **unscheduled delays**. Some of them are due to other companies, while others are due to the weather.

While these differences may make the “usual” approaches a bit more difficult, they do not prohibit the use of lean, but require adaptation to the issues in construction. Let me give you some suggestions:

47.2 Improve Repetitive Processes

Even though every construction site is unique, sites do have many repetitive tasks. Please note that the parts do not need to be identical, but the work should include similar steps. The more frequently something is done, the easier it is to optimize. Find these repetitive tasks. Improve them. Optimize the steps and look for waste, unevenness, and overburden (muda, mura, muri).

47.3 Establish Kanban for Your In-Stock Material

Kanban, or pull production in general, is a great way to manage inventories of goods that you have regularly in stock. Whenever material is consumed, order more of this material to refill your inventory to its target level.

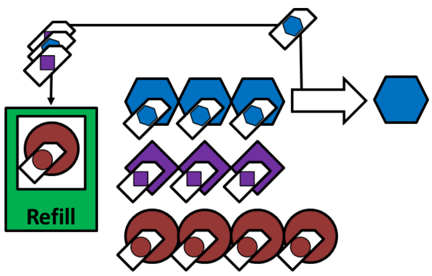


Figure 399: Kanban System (Image Roser)

You can use regular kanban systems for more valuable items, larger items, or items that spoil quickly. Attach a kanban card to every pallet, bag, or box. Whenever this pallet, bag, or box is used, you take the card as a signal to order one more pallet, bag, or box.

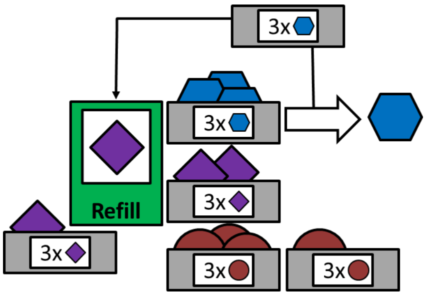


Figure 400: Two Box System (Image Roser)

For less frequently used items, you can use a two-box kanban system with two boxes (or pallets or bags, etc.). Whenever one box is empty, you refill or reorder a box and use another box in the meantime.

Figure 401: Simple triangle kanban (Image Roser)

For cheap and small items, you can also use a triangle kanban. While these cards were originally triangular, they can be any shape. You also need only one card per material type. I use these for my A4 paper and printer ink, and generally they are well suited for office material. The last pack of paper has a note to "Order 2500 pages A4" as shown in the image here. Whenever I reach this pack and the kanban, I order more paper. If you consume a lot of paper, you may put the card on the second-to-last stack or even on the last full box of paper.

All of these are described in more detail in my posts [Different Ways to Establish a Pull System – Part 1] and [Part 2] for more details on the approaches below.

47.4 Example of Kanban for Asphalt


Figure 402: Street Paving (Image Ellin Beltz under the CC-BY-SA 3.0 license)

Another example I know was the organization of asphalt delivery for paving streets. There was a small number of trucks supplying asphalt to the paver machine. Originally, these trucks tried to refill with fresh asphalt at the refill station quickly and then return to the site waiting to supply the paver. This resulted in many trucks waiting and the asphalt cooling down, which reduced quality as shown below.

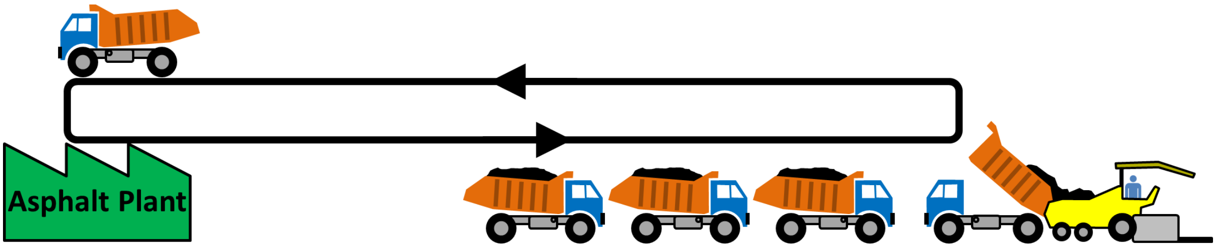


Figure 403: Street paving Push (Image Roser)

A much better approach was to create a pull system. Rather than full trucks waiting at the paver, empty trucks were waiting at the asphalt plant. When the asphalt in the paver was getting low, a signal was sent to the truck in the asphalt plant to fill up and deliver. The timing of the signal depended on the refill time and the travel time from the plant to the paver plus a bit of buffer for traffic, etc. This ensured that the paver was always supplied with hot asphalt. A similar approach could also be used, for example, for concrete delivery or other "perishable" goods.

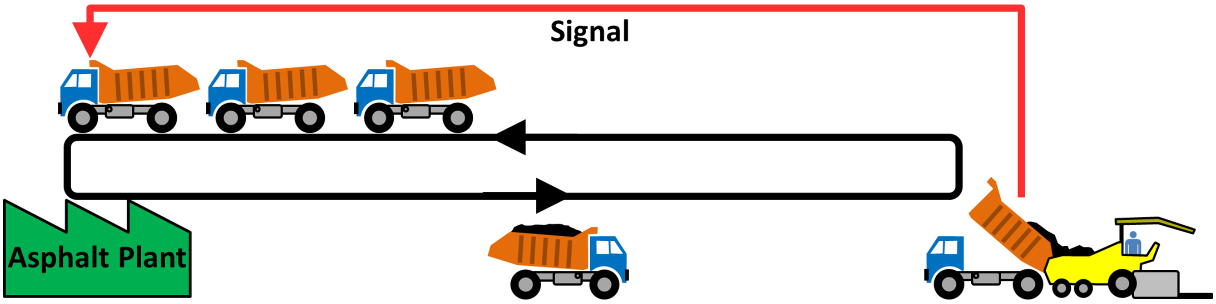


Figure 404: Street Paving Pull (Image Roser)

47.5 Construction Site Layout

Another example is the creation of a construction site layout. During construction you have to store multiple and often bulky materials on site. What do you put where? The idea is to reduce walking distances. Stuff you don't need like excavated earth will be stored in the back. Offices and break rooms should not be underneath the crane loads for safety reasons. The wood storage could be close to the carpenters shop. Below is an (incomplete and not optimized) example for an European-style stone and concrete construction.

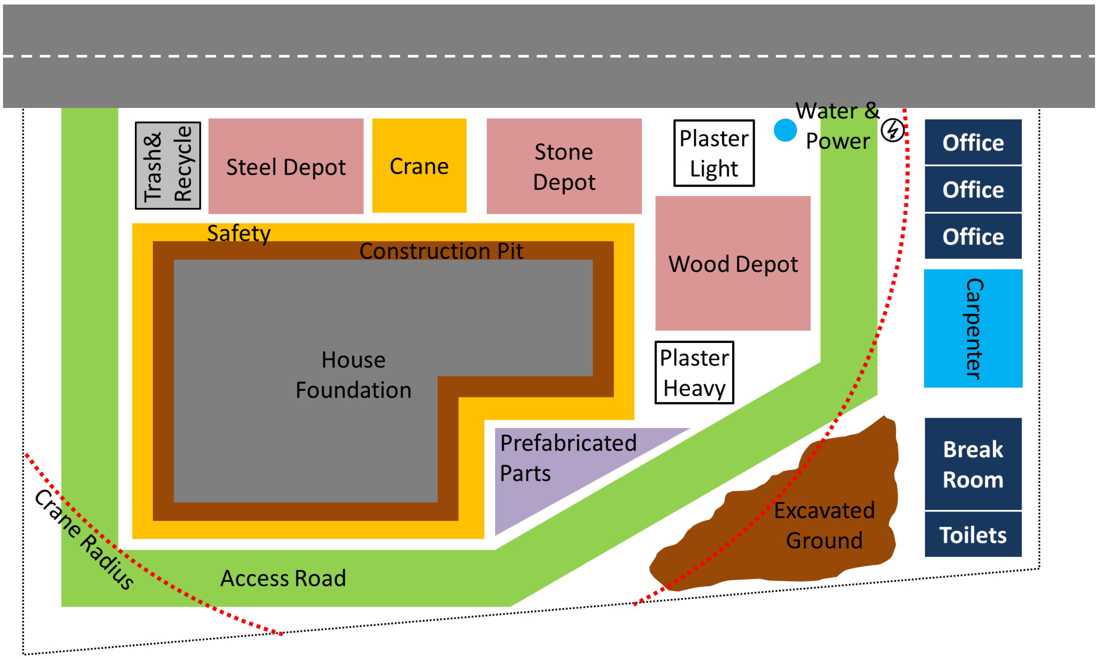


Figure 405: Example Construction Site Layout (Image Roser)

The first plan you come up with is probably far from the best you can do. Usually, creating multiple plans and selecting the best one is often beneficial. The plan can also change over time as the nature of the construction changes. A related tool that may help you is the spaghetti diagram, although due to the often temporary nature of such sites, a spaghetti analysis is more useful as lessons learned for the next site.

47.6 Visual Management

Another example is visual management. How can you help your people by marking and labeling your goods? One possible problem at construction sites is the mix up of materials. If you have two types of plaster, you may use the wrong one. Similarly, if you have bricks or wood of different strengths or treatments, you can mix them up. Make sure that they are clearly labeled and maybe colored. You could also store them in different locations like the plaster in the site layout above. There are lots of possibilities, so find what is right for you.

47.7 Summary

These are only a few examples of lean tools that could help you in improving your efficiency and quality. There are many more ideas from lean that could be beneficial to your situation. **It does not help if you use solutions for problems of Toyota mass production; you have to find solutions that work for your problems!** Now go out and organize your industry!

48 Introduction to Point-of-Use Providers (or Mizusumashi)

Christoph Roser, November 27, 2018, Original at https://www.allaboutlean.com/point-of-use-provider/

Figure 406: Make to Order at the Munich Oktoberfest (Image Markburger83 under the CC-BY-SA 3.0 license)

The point-of-use provider, also known as *Mizusumashi*, water strider, or water spider, is a worker that supplies material to the point of use. Similar to a waiter bringing food and drinks (and beer ☺) to the customer, the point-of-use provider brings material to the workers. The latter, however, merely refills materials rather than custom orders. This point-of-use provider fulfills an important role between the inventory and the final point of use. Let me give you the details:

48.1 Introduction

Ideally, you have a pull-supplied supermarket at every location where you need material. The worker merely has to turn around and grab the part he needs for his assembly or process. Such a supermarket can, for example, be supplied with a milk run (see my extensive series of posts on milk runs starting with [Introduction to Milk Runs](#)).

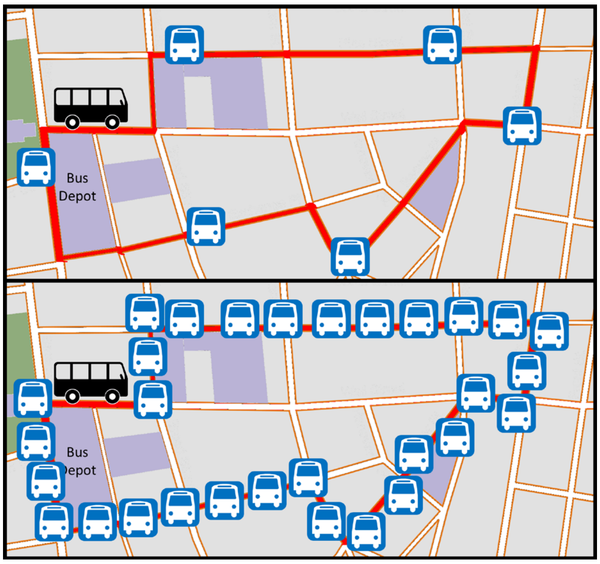


Figure 407: Bus Route with Few or Many Stops (Image modified from Hu Totya in public domain)

The milk run is a regularly scheduled supply with fixed stops. It delivers material to supermarkets at these stops like a bus route brings people to stops on its route. However, as a bus stop is rarely your final destination, so a supermarket is rarely the final destination for material. As you may walk home from the bus stop, the material may move from the supermarket to where it is needed. You could – in theory – have a bus stop at every house, but this would slow down the bus enormously and would be very inconvenient.

The same often applies to material supply. Having many stops slows down the milk run. The difference between this and the bus example is that people can walk the last few hundred meters on their own, whereas the material needs to be carried by someone. This someone is our point-of-use provider.

Figure 408: Water Strider (Image Katja Schulz under the CC-BY 2.0 license)

The English term is self-explanatory; the *point-of-use provider* provides material for the point of use, sometimes abbreviated to POU. In Japanese, the word *Mizusumashi* (水澄まし or 水すまし) is sometimes used. This is the Japanese name for the small insects that you often find walking on lakes or ponds, the water strider. This name was chosen because the person moves around his area like a water strider on its pond.

As lean often uses Japanese words to sound fancier, *Mizusumashi* is often used even in English. The correct English translation *water strider* is also used as is an incorrect translation of *water* **spider**, which is not only a completely different animal, but also a different phylum from insects. The water spider also lives mostly underwater. Nevertheless, this term is also used for the point-of-use providers.

48.2 Basics for Point-of-Use Providers

The point-of-use provider takes care of the “last mile” (or more precisely last few meters) of the material transport. This is often for assembly lines, as there is a lot of material arriving. It may be not necessary, for example, in a milling or drilling process, as there is little material arriving.

In the example below, the point-of-use provider (dark red, POU-arrow) takes material (blue) from the supermarket and brings it to the assembly line (green, U-line) so the workers can work without interruption.

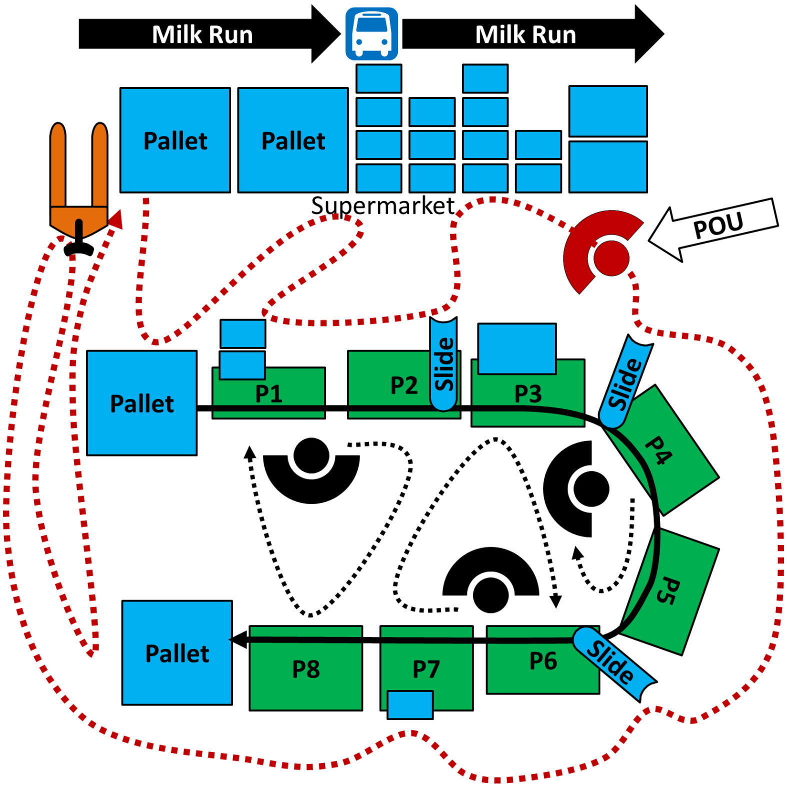


Figure 409: Point of Use provider (Image Roser)

- **The primary objective of the point-of-use provider is to keep the workers supplied with material**. Hence the workers can focus on the work and do not need to leave their post looking for material. Therefore we achieve the separation of cyclic work (the workers) and non-cyclic work (the point-of-use provider) to improve efficiency.
- The work of the point-of-use provider is not necessarily repeating itself identically. The provider does not necessarily stop at every station every time, but instead goes wherever he is needed. For U-shaped lines or cells, his route is usually on the outside of the line so he does not disturb the workers. However, it is common and recommended that he develops a regular route (i.e., circling the line). This way he can check up on every station frequently. While it is not always easy, the more repetitiveness in his route, the more efficient he will be. Over time he will get his routine and optimize his walking distance, but it is very difficult to pre-describe a fixed route. Ideally, he will also develop his own standard that he can repeat. I find that with this standard he usually does a better job over time than a manager who writes him a standard at the beginning. But do not forget to give him the task to optimize himself.
- The material is supplied by other processes, ideally milk runs, into a supermarket for the line. This supermarket should be not too far from the assembly line. There may be more than one supermarket for longer lines.
- Whenever he removes material from the supermarket, he puts the kanban card into the kanban box, or – if the box is the card – returns empty boxes. If the box or kanban goes from the supermarket to the actual line, make sure that you include this additional distance – or more precisely its time – for the calculation of the replenishment time and subsequently the number of kanban in the loop.

Figure 410: Pallet Jack (Image Wikiaanvullen under the CC-BY-SA 3.0 license)

- The point-of-use provider carries lighter material by hand, while heavier material may require a pallet jack, pushcart, or similar device, which should be readily available for him and ideally not a shared device.
- He may repackage items to make it easier for the workers. For boxes he may remove lids or packaging. Smaller items like screws may be taken out of the box and added to, for example, a slide or chute to optimize the material for the worker. He may also wrap completed products, for example by securing a pallet using plastic wrap.

48.3 Yes, It Is Pull!

Figure 411: Children Tug of War (Image Christian Schwier with permission)

The material supply through a point-of-use provider is usually a pull system. If the boxes are the kanban, it is automatically a pull system. But even if the point-of-use provider repacks the material and removes the kanban, it is still pull.

First of all, do not create an additional kanban loop between the supermarket and the assembly line. The effort would heavily outweigh the benefit, making the whole idea pointless. Instead, the point-of-use provider is close enough to the line to keep an overview about what is needed. Rather than handling additional kanban cards, his job is merely to fill up the material at the line to its target levels. As there is usually only a small number of parts involved, the point-of-use provider can simply memorize what is needed. If on his route around the line he sees a material that is getting low, he only has to memorize it until he arrives at the supermarket and picks up more material. This can be done usually by memory and does not require an additional kanban card or similar.

Figure 412: Ummm … how about NO! (Image Eric Lewis under the CC-BY-SA 2.0 license)

However, it does **require a clearly defined material inventory at the assembly line**. This material has to last until the point-of-use provider can resupply material. Often, a two-box system is good enough, and the point-of-use provider merely replaces an empty box while the worker takes parts from the other box. If the material is in a slide or chute, the chute should also contain enough material until the point-of-use provider can refill the chute. As always with pull inventories, you may make the inventory a bit larger to add some safety buffer.

This post gives you a brief overview on point-of-use providers (also known as water spiders, water striders, or *Mizusumashi*). However, there is more on the topic. As so often happens, I wanted to write a single blog post on a topic, and I ended up finding enough things to cover for three blog posts. Hence there are two more. In my next post I will go a bit more in detail on the calculation of the workload … although with the quality of the data that is usually available, it is much less a calculation and more of an educated guess. In my last post I will talk about the routing of the point-of-use provider. Now, go out, get your material flowing, and **organize your industry!**

49 Point-of-Use Provider Calculations

Christoph Roser, December 04, 2018, Original at https://www.allaboutlean.com/point-of-use-provider-calculations/

Figure 413: Waitress in Argentinia (Image Gobierno de la Ciudad de Buenos Aires under the CC-BY-SA 2.0 license)

In this second post of my series on point-of-use providers (also known as *Mizusumashi*, water strider, or water spider), I will discuss the calculation of the workload for the point-of-use provider … although *calculation* is a way-too-big word for what is, in practice, guesswork with limited data of low quality. However, I hope it helps you with planning your point-of-use providers.

49.1 Calculating the Workload

Calculating … or, more likely, **estimating** the work load of the point-of-use provider depends very much on the situation you have in your factory. How much material does he have to carry, how heavy it is, how long are the walking distances, what kind of tools (pallet jack, forklift, etc.) does he need, how big are the buffer inventories at the line, how long do they last, and so on.

49.2 Estimate the Duration of the Route

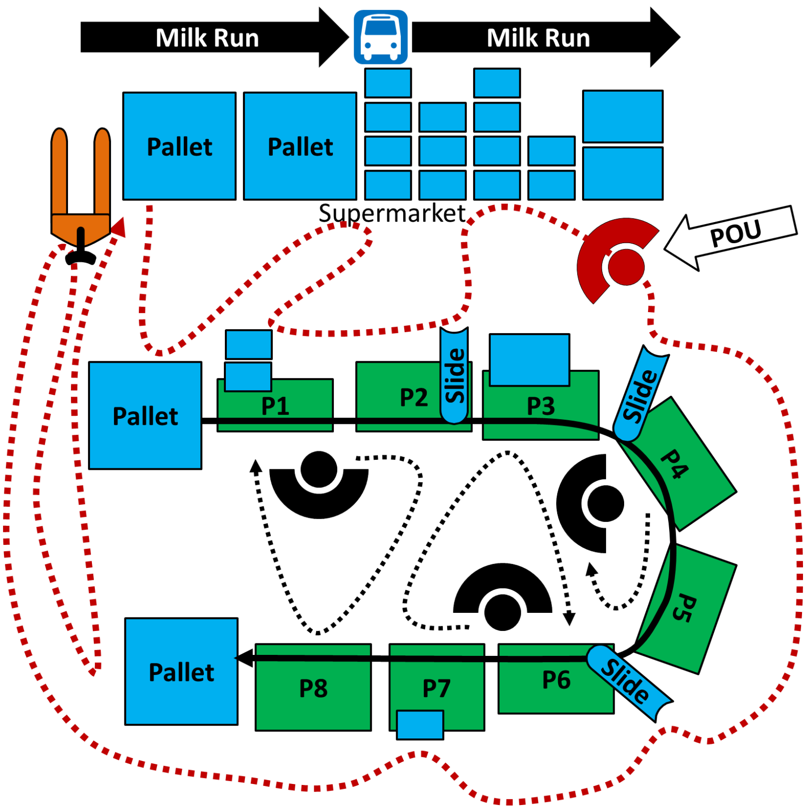


Figure 414: Point of Use Provider (Image Roser)

Your goal is to make sure that the point-of-use provider can refill any material on the line before it runs out. For this you would need to sum up the time the point-of-use provider needs to refill all of the material. This is best done with a detailed layout of the line showing all the required stops, including the required quantities, the demand, and the inventory sizes and reach at the stations.

Sum up time for walking distances, handling time, and other tasks like kitting and repacking. Do not forget the way back to the starting point and trips to pick up a pallet jack, etc. Also keep an eye out for how much he has to carry. You get the time the point-of-use provider needs for his loop.

49.3 Compare with the Material Quantities

Figure 415: Warehouse worker checking the inventory (Image WavebreakMediaMicro with permission)

This time needed to supply all stations needs to be compared to the inventory at the stations. Is there enough inventory (plus safety) to last until the point-of-use provider comes back? If the time for the route matches the inventory reach well, then you have a well-balanced route for the point-of-use provider. However, this is unlikely to happen in the first iteration of your calculations.

If there is additional time for the point-of-use provider, how much time does he have left? Maybe he can do some additional tasks (more on this below)?

If there is not enough time, then you have a problem. The point-of-use provider has too much work and will be unable to supply your line with enough material. Now you have multiple options.

Figure 416: Too much! (Image Ermell under the CC-BY-SA 4.0 license)

You could increase the buffer inventory at the stations and the quantity of material that the point-of-use provider is carrying. He does not come more often, but he brings more stuff. However, if you find that he now has to carry 80 kg on his route, you have another problem. He won’t be able to do this. Even with less weight, carrying multiple packages and boxes at the same time is cumbersome and risks dropping items. A pushcart could make it easier. Rather than carrying items, he would put them on his cart and just push them along. Just make sure that this does not get too heavy, as he won’t be able to push half a ton along the line safely or reliably. Now you could up the ante even more and give him a small material train, but this is absurd for short distances. Besides, you would need a lot of space at the stations to store all this material. Eventually you may need a second (or even more) point-of-use providers.

49.4 Optimize

But before you get additional point-of-use providers, see if you can optimize his workload. Can you simplify handling tasks? Can they be automated or mechanized (see karakuri kaizen)? Could he do a short trip for nearby stations and then a longer one for farther-away stations? Or could he do one trip for the left side and then one trip for the right side of the station? The whole process is iterative. You try out different routes; calculate the time, material reach, and weight; and see if it works. I also suggest that instead of optimizing one solution until it fits, you should try multiple independent solutions and see which one is the best (see my post on Japanese Multidimensional Problem Solving).

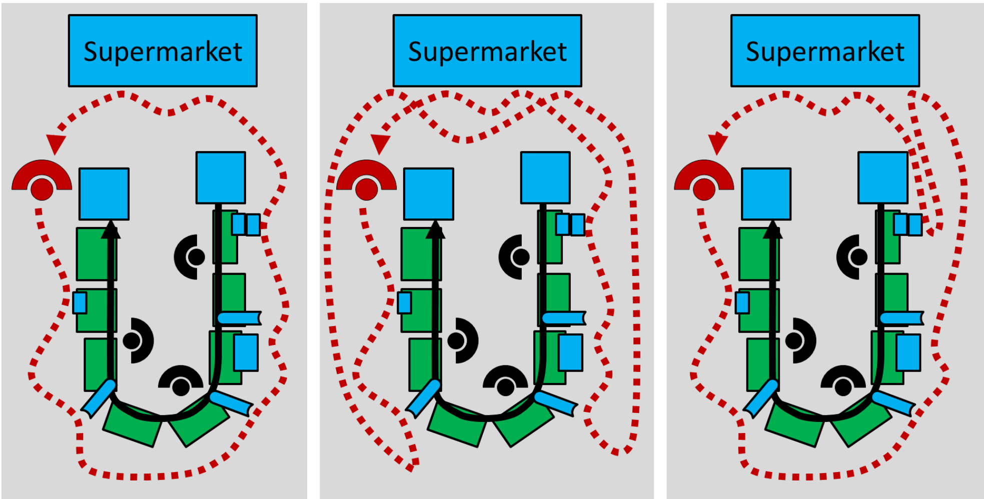


Figure 417: POU Route Optimization (Image Roser)

49.5 Worst-Case Scenario?

Do not estimate this for the average situation, but lean toward a worst-case scenario! For example, while the point-of-use provider may have enough time to supply each material after another, he may run into problems if two different locations run out of material at the same time!

Figure 418: Overworked worker (Image Roser)

At the same time, you do not need to include the absolutely worst-possible scenario. First of all, you will never be able to afford a cover for every eventuality. Second, a point-of-use provider is a human, and he can and (hopefully) will speed up in times of need. Hence, he may be able to defuse **temporary** and **short-term** overloads by putting in an extra effort. However, if the point-of-use provider has to run all the time, he soon will run out of energy, motivation, and (understandably) morale, and the line will suffer. Therefore, such moments where he has to work “on the double” should be rare and exceptional, as this would be an overburden (muri).

Overall, it is difficult to calculate, but you have to make an estimate if you create a new line or change an existing one. Include a point-of-use provider that has experience with similar situations and has a good "gut feeling" on these things.

49.6 How About Side Jobs?

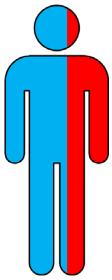


Figure 419: How much can you split your workers? Be Careful! (Image Roser)

Ideally, the point-of-use provider is fully occupied with his tasks, having no idle periods while always supplying the line with material. In reality, however, he may have a bit of slack or available time. Since these waiting times are waste (muda), it may be tempting to fill up this available time with additional work.

It can be done, but be very careful with this. As I said above, **the primary objective of the point-of-use provider is to keep the workers supplied with material**. Hence, any additional work should be work that can be dropped at any time to take care of the material supply. If the additional work would be time critical (e.g., an assembly process where others would have to wait), then sooner or later the point-of-use provider is needed both for the critical add-on work AND the material supply. No matter what he does, others will have to wait for him, and that is no good. Again, **the primary objective of the point-of-use provider is to keep the workers supplied with material!**

However, if you take care, side jobs are possible. Here are a few examples:

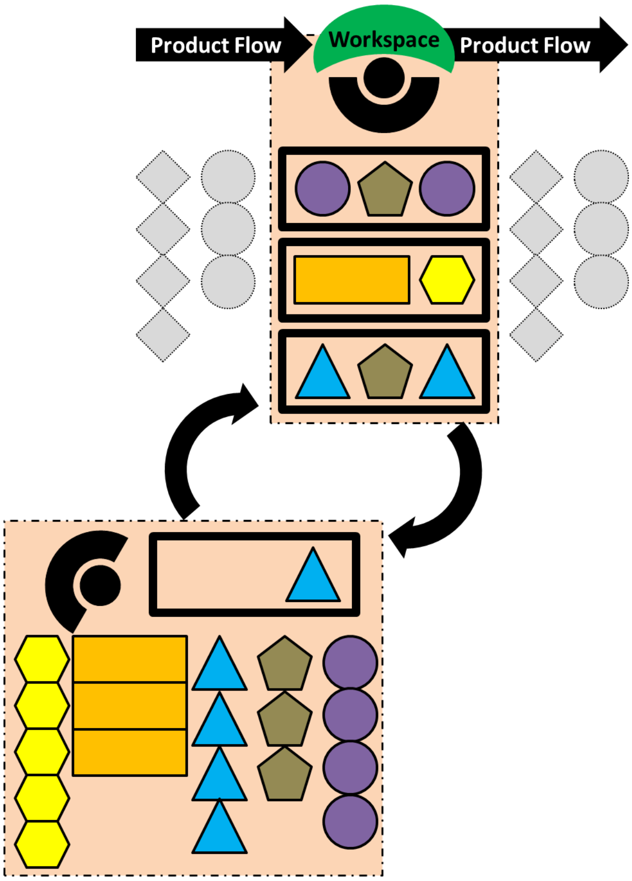


Figure 420: Assembly Space Kitting (Image Roser)

- Often the point-of-use provider also helps the workers in case of problems and is the first responder if there are issues to resolve. For example, if the milk run made a mistake, the point-of-use provider can try to get needed material from the warehouse.
- Another task that is common for a point-of-use provider is kitting.
- The point-of-use provider can also be part of the assembly-line process. However, in this case he still must be able to interrupt his work to supply material to everybody. His work in the line should be much less, and it must be buffered with inventory so that an absence from assembly in order to supply material does not stop the line.
- Irregular tasks that can wait can also be added to the point of use provider, like packing finished goods or returning empty packaging like cardboard to the recycling station (nearby!)

This concludes the second post of this three-post series on point-of-use providers. In my previous post I explained the basics of point-of-use providers. My next post will go into details on the routing of point-of-use providers. I hope you will enjoy it :). Now, **go out, get your material flowing, and organize your industry!**

50 Point-of-Use Provider Routing

Christoph Roser, December 11, 2018, Original at *https://www.allaboutlean.com/point-of-use-provider-routing/*

Figure 421: Just what you need … (Image desertsolitaire with permission)

This is my last post of a series of three posts on point-of-use providers (also known as *mizusumashi*, water strider, or water spider). In this post I will go into much more detail on the routing of the point-of-use provider. A less-busy point-of-use provider can handle multiple lines. Similarly, very busy lines may have multiple point-of-use providers. Here I will show you some more details on these possibilities.

50.1 Multiple Lines

Many point-of-use providers are circling around one line, with the material being supplied to a supermarket close to the line through a milk run. If the line does not need much material and the worker has a lot of idle time, he may be able to take care of the material supply for more than one line or cell at the same time. These cells should be very close to each other to avoid unnecessary walking time. Ideally, they are right next to each other. However, make sure not to overload the point-of-use provider, or your system performance will suffer.

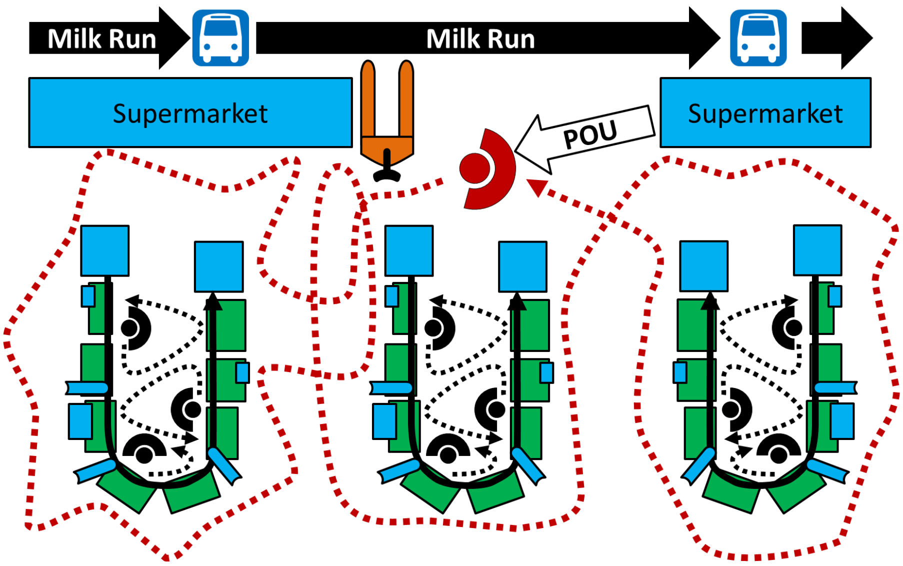


Figure 422: Point of Use provider Multi Lines (Image Roser)

50.2 Multiple Point-of-Use Providers

Longer and more complex lines or lines that consume a lot of material may have more work than what one point-of-use provider can handle. In this case, you can also use more than one point-of-use provider at the same time, as shown below.

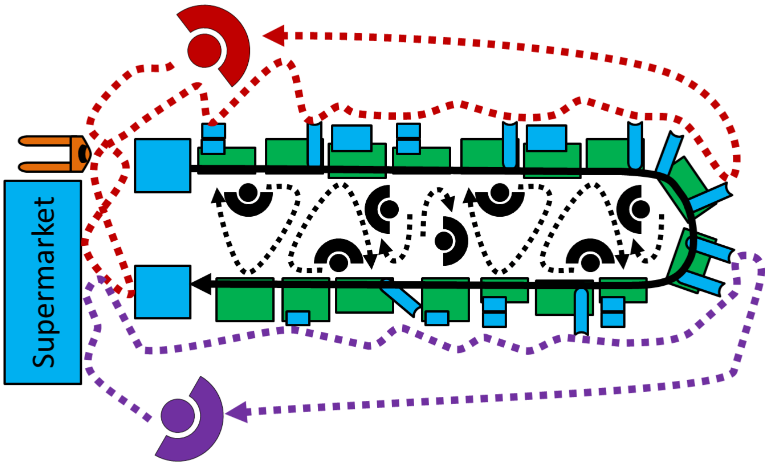


Figure 423: Two POU with a good division of work (Image Roser)

Ideally, you mentally divide the line into different sections for the two point-of-use providers. While your initial impulse may be to have two segments of equal length, or (better but still not good) equal work, I would suggest creating one segment that has enough work to keep one point-of-use provider busy. The rest goes to the second point-of-use provider (or to the third, etc., if the line has work for more than two point-of-use providers). Hence one point-of-use provider will likely have significantly less work than the rest. This is good!

While ideally every point-of-use provider should have a full workload, it is better to have one of them with a lot of available time than all of them with a little bit of available time if you would divide the work equally. It is much easier to use one larger block of available time for something else than to use three small blocks. Therefore, using all but one point-of-use provider 100% makes it easier to use the remaining time of the last point-of-use provider productively for something else.

In any case, it is very important that **every material location at the line is clearly assigned to one point-of-use provider only!** If you don't do that, two things are likely to happen. The first possibility is that you have one or more stations where each point-of-use provider thinks the other one will take care of it. In the end, no one is supplying the stations and they will run out of material. The line stops, the workers yell for the point-of-use providers, and some chaos ensures until it is running again. Wasteful!

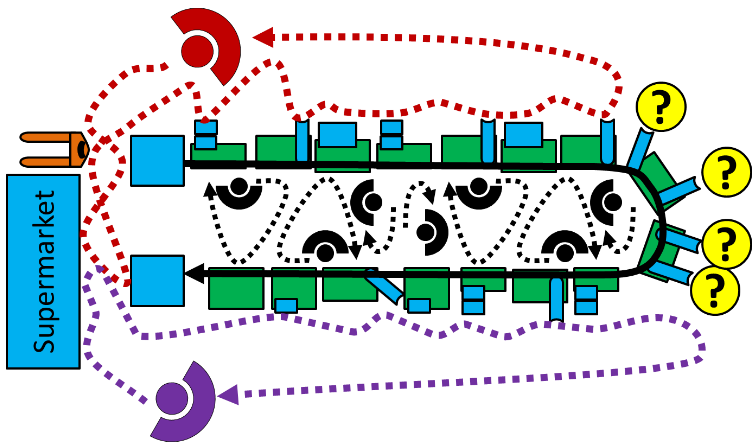


Figure 424: Two POU with a gap in between! (Image Roser)

The second possibility is marginally better, but still far from good. Two point-of-use providers think they both have to take care of a station. In the end, both will come to that station with material. This is redundant work, and there may not even be enough space for a double load of material. One point-of-use provider would have to bring material back to the supermarket, where the corresponding kanban already may have gone back with the milk run, which may overfill the supermarket, and so on. While the line does not stop, it also leads to some chaos. Also wasteful!

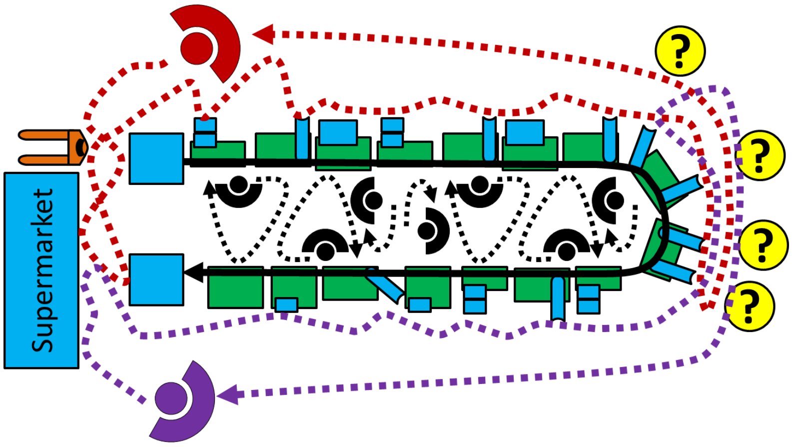


Figure 425: Two POU with an overlap. (Image Roser)

Hence, do make sure all stations are clearly assigned to the point-of-use providers. Include visual management (e.g., a blue "*POU-1*" sticker for stations of the first point-of-use provider, and a green "*POU-2*" for the second one.) Like any standard, they can optimize that over time, but do require a clear assignment.

Also, with multiple point-of-use providers you can optimize walking distance a bit. For example, if they use a pallet jack or similar to bring pallets with material to the line and pallets with completed goods from the line, it may make sense to have the same person do this work. In this case, he can bring a completed pallet back and pick up a fresh one on the way back, rather than two people doing half of that and walking empty for one leg of the trip.

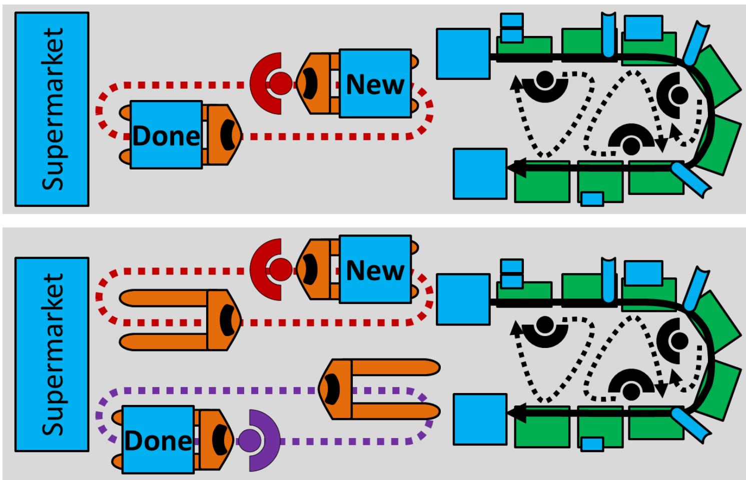


Figure 426: Two POU Optimizing (Image Roser)

50.3 Extended Point-of-Use Provider

However, it is also possible to have a point-of-use provider that gets the material from a central warehouse. This is illustrated below. However, this significantly increases his walking distance. In these cases, it is highly suggested to give the point-of-use provider additional tools to help him transport more at the same time. If he would have to carry every box by hand, it would be a waste of his abilities and the line may run out of parts.

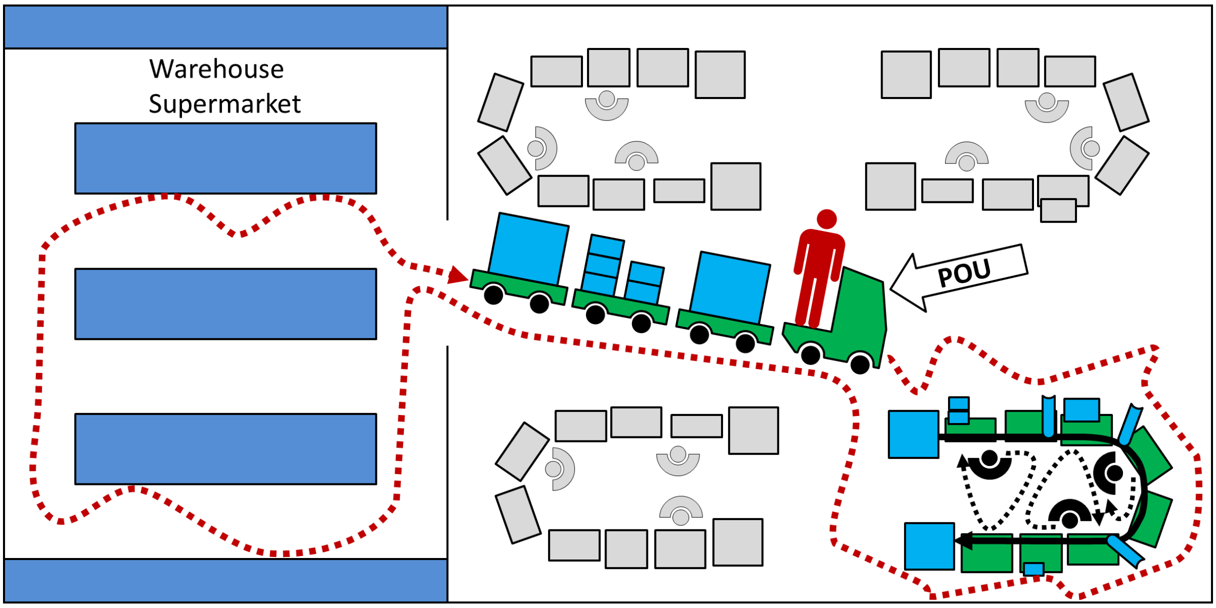


Figure 427: Point of Use provider and a Central Warehouse (Image Roser)


Figure 428: Milk run or point-of-use provider? (Image Still under the CC-BY-SA 3.0 license)

Depending on the expected material quantities needed, such a tool could be a pushcart, a forklift, or a small train similar to a milk run. In fact, the mode of transport may look and feel like a milk run, with one crucial difference! The milk run has a timetable when to drive. The point-of-use provider does not! Overall, he may have to be able to transport larger quantities than he could carry by hand.

This concludes my three-post series on point-of-use providers. I hope these were helpful to you. Now **go out, get your material flowing, and organize your industry!**

51 25 Years after W. Edwards Deming

Christoph Roser, December 20, 2018, Original at https://www.allaboutlean.com/25-years-deming/

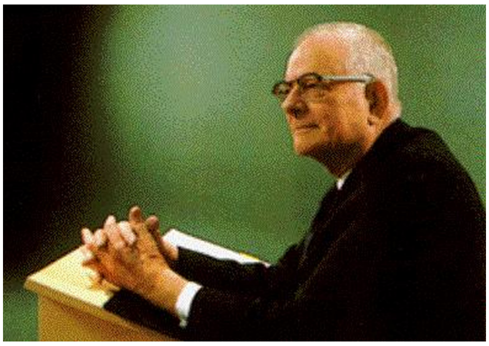


Figure 429: W. Edwards Deming (Image FDA in public domain)

Twenty-five years ago today, William Edwards Deming (October 14, 1900 – December 20, 1993) passed away. He greatly influenced the management of quality in Japan, where he is still revered as one of the great gurus in manufacturing. Through his influence on Toyota, his ideas are now common in the lean world. Time to look back at his life.

51.1 Family Life

Figure 430: Sioux City, 1900 (Image unknown author in public domain)

Deming was the eldest of three children of William Albert Deming and Pluma Irene Edwards, born in October 14, 1900, in Sioux City, Iowa. His name is a combination of his father's first name and his mother's last name, and he was called Edwards to avoid confusion with his fathers name, William. His dad was an insurance broker and his mom was a piano teacher. He had a brother Robert (1902) and a sister Elizabeth (1909).

While he grew up rather thrifty on a farm in Polk City, Iowa, and later in Powell, Wyoming, his parents were both well educated and valued the education of their children.

He married his first wife, Agnes Bell, in 1922, and they adopted a daughter, Dorothy, in 1924. However, Agnes died in 1930, and he married again in 1932 to Lola Elizabeth Shupe, a mathematician. They had two more girls, Diana (1934) and Linda (1943).

51.2 Academic Career

Figure 431: University of Wyoming, Laramie, 1908 (Image Haines Photo Company in public domain)

Deming obtained a bachelor's in engineering at the University of Wyoming in Laramie in 1921. He also taught briefly at that school.

In 1922 he became an assistant professor of physics at the Colorado School of Mines, while simultaneously obtaining a master's degree in mathematics and physics at the University of Colorado in 1924.

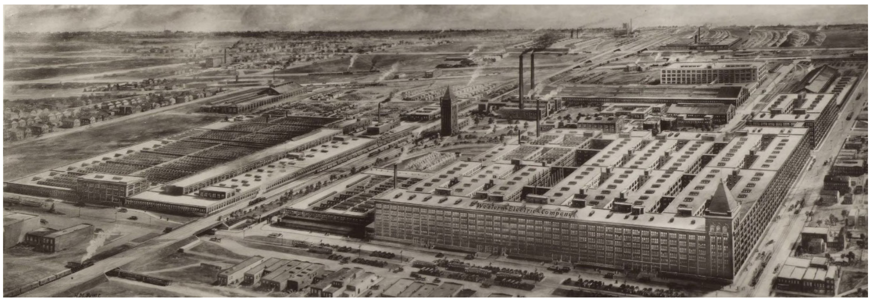


Figure 432: Hawthorne Works 1925 (Image Western Electric Company in public domain)

Afterward, he worked briefly as an hourly worker at Western Electric's Hawthorne Works in Chicago. Maybe you have heard about the famous Hawthorne Experiments. These studies by Elton Mayo and Fritz Roethlisberger analyzed the influence of different factors such as illumination on work performance. Surprisingly, the performance increased regardless if they made it brighter or darker, no matter what they did, as long as they paid attention to the workers (although modern researchers are much more critical about the quality of the study). While Deming was not involved in the study at all, the calculation of the payments he received from his manual work set his opinion firmly against financial incentives of any kind.

In 1926 he went to Yale, and received his Ph.D. in 1928 for "A Possible Explanation of the Packing Effect of Helium."

Figure 433: Walter A. Shewhart (Image unknown author in public domain)

Afterward he worked for the United States Department of Agriculture, first as a mathematician and later as a lecturer. During this time his career took a turn from physics to quality control. It was also at this department where he met Walter Shewhart (1891–1967), which developed into a flourishing professional exchange over the next decades. Shewhart is considered the father of statistical process control, and he developed a cycle for quality control in his book edited by Deming in 1930. Later Deming updated this to the Deming Cycle, which slightly modified made its way into Japan, and now is known as PDCA, although Deming disliked the PDCA version (see here for more).

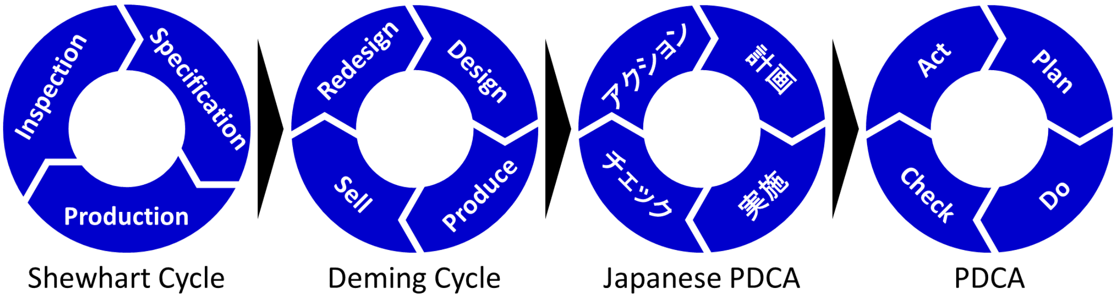


Figure 434: PDCA History (Image Roser)

In 1939 he switched jobs and joined the Bureau of Census. There he developed statistical survey methods that significantly influenced the 1940 census.

51.3 The War Years

Figure 435: United States Department of War Seal (Image United States Department of War in public domain)

In 1942, Deming was asked to help with statistical training to help the war effort, and he soon trained engineers, inspectors, and industrial people in an intensive eight-week course. The impact of this course on the war is disputed; you can find a lot of praise but also some critical voices.

After the war was over, his work was no longer needed, and he worked as a consultant for some time. A lot of the productivity and quality achievements during the war were now on the back burner or even forgotten.

51.4 Deming in Japan

In 1946, Deming was asked to come to Japan to support agriculture production, and in 1947 to help with the 1951 census. He and Joseph Juran were part of a group of experts of the U.S. Headquarters in Japan tasked with improving productivity and (the back then still arguably shitty) quality of Japanese products, although Deming only got on board because the first preference declined to go to Japan. Unlike many other experts, Deming and the Japanese got along well. He became a frequent visitor of Japan.

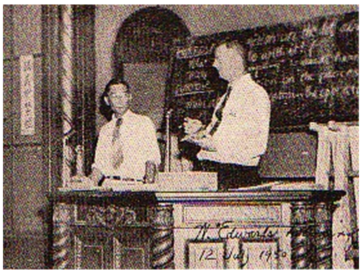


Figure 436: Edwards Deming in Tokyo, 1951 (Image unknown author in public domain)

The Union of Japanese Scientists and Engineers (JUSE) tried to understand the U.S. concept of statistical quality control, but got stuck in some theory. Hence, in 1950 they asked Deming to come back and help them. Deming developed and held numerous lectures and seminars on statistical quality control, which were well received and very well attended. His courses were subsequently also taught by others. Other courses on sampling methods had much less popularity.

Deming did not accept royalty payments for his course. As a sign of gratitude, JUSE established the Deming Prize for Quality in 1950, with the first awards given in 1951. This is by far the most prestigious quality award in Japan. Nissan won the price in 1960, and as a response Toyota introduced Total Quality Control (TQC) in 1961, also winning the Deming Prize in 1965. In 1950, Deming also met with twenty-one of Japan's most important industrial managers, which was a turning point for his influence. Overall, Deming is still revered in Japan.

51.5 Re-Import of the Japanese Methods to the United States

Figure 437: 1973 Oil Crisis (Image David Falconer in public domain)

All these achievements in Japan were pretty much unnoticed in the West, and Deming, too, was pretty much unknown in his home country except to insiders.

This changed in the aftermath of the 1973 oil crisis that seriously hurt the Western automotive industry but apparently not the Japanese. Besides the study of "the machine that changed the world," another landmark was the 1980 NBC documentary *If Japan Can, Why Can't We?*, which talked about and with Deming for fifteen minutes.

As part of the wave of lean manufacturing, quality control and Deming's ideas made their way back to the United States. A lot of the methods that the United States developed during the war and pretty much abandoned afterward were re-introduced through Japan. During this time, Deming also rose to industrial superstar status in the United States and the Western world.

He died on December 20, 1993, in Washington, DC, aged 93.

51.6 A Demigod of Quality?

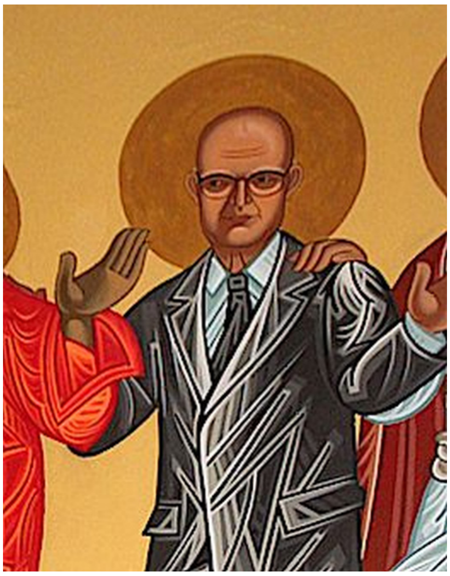


Figure 438: Saint W. Edwards Deming? (Image Peter Kazanjy under the CC-BY 2.0 license)

As Deming rose in prominence in the United States, the media outdid itself with praising his achievements, making him appear much larger than he truly was, and calling him "the man who discovered quality" and "founder of the third wave of the Industrial Revolution."

If you believe in Deming as a flawless demigod of quality, you better stop reading. He achieved a lot, but this is nowadays often exaggerated. He even made it on a mural of a church as a (sort of) saint. Selected sources are below.

From 1964 onward, JUSE started to believe that while Deming was excellent in statistics, he lacked practical industry experience. Also – and this is common with successful people – he valued his own achievements while overlooking all the people who contributed. While he developed the courses for statistical quality control in Japan, the method originated from Walter Shewhart, and Shewhart should get the praise for that.

Another common flaw of people who are praised excessively is to eventually believe the praise (just ask your CEO how wonderful he is …). And Deming as an academic with many publications was just much more accessible than Homer Sarasohn, who also taught statistical process control in Japan, but as an industrialist and with a much higher focus on practicability.

Deming once dissed the Malcolm Baldrige Quality Award, since he believed it should have been named after him. He also believed that he alone made the difference in Japan's success. Personally, I believe Joseph Juran (1904–2008) had a much bigger influence in Japan in particular and on quality management in general. Deming also gave his name to the American Society for Quality (ASQ) for an (U.S.) Deming Prize. This greatly offended JUSE and their (Japan) Deming Prize, and they were not consulted on this second prize with the same name.

Deming opposed Total Quality Control (TQM), stating that Statistical Quality Control was all that is needed.

On the other hand, there are also numerous reports and anecdotes of his kindness and helpfulness. He was also known for his humor and consideration of others. Overall, he was the right person at the right time and helped to spread the valuable tool of Statistical Quality Control in Japan and later in the rest of the world.

51.7 His Legacy

Deming is known for spreading statistical quality control in Japan and the world, as well as helping to put quality on the agenda of industry. He is also the author of 14 key principles for Total Quality Management (not to be confused with the 14 Management Principles of The Toyota Way by Jeffrey Liker). These principles are, in my view, sound and good common sense, although Deming took a lot of inspiration from other sources for that list. (Source for the two lists below: Wikipedia article on Deming.)

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive, to stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for massive inspection by building quality into the product in the first place.
4. End the practice of awarding business on the basis of a price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.
5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
6. Institute training on the job.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and usage that may be encountered with the product or service.
10. Eliminate slogans, exhortations, and targets for the workforce asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the workforce.
    - Eliminate work standards (quotas) on the factory floor. Substitute with leadership. [Please note that I am a fan of standards, but not a fan of pay-by-piece. I believe Deming here means pay-by-piece rates]
    - Eliminate management by objective. Eliminate management by numbers and numerical goals. Instead substitute with leadership.

1. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.
2. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objectives.
3. Institute a vigorous program of education and self-improvement.
4. Put everybody in the company to work to accomplish the transformation. The transformation is everybody’s job.

He also created a list of the "Seven Deadly Diseases," which are also sensible.

1. Lack of constancy of purpose
2. Emphasis on short-term profits
3. Evaluation by performance, merit rating, or annual review of performance
4. Mobility of management
5. Running a company on visible figures alone
6. Excessive medical costs
7. Excessive costs of warranty, fueled by lawyers who work for contingency fees

So, here you have it. Overall, I like Deming and his contribution to Japan, although I am a bit skeptical of his glorification. Now, **go out, improve your quality, and organize your industry!**

51.8 Selected Sources

Juran, Joseph M.: Architect of Quality. McGraw-Hill, 2003. Especially pages 300–306 have a critical view on Deming.

Hopper, Ken, and Hopper, Will: The Puritan Gift: Triumph, Collapse and Revival of an American Dream, I. B. Tauris 2007

Murals of Deming can be found in the St. Gregory of Nyssa Episcopal Church in San Francisco, along with Anne Frank, Mahatma Gandhi, and many others (and yes, I know that neither Anne Frank nor Gandhi were Christians … don't ask me to explain religious logic …)

52 How Cheap Can You Make it?

Christoph Roser, December 25, 2018, Original at https://www.allaboutlean.com/how-cheap-can-you-make-it/

Figure 439: Different Ballpoint Pens (Image Roser)

I was on a quest, a quest to find the cheapest ballpoint pen possible. And what I found was amazing. Modern manufacturing has achieved stunning productivity, where even a complex product like a ballpoint pen can be produced at costs that were unbelievable only a few decades ago. While everybody can make a pen, the goal in manufacturing is always to make it cheaper! For the same functionality, the customer will almost always go for the cheaper products. Let me show you the results of my quest.

52.1 The Product

The product I was after is simple. A ballpoint pen with a retractable point. You all used it at one point or another. With cheap pens you probably don't bother with replacing the ink reservoir, but simply throw out the pen when it is empty, unless of course you lost the pen beforehand. Pens nowadays are so cheap, it is just not worth fixing them. I wanted to see how cheap I could get. The price I was looking at was for bulk purchase (think 100,000 pens or so) and would not include shipping and value added taxes.

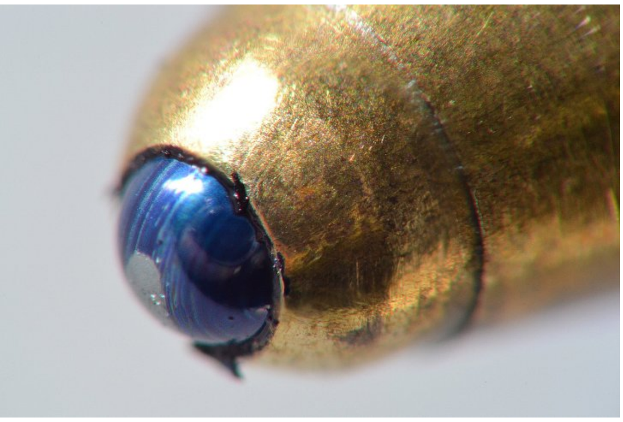


Figure 440: Ballpoint Pen Tip (Image Carlos E Basqueira under the CC-BY 3.0 license)

But please be reminded that a pen is a by no means simple product. It has multiple moving parts, including a precision ball in a socket that gave the pen its name. This ball is often made out of tungsten carbide for reduced wear, although I could not analyze the material of my quest pens.

There is also a mechanism for the retracting and extending of the tip and the ink reservoir. Overall, it is a complex product with quite a few engineering specifications and tolerances.

52.2 The Pens

52.3 Pen 1: Manors

The first cheap pen I found – surprisingly enough – in Germany. For a measly EUR 0.0637 (around USD 0.0723) I get a working pen (for quantities of 70,000 and up). And – second surprise – it is actually a pretty decent pen. It writes well, the retracting mechanism feels good, it does not look ugly, and it even has a small rubber grip to make it easier to hold. When I say it writes well, I mean of course for a low-cost pen. Naturally, you can find high-end pens that promise eternal bliss while writing, but if you just want to get a line on the paper, this is good enough. Altogether this pen is made of eleven components. Since I bought only around fifteen pens, I had to pay around €5 in shipping for €0.95 worth of pens

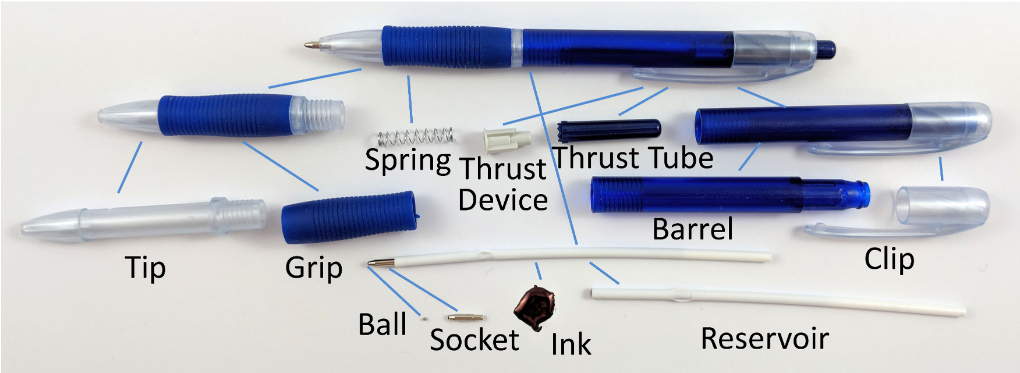


Figure 441: Disassembled Ballpoint Pen 1 (Image Roser)

52.4 Pen 2: Wessex

On the same site I found an even cheaper pen for only EUR 0.0606 (USD 0.0688) (for quantities of 75,000 and up). Since it did not have a nice rubber grip, it felt a bit cheaper, and to me it also looked a bit cheaper, even though the barrel had a metallic finish (still plastic though) and the tip had a fancy over-mold, where the blue part seems to have been directly molded on top of the gray part. This makes the mold a bit more expensive. Since each pen was in a clear plastic bag, the product still had eleven parts, although I could not disassemble the clip without breaking it.

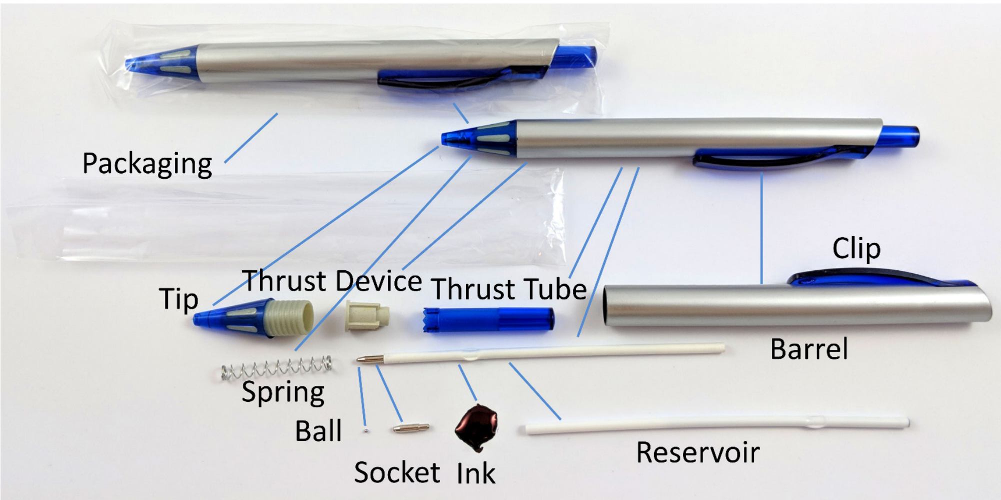


Figure 442: Disassembled Ballpoint Pen 2 (Image Roser)

52.5 Pen 3: No Name

Next I set my sights on the source of probably most pens in the world: China! And a good site to browse Chinese products is Alibaba. Here I found my next quest item from the Yiwu JC Import & Export Co., Ltd., a pen for a whopping USD 0.0450 (EUR 0.0396) (price asked for a quantity of 115,000). This one also looked nice and had a rubber grip. The design was also not bad. As part of the assembly, the end cap was screwed onto the thrust tube, hence the mold for both the end caps and the thrust tube needed a thread. The clip was also glued on. With altogether thirteen parts (including glue), it had the highest number of parts of the pens I looked at in more detail.

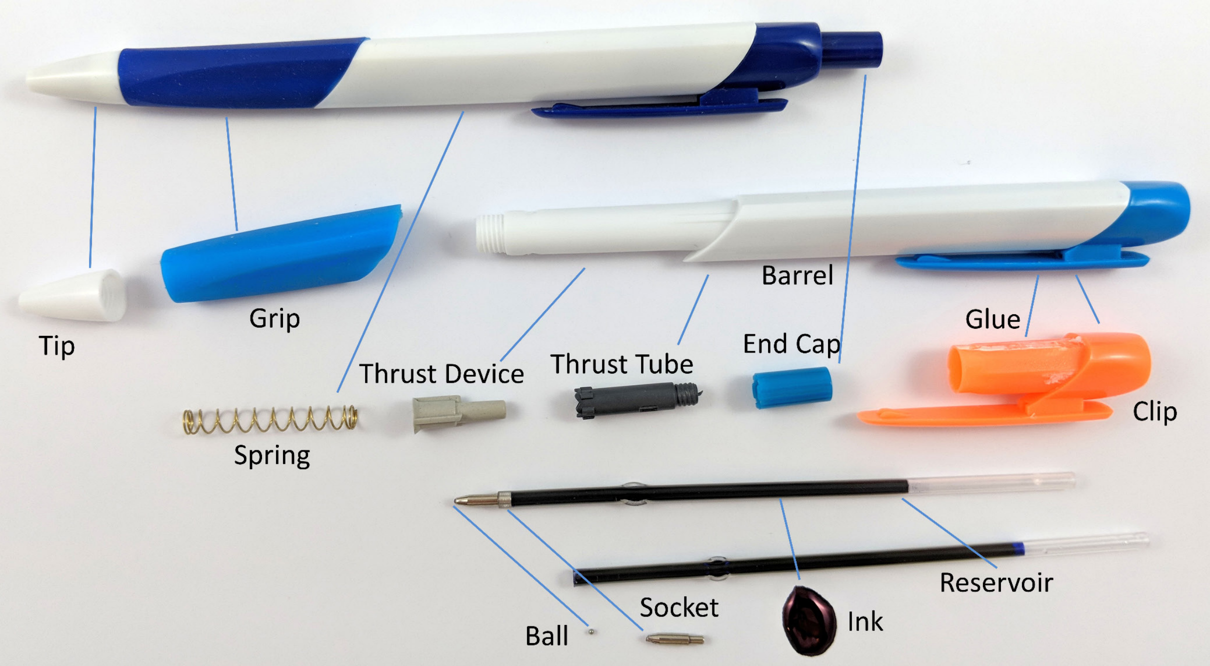


Figure 443: Disassembled Ballpoint Pen 3 (Image Roser)

52.6 Pen 4: No Name

The same source at Alibaba also had an even cheaper pen for USD 0.035 (EUR 0.0308)(price asked for a quantity of 115,000). But now it starts to look and feel cheap. The pen still writes well, but they did save money on the clip mechanism. Rather than clipping with your thumb on the end cap, the end cap only pushes it in until the integrated clip arrests. A second press on the clip releases the reservoir again and it jumps back out. Hence, you have to press different locations for extending and retracting the tip. This pen has only seven different parts, the lowest of any of these four pens. However, I feel for USD 0.035 I cannot complain (although including shipping I paid $5 per sample pen). Shipping for 115,000 pens to Germany would have been $300 within forty to forty-five days.

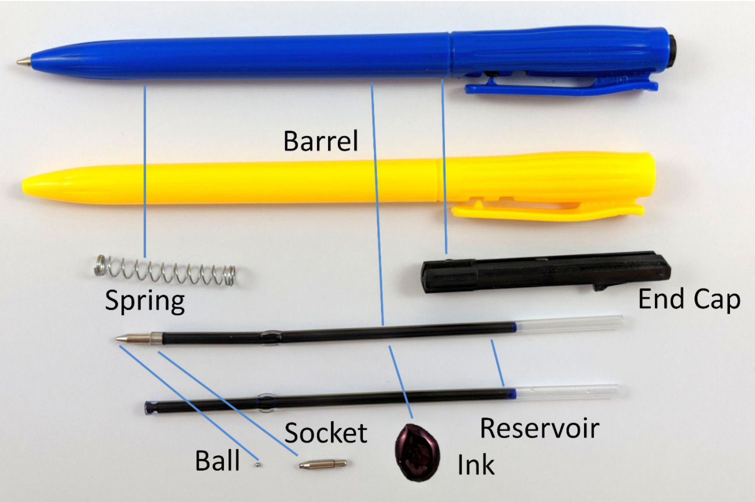


Figure 444: Disassembled Ballpoint Pen 4 (Image Roser)

52.7 How Do You Make a Pen for USD 0.035???

While pen #4 was definitely not the nicest pen, it was the cheapest, and hence I will look at this one in more detail. How on earth do you make a pen for USD 0.035 per pen?

Let's put this in perspective. Among the cheapest industrial wages paid in the world are around $1 per hour. You can get cheaper wages, but then the workers would not know how a light switch works, and would need to be trained before they can be used in industry – at which time they would commandeer higher wages. Even $1/hour is a bit extreme, especially since I do not include taxes and other overhead. But for the sake of the argument, let's stick with $1.

At $1/hour you will get for $0.035 a measly 2 minutes and six seconds. Hence, the entire labor in making this pen is less than 2.1 minutes! While this does not sound like much for assembling a pen, this 2.1 minutes also includes the mining, processing, shipping, and manufacturing of the pen.

You have to get the metals out of the ground as well as the oil for the plastic and ink. These have to be processed, formed, shaped, transformed, molded, and assembled. All of this needs (expensive) equipment. Do not forget the work of the engineers designing this pen as well as all the different machines, and they usually do not work for $1 per hour. Also do not forget logistics, energy, and a lot of other things.

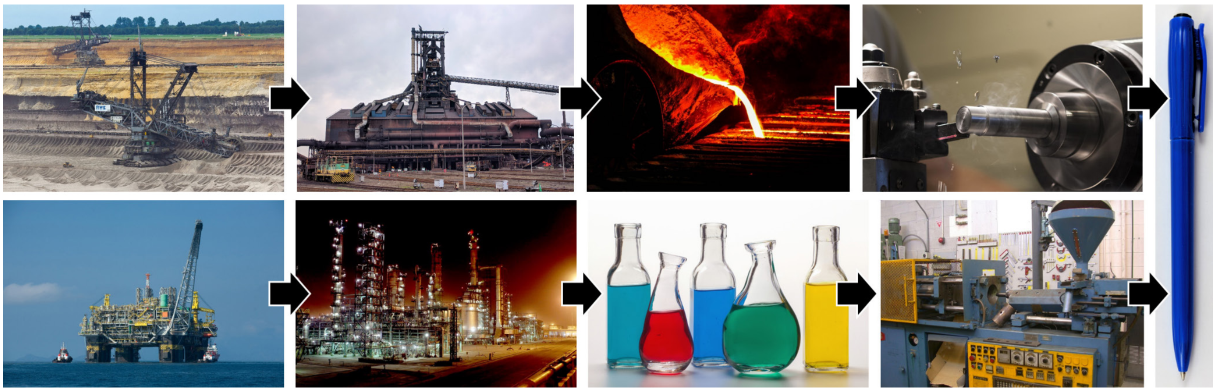


Figure 445: How to make a Pen (Images Roser; Raimond Spekking and Kendash1987 under the CC-BY-SA 4.0 license; unknown author and Staff Sgt. Michael Washburn in public domain; Divulgação Petrobras / Abr under the CC-BY-SA 3.0 Brazil license;and Glenn McKechnie under the CC-BY-SA 2.5 license)

The total human contribution is probably way less than 2 minutes. All the other contribution is through machines, automation, and other mechanical gadgets and gizmos. But if you buy a $0.035 pen, an infinitesimal small fraction of the money goes to the oil rig, the mine, and many other companies. The contribution is probably too small to measure, but it is making a profit for the industry!

Below is an overview of the components with their weight (measured), the material (educated guess), material cost (polypropylene $1/kg, steel $0.60/kg, ink $1/kg), and a very rough estimate of the production cost assuming production in very large quantities. I also added a generous half a cent for the final assembly. The total cost of the pen is probably USD 0.0051 for material and 0.015 for manufacturing for a total of USD 0.021 before profit and shipping (or less, I am not that familiar with Chinese prices). Still, amazingly cheap.

Component	Weight (g)	Material	Material Cost ($)	Production Cost ($)
Barrel	3.519	Polypropylene	0.0035	0.0033
Rear Cap	0.826	Polypropylene	0.00083	0.0033

Spring	0.175	Steel	0.00011	(n/a)
Mine Assembly	0.731	(assembly)	n/a	0.00047
Ball	0.0003	Steel	0.00000018	0.00064
Ball Socket	0.159	Steel	0.000095	0.0032
Ink	0.098	Pixie Dust?	0.00098	n/a
Reservoir	0.474	Polypropylene?	0.00047	0.0034
Total	5.2513		0.0051	0.015

By the way, the hardest and most high-tech part to make is the ball and the ball socket. Until recently, China had to import all balls from Japan and Europe, since they did not have the technology to make them. The Yiwu JC Import & Export Co., Ltd. that made the two pens above also produces their own balls and ball sockets.

52.8 Can It Be Even Cheaper?

It can definitely be cheaper. If not now, then definitely in the future as manufacturing continues to advance and become even more productive. But probably even now you can find cheaper pens, although I believe not by much. I found even cheaper pens advertised, but these prices turned out to be doubtful.

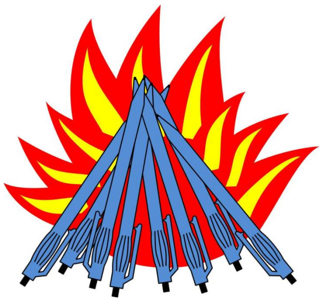


Figure 446: The solution to our energy problems? (Image Roser)

Amazon has plenty of pens for USD 0.01, but they come with $3 for shipping, and I guess the profit is in the shipping. The cheapest pen I saw advertised on Alibaba was less than half a cent at USD 0.004 (EUR 0.0035), but the supplier never returned my messages. Another pen advertised as USD 0.01 was not available at this price.

I guess the price was just to get my attention and not really an offer. Besides, at USD 0.004 for a 7g (0.24 ounce) pen, the pen has the same price by weight as heating oil. You may just as well heat your apartment by burning pens.

52.9 What About the Other End?

Of course, there is not really a firm upper limit on the price of ballpoint pens. At the time of writing, the most expensive ballpoint pen on Amazon.com was the Limited Edition Montegrappa Ernest Hemingway Traveller Ballpoint Pen, Gold 18k for USD 39,150.00 (and don't forget the 5.99 shipping).

For the same price you get 1,118,571 pens at 0.035 each. Is the writing of this Hemingway pen truly one million times better? I doubt it. But it does make a great conversation piece. Although for that price I still would rather buy two cars. Besides, with a weight of 99g (3.5 ounces), it is quite a hefty piece.

52.10 Summary

Please excuse me for getting a bit misty-eyed, but I find it just utterly amazing how much modern industry can make things cheaper and cheaper … and the journey is long from being over. As we speak, thousands of engineers, technicians, workers, and industrialists work on making their products even cheaper.

So, no matter if your work improves price, speed, or quality, it does not only improve your companies bottom line, but you are also a part of human ingenuity that constantly works on improving their products and its production. Your work contributes to human prosperity! Now **go out, shave a few more cents out of the product, bring humanity forward a bit more, and organize your industry!**

52.11 Pen Sources

- Pen 1 Manor at werbeartikel-discount.com
- Pen 2 Wessex also at werbeartikel-discount.com
- Pen 3 & 4 from the Yiwu JC Import & Export Co., Ltd. on Alibaba

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54 Author

Figure 447: 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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