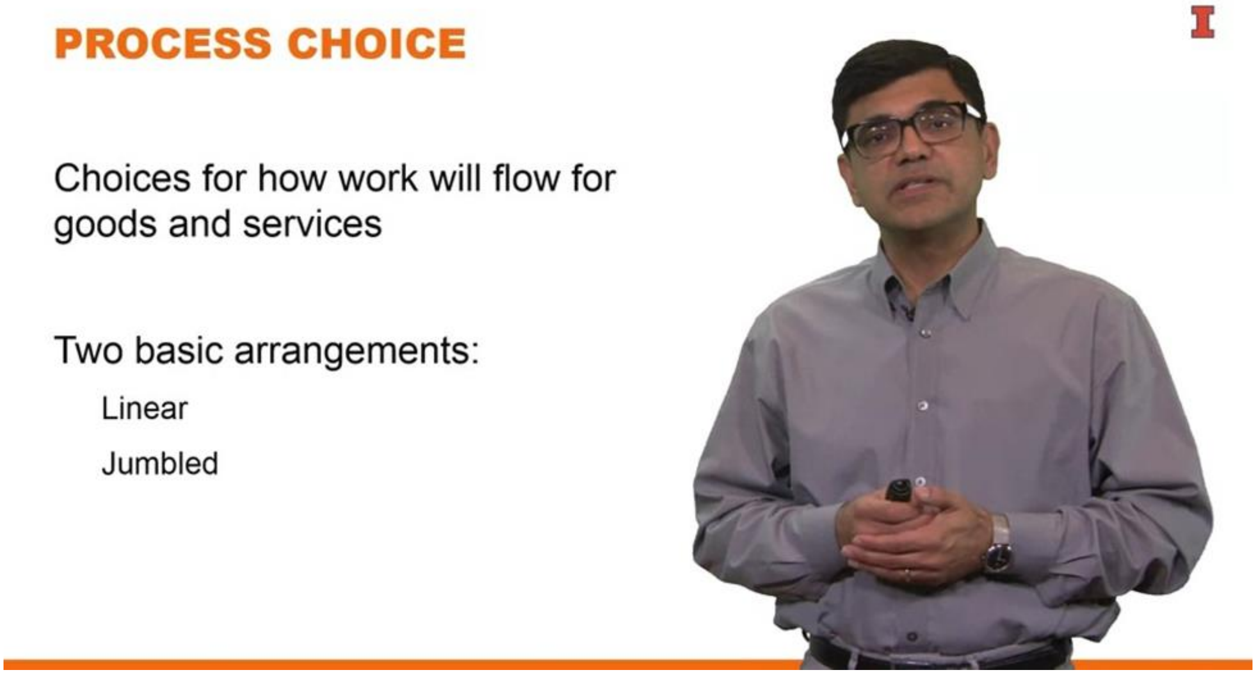
Module 2: Process Configurations and Metrics

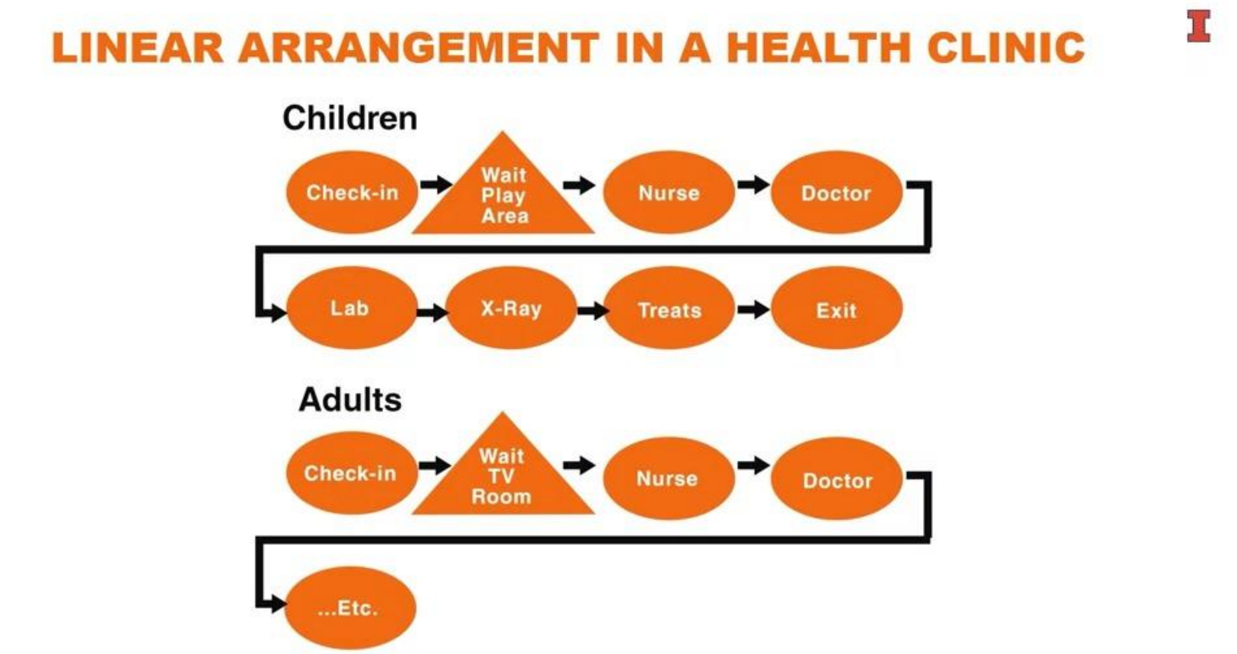
Table of Contents

Lesson 2-1: Process Types

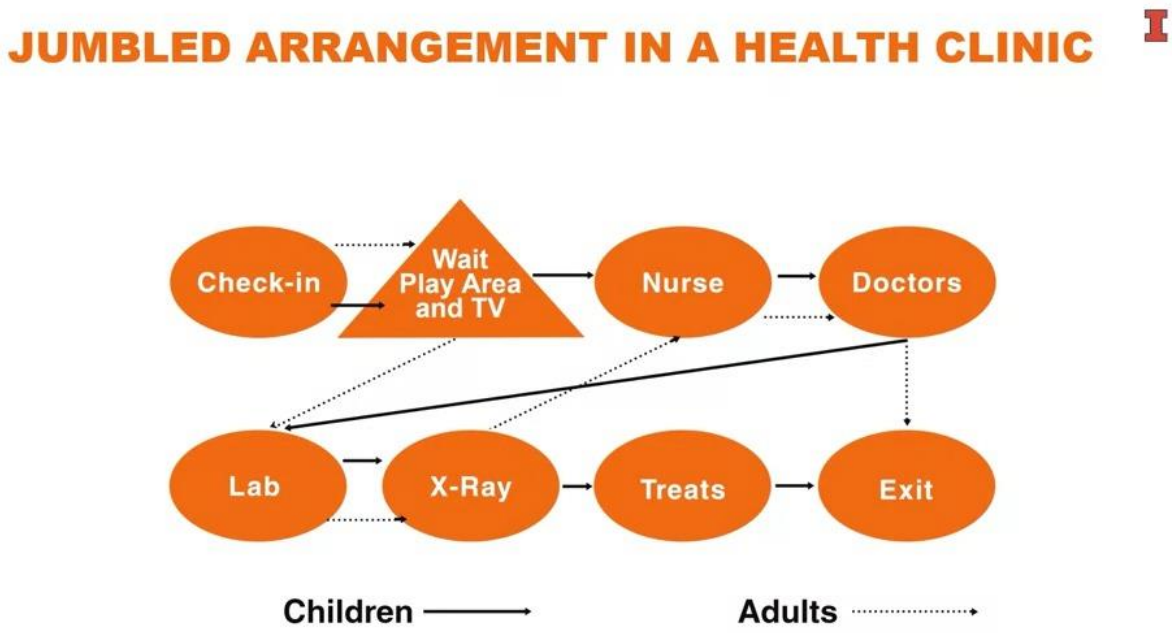
Lesson 2-1.1: Process Arrangements - Linear and Jumbled



One of the most fundamental decisions for implementing an operation strategy is how you arrange the different activities in the process. It's what we call process choice. It's determining what kind of configuration the different activities are going to be in. Whether they're going to be working exclusively on a product, whether they're going to be shared activities. And we call this element of operation strategy, the process choice element. You should recognize that this is a long term decision very rarely are you going to be able to change the configuration of the activities very often? It's going to be expensive for you to change how you have situated your different machines, whether it's in a manufacturing plant or whether it's in a fast food restaurant, it is going to be time consuming. And it's going to require a lot of investment to be able to set it up in certain ways. So let's start off with taking a look at two very basic types of process arrangements. One of them is a linear arrangement, and one of them is what we're going to call a jumble. So we're not going to get into the definitions of the formal process types that we see in operation strategy, but we're simply going to call them linear and jumbled at this point.

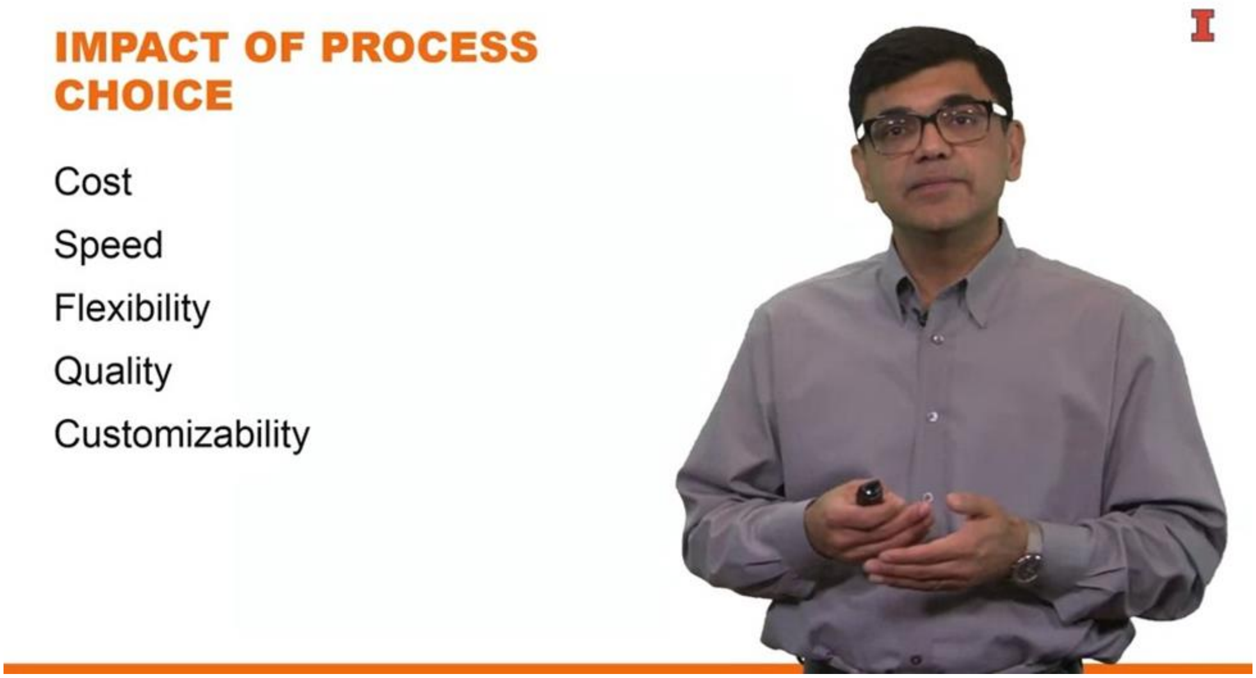


So let's take a look at these basic types of process types, right? So, let's take an example here. I want you to think of a health clinic in which you have kids that go through the health clinic, they get treatment as well as you have adults. So here is an example of a linear arrangement for that health clinic. So you have Children that go through the whole process. They go through the activities like checking. They have to wait, they get seen by a nurse. They get seen by a doctor. They may have to go get labs, get an X ray, get some treats before they leave and then they exit out. So that's going to be the arrangement for children. And for adults, it's going to be a similar arrangement except it's going to be maybe a different sequence, maybe a different set of activities. So what you have here, the basic difference between this and the next arrangement we're going to see is that you have a dedicated set of activities. The play area that we have here is dedicated for kids. The weight room for adults has a television in it which you don't have for the kids. So that's the main difference between this and the next arrangement that we're going to look at is that. Each of these activities is dedicated to that particular type of customer that is going to go through it and in this case it's patients being kids and adults.



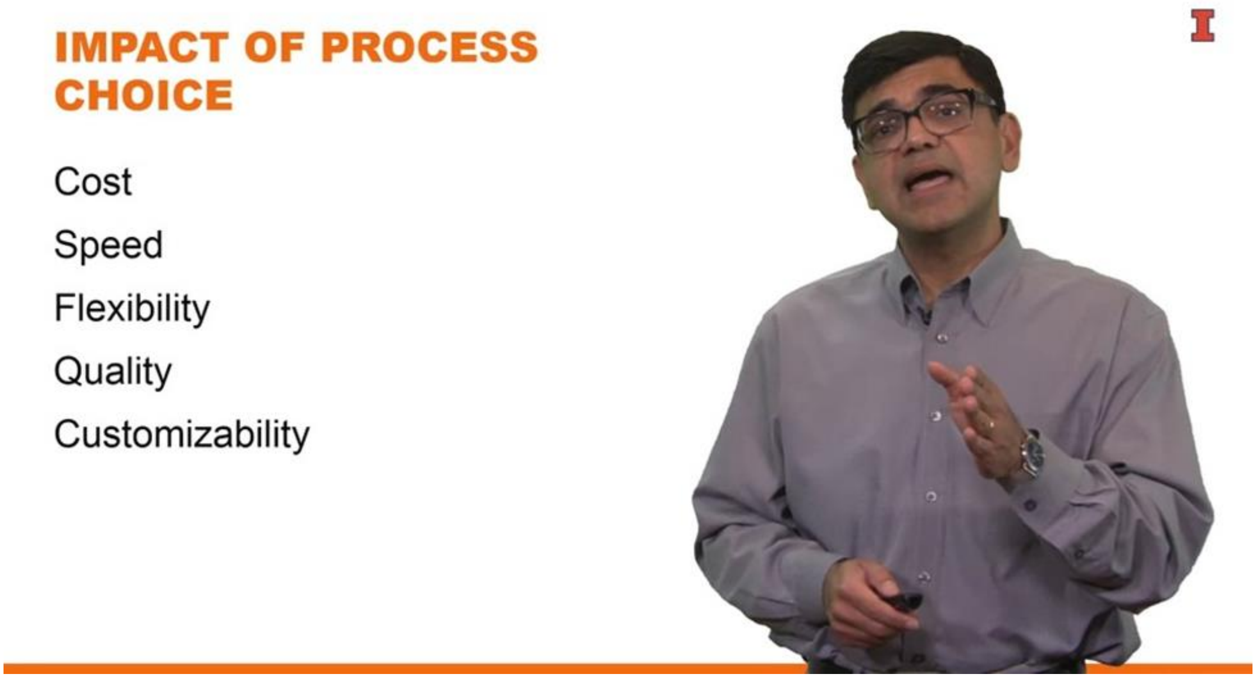
Now let's take a look at the other kind of arrangement to make a contrast between a linear and jumbled arrangement. So in a jumble arrangement you're not going to have these activities being exclusively used for a certain type of customer. So what you have here is a set of activities that are placed in sort of departments. There is a wait department where people can wait whether it's customers who are kids, whether it's customers who are adults. And you can even add customers patients who are going for geriatrics so the older patients. It's a common weight area in this case It's a common area of being seen by nurses and doctors. So these are all common areas. And what I have depicted over here, what you see over here is that the process flows for kids are depicted by the solid line while the process flow for the adults is depicted by the dotted line. So the kids go to the wait, to the nurse, to the doctors, while the adults have to go to the wait. And from there they have to go first, get their laps done before they go through the rest of the activities in the process. So two things here, one, the activities are being shared across two different types of customers in this case could be shared among many different types of customers. Otherwise the other thing is that the flow is going to be jumbled. It's not in a linear fashion. Not every customer, not every patient is going to go through in the same sequence through each of these activities. So that's going to be the difference between these two types of activities, these two types of processes rather.

Lesson 2-1.2: Implications of Linear vs. Jumbled

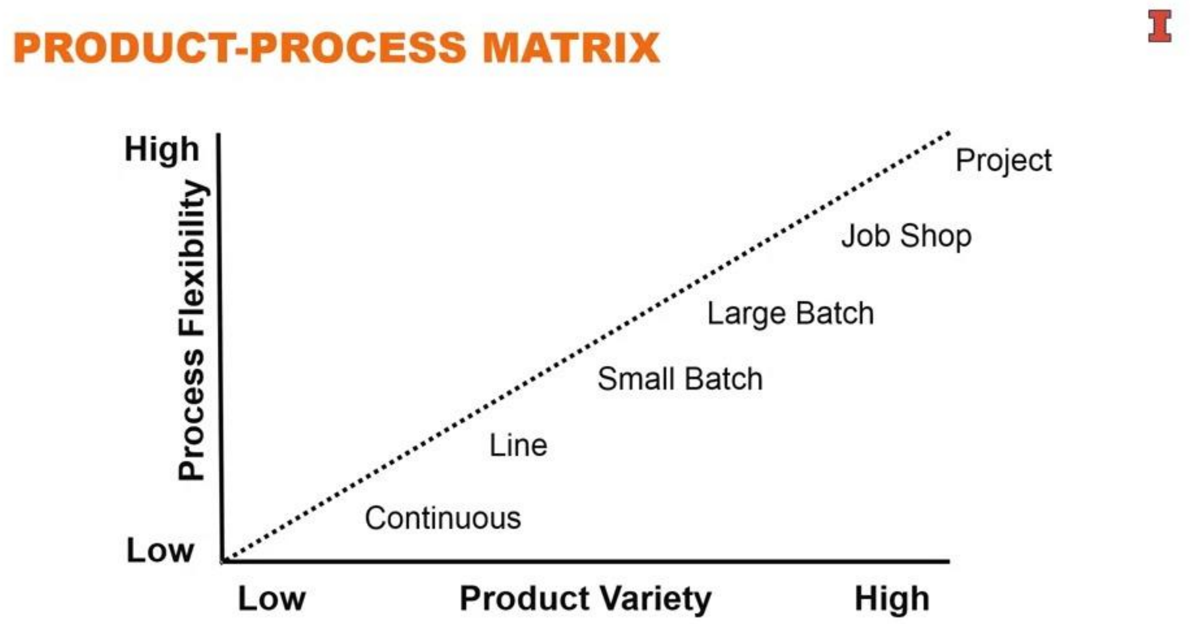


So what are the implications of a decision of process choice? Whether you've picked, let's say a jumbled process or whether you've picked a linear kind of a process. Let's take each one of these and talk through the implications of them. So cost. Obviously when you have a dedicated set of activities for different types of customers, the up front cost is going to be very high, right? You have to invest separately for a process for the kids as as patients as well as for the adults as patients. So they're going to be two parallel processes. You have two wait areas, you have two radiology departments, two pharmacies and so on and so forth. So the up front cost is going to be high. Now what you have to think about is over a long period of time, if you have enough volume of each of these different types of customers. Your cost per customer, your cost per patient in this case might be lowered. So if you're going for that kind of an advantage based on volume. And there is enough volume of each type of patient of each type of customer. Then it may make sense for you to make that upfront investment into two different types of processes. Two different arrangements that are dedicated for each of those two customers, right? So that would be the cost benefit analysis that you would have to do. When you were looking at should we go in for a linear arrangement or should we go in for a jumbled arrangement. Because if you were to do a jumbled arrangement, you could share the activities. However, it might get expensive from the point of view of the customer. They have to adjust to not having a dedicated playroom as the wait area. Or a dedicated TV room as the wait area for adults. And that's the cost of the customers sort of have to face. And so you have to think of the implications of that. Well, let's take the second element of speed. So, if you recognize what we're going through here are things that customers care about things that organizations care about. We care about the cost of producing something. The cost of providing something to a customer. We also care about the speed at which we are able to deliver something to a customer. And the customer also cares about that obviously. So in terms of speed, if you have a linear arrangement. If it's in a straight line, the obvious implication is that it's going to go much quicker than it would if it was a jumbled kind of flow. So speed is going to be higher if it is in a linear arrangement. And jumbled, it's going to be more messy. What's also going to happen is that there will be some scheduling issues getting into the picture here. Because you'll have some adults that take longer for certain tasks and kids might take longer for some other tasks. And that's going to mess up the way that you have each of the patients going through. And if they're in mixed sequence, you're going to have issues of there being more waiting. So the speed is going to get affected. Now, let's take a look at the next one, flexibility. In a linear arrangement, you have less flexibility of being able to cater to different types of customers. Cater to different types of patients in this case. And that's by design, right? We've arranged the process for more efficiency. We've arranged the process for more speed. When it's a linear arrangement, you're sacrificing flexibility in that case. Whereas in a jumble flow, there's going to be more flexibility. If there are different needs of customers, they can be tackled in a different sequence through the jumble flow. And that's going to work fine. Quality. The next aspect that customers care about, that organizations care about. Now quality from a very broad perspective, if you were to take a look at it. The linear one is going to be focusing on speed. But might be sacrificing quality in one way. If everybody is being treated like a going through an assembly line. On the other hand, if you're thinking about there being specialists that are dealing with each type of patients. So you have people who are doctors and nurses who are trained not only to to deal with the ailments of kids. But also deal with the way the different kids react. How they are different from adults. That's going to give better quality, a better experience to the to the patients. But if you think about it from a different perspective, now quality may be affected. In the sense that if there is a problem that needs a broader outlook. So, if there's a teenager who's going through and has gone through the kids process, they are trained to deal with kids. And they might not have some of the broader knowledge that might exist if you are going through a jumble flow. And there are people trained in that jumble flow to deal with different types of ailments. So, having a process flow of one type. What you hopefully you're seeing is that it has implications on the other operations strategy elements. Of how they are going to have people trained for each different each of the different types of processes. Whether it's a jumble flow or a linear flow. Finally, customizability. Again, the linear one, the linear flow is not meant to be customizable. It's meant to be for a certain type of patient. And so customization is going to be difficult if you are going to ask for any kind of changes within a linear flow. Worse is when it's a jumble flow. They are trained to be more flexible. The people are trained to be more flexible, process is designed to be more flexible. The kind of training that people have got is more broader. So customization, they might be used to that. It might be possible for them easily. So you can see that a simple decision. Or what seems like a simple decision. Should be a jumbled or a linear flow of activities is going to have implications on what you're trying to achieve from a process. From an operation and and the customer experience, what they are able to get from an operation, from a process.

Lesson 2-1.3: Generic Process Configurations



Now let's take these two types of process types, we said jumbled and linear,



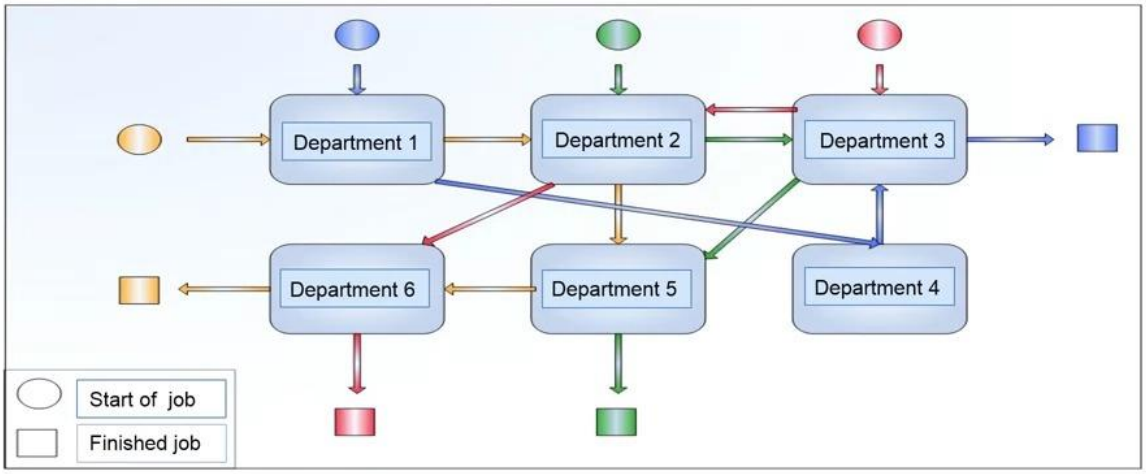
and place them in this big arrangement of process types that we normally talk about in operations. We think about process types on a spectrum that goes all the way from continuous to project. What you have here is a graph, on the x-axis you have product variety going from low to high, on the y-axis you have process flexibility going from low to high. The diagonal represents the spectrum of process choices that you can pick from for your particular operation, for your particular process. So if you think about the linear and jumbled that we just talked about, the linear is going to be the one that is second from the left, it's a line kind of process, and the jumbled is going to be the second last one, which is a job shop. If you're going left to right, the job shop is the second last one, and that's the more jumbled flows. On the extremes, you have continuous and project. Continuous is where things are going to be even more extreme than linear, in the sense that they are going to flow on a continuous basis, and then you have the line which is a linear. The small batch and the large batch which is next, they represent the intermediate between the line and the job shop, so they are neither linear nor jumbled. The job shop is where you have different types of departments that are okay with dealing with different types of customers, it's not dedicated, then finally, you have a project which is dealing with just one customer. There, the sample size or the number of customers for which the product is being built or being catered to is one, so it's a very unique product that you're giving to a customer. Let's go through a few examples of each of these different types to get a better sense of what these different process types actually mean, what they are.

PROJECT – ONE UNIT AT A TIME

(U.S. Dept .of Labor, Bureau of Labor Statistics, n.d.)

For the first one here, you have the example of a project. This is what we talked about in the previous slide as being one unit being built for a customer at a time. Here, you see an example of an airplane that is being developed. This is in its R&D phases and it's being developed one at a time. This is where there are different people who are experts in different areas who are coming together to where the airplane is located, and they're working on it to try out different things. It's a unit of one, the experts: the people who are working on this particular product are actually going to the site to where the product is being built. You can take this and think of other examples of where you would be using a project type of configuration. For example, if you are arranging a vetting, now that's a project. You have a unique product that is being done for a particular set of people, and it's all the experts that are coming together. Making a movie is a project, every movie is unique, it's a project, it needs process type of a project type because there are going to be different experts coming together in order to get that project done. That's one extreme of this spectrum of process types.

JOB SHOP – SIMILAR FUNCTIONS/EQUIPMENT GROUPED TOGETHER



(commons.wikimedia.org/Younes2000, 2006)

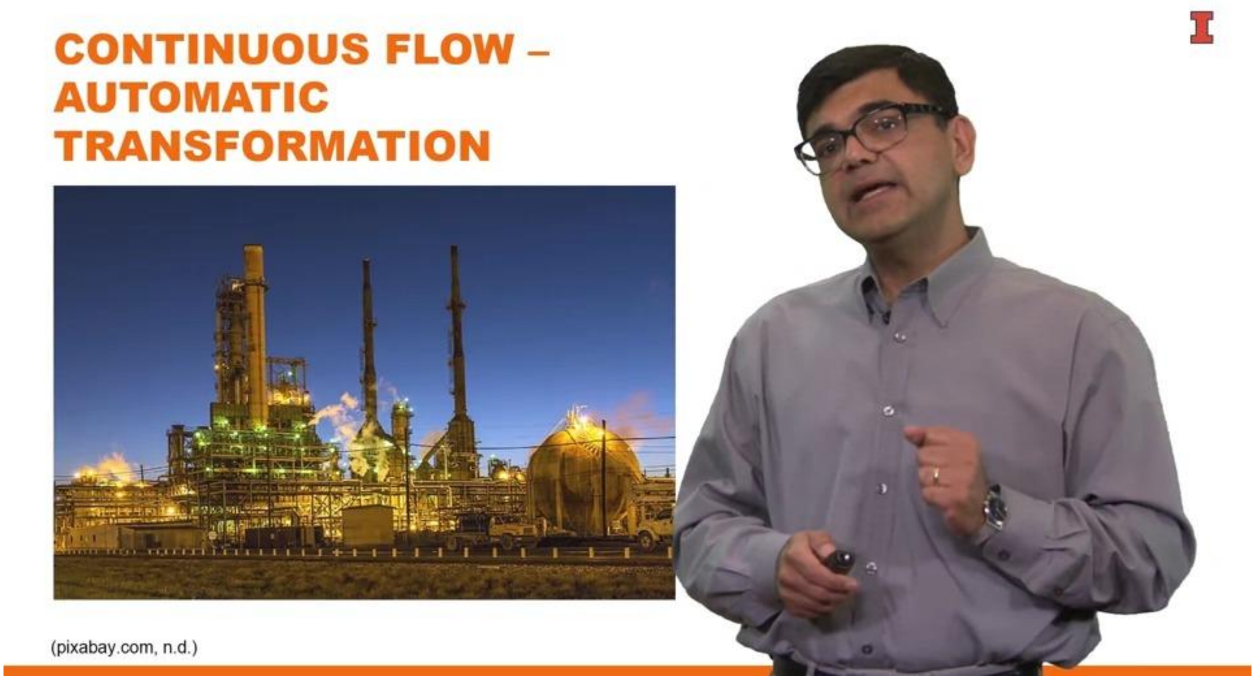
Next one, this is what we learned earlier as being the jumbled flow. You're looking at, here, six different departments, four different products, and the four different products, the yellow, the blue, the green, and the red have a different sequence in which they go through these six different departments in order to get into a finished product. The circles here represent raw materials, these represent the start of the job, and the squares represent the finished product, the finished service, or the finished goods that are being delivered to customers. Here you see it's jumbled flows, this, again, it could be a product that's being built, the product that's being assembled, that's being manufactured, or it could be, as we saw in that earlier example, patients going through different departments in different types of patients requiring different sequences, and some of them may even skip some departments if that is what is needed for their particular treatment. This could be a service or a manufactured good.

BATCH – SOMEWHAT STANDARDIZED JOB SHOP OR A SOMEWHAT FLEXIBLE ASSEMBLY LINE

Left: (Kabel, 2005) Right: (commons.wikimedia.org/Emil76, 2008)

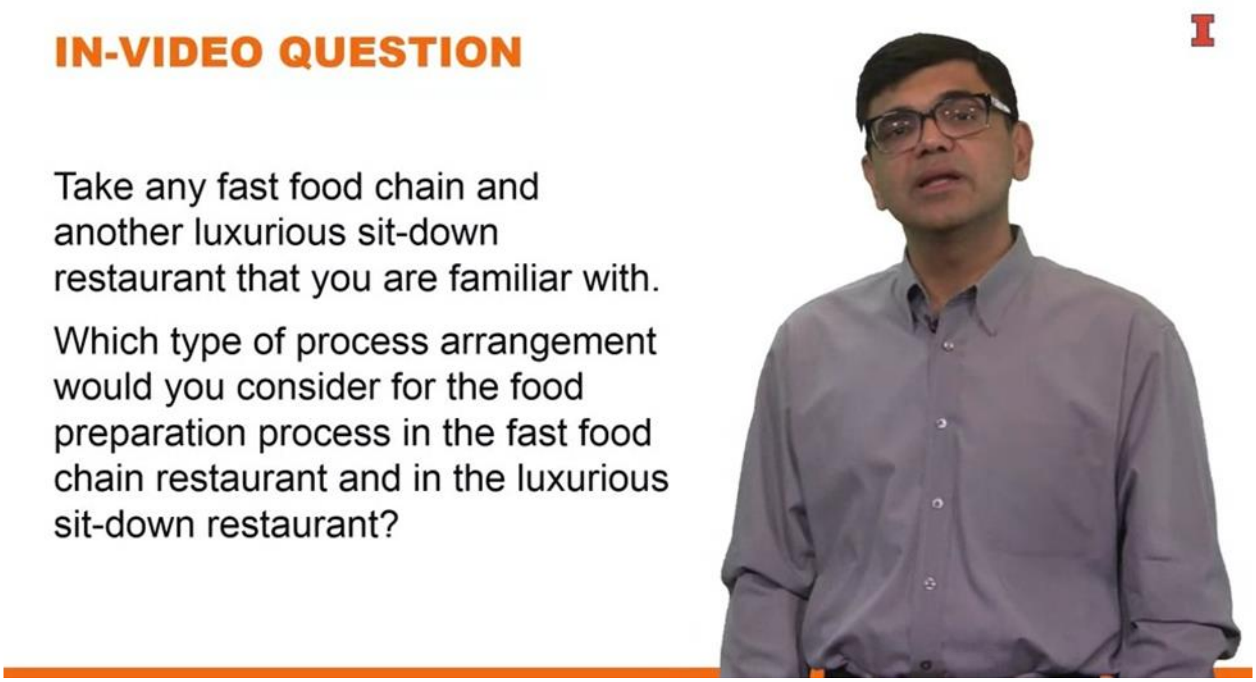
Next is the intermediate one, the batch one. The best way to describe this would be, well, it's neither a job shop and nor is it an assembly line. It's neither completely jumbled, nor is it completely linear, it's somewhere in the middle. It's a job shop that makes a single type of product at any point in time. Here you have an example of a cheese making factory. If you think of cheese making, they make it in batches. They make a certain type of cheese. They may make it from a job shop kind of environment and while they're making that they don't work on anything else. They get that done, and then they move on to the other type of product. Now, you can take a job shop and convert that into a batch kind of environment or you can think of a linear arrangement and convert that into a batch type of environment. What do we mean by that? You can have an assembly line that's making different types of products but let's say you don't have enough volume to say that we're going to dedicate this assembly line to this particular product, then you might say, well, we'll run this assembly line for a particular kind of product for a few days and then there's going to be a long changeover and then we're going to run something else. If you think of, let's say, different types of pharmaceuticals that are being made on an assembly line, they might be being made in batches. You don't have enough volume of a particular kind, you run a certain type of a pharmaceutical, a certain type of medication on it, and then you pause, you clean, there's going to be a thorough clean up, a thorough scrubbing off the assembly line before you can move on to the next kind of drug or medication that you're making on the assembly line. That's going to be a batch kind of a process for you. It's in the middle of a linear versus a job shop.

Next, we come to what we may be most familiar with and that is this division of cars moving down in assembly line. Or when you're talking about computers being assembled, people sitting next to each other and passing it on after doing whatever little task that they're doing. It's people who are doing a little part off the whole task and then it's being moved to the next task. This could be just looking at those two examples. In the case of a car, it's a machine paced assembly line. In the case of an assembly of a computer, it might be a human paced assembly line. I do my job in terms of whatever little task I'm supposed to do, whatever little part I'm supposed to put in for the assembly of this computer and pass it on to the next person. I physically pass it on and they pass it on to the next person and so on and so forth. That might be the way in which these things get accomplished through a manually paced assembly line or a machine paced assembly line. In the case of cards, it's a machine paced assembly line. Now, as you're thinking about these different types of configurations, you can think about the car being made from a different type of a process configuration as well. It could be made from a job shop kind of configuration. It's not that you are always going to make a certain product from a certain type of process configuration, there might be contexts in which you would use one or the other. That's what we're going to talk about in this lesson. What are the advantages and disadvantages? What are the implications of choosing one process type over another?



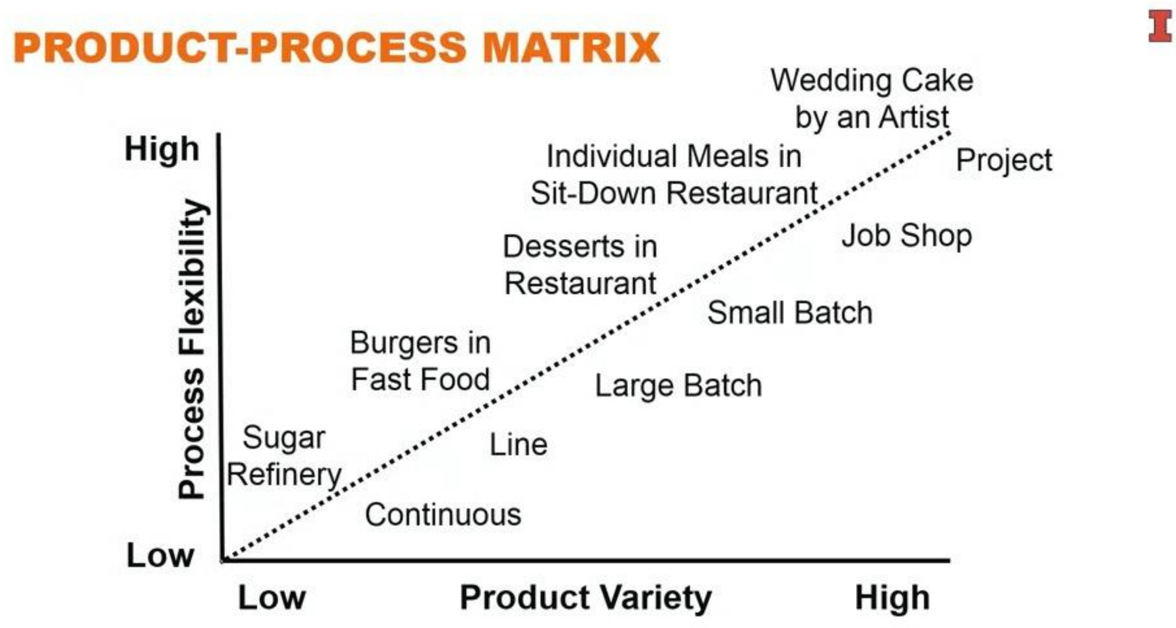
Finally, let's look at this extreme of the spectrum of process configurations. Here we're looking at a process that is generally called process industries. We call it process industries, because it's a continuous process. The products that get made in these kinds of industries are petroleum, for example. You have fertilizers that get made in plants. What is a characteristic of this type of process? It's very highly automated. You start the petroleum plant and it's a refinery that's making product from crude. You rarely stop it. You stop it maybe once in a year to do some maintenance and it's a huge deal to have to stop it and then to restart it again. That's what we call the continuous flow. A lot of p times it's called process industries when you're talking about these types of process types. Process industries have a continuous flow type of process.

Lesson 2-1.4: In-Video-Question: Selecting Process Configuration



Right, now what I'd like you to do is take these concepts and apply them on your own. So, take the idea of a fast food restaurant that you might be familiar with. And a sit-down restaurant that you're familiar with. Now, you may have seen this context being used when you're talking about order winners and qualifiers. And you're talking about, what do customers care about. But now we're talking about what kind of process arrangement might be needed for these two types of restaurants. One is a fast food restaurant and one is a luxurious sit-down restaurant. So take a minute and think about the different process types that might be needed. And then think of the implications that it has for the kind of people that you would hire for. Whether you would be able to get some of the production being done outside of that restaurant. So take a minute and think about that.

All right, so the obvious thing that you might have thought about for a fast food restaurant is going to be some kind of assembly line, right? You're going to assemble the burgers in an assembly line, or you are going to take something that has been sent to you ready from the main supplier, and then you're just going to do the finishing touches for it. So, the original product was produced in an assembly line, it was sent to to the store, to the restaurant, and it was just zapped in the microwave or heated up in some way and and being delivered to the customer. On the other hand, when you're thinking of a luxurious sit-down restaurant, you're thinking of the chef, the sushi chef and different types of departments within that big kitchen for that luxurious sit-down restaurant that's taking care of different aspects of the production of the food for you. So here you see the contrast between these two types of process arrangements.



Now, let's place these on this diagonal that we looked at earlier. And if you think about it, you're talking about the fast food restaurant having a line process. You're talking about the individual means coming from a job shop. And just for completion sake, if you were thinking about the other types of processes, desserts in a restaurant might be made in small batches, they might be ready. You're making them and stocking them, you're not waiting for the customer's order for them. On one extreme, you have wedding cakes that are being made by an artist. So they are a unique product that's being put together by a cake artist. And finally on the bottom extreme, you're looking at a sugar refineries. It's making a food product that's coming out of a continuous process. So hopefully what you've seen here is the spectrum that you can have a different process types for the same industry. So here we're talking about the food industry and different types of process types based on what the customers desire.

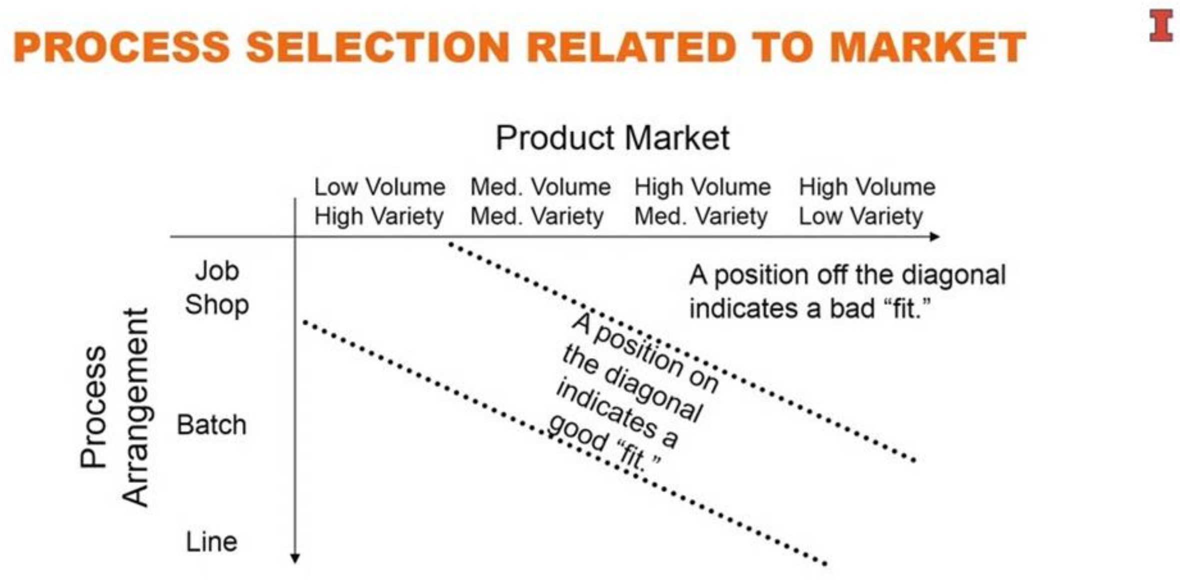
Lesson 2-1.5: Implications of Process Configurations

PROCESS ARRANGEMENTS

Features	Project	Job Shop	Batch Process	Assembly Line	Continuous Flow
Flow	None	Jumbled	In-between	Connected	Continuous
Flexibility	Very High	High	Moderate	Low	Very Low
Product Types	Unique	Many	Several	Few	One
Expansion	Gradual	Gradual	Gradual or In Chunks	In Chunks	In Chunks
Human Skills	Broad or Specialized	Broad	Broad	Specialized	Specialized
Volume	One Unit	Low	Moderate	High	Very High

We've looked at these different types of processes. So going from project to continuous flow, let's take a look at the implications of each one of these in terms of what we care about from an operations strategy perspective. On the left most column, you have the features of each of these different process types. The first one is flow. Now in a project type, so if you're thinking about making a airplane that is being made at one spot instead of on an assembly line, there's pretty much no flow. Now if you think of a wedding that's being planned, there's no flow of activities. It's basically being done at one spot. You could be thinking of the construction of a bridge, a building. You could be thinking of an installation of a software for a particular company. Let's say you're installing ERP software for a particular company. You have to go to the site of the customer and install it. It's a project that's being done at the customer site. There's pretty much no flow. Moving through the different process types. Job shop, there's going to be jumbled flow. We saw that in some of the previous slides. On the other extreme you're going to have the assembly line and the continuous flow. The assembly line is going to have some connected flow. There may be some passing of things that is happening between different tasks, between different activities. Whereas in a continuous flow, it's going to be hard for you to even identify a discrete unit of that particular product. It's petroleum that's flowing through the pipes. It's fertilizer that's flowing through the pipes and going to the next step and getting done. In the end coming out in terms of bags or tankers that are being filled up. Second aspect, flexibility. We talked about this a little bit earlier. In terms of projects, you're going to have very high flexibility. You're going to be able to arrange that wedding for that particular customer based on different idiosyncrasies that they might have about how they want certain things to be done. That's going to be easier for you in a project. On an assembly line, the way it's going to be designed is it's not going to be designed to be very flexible. I'm jumping from the project all the way to the other end of the spectrum, the assembly line to make the contrast between these two. In an assembly line, you are going to set it up for making, for example, a certain type of car. In order to make a changeover from that one type of car to another, it's going to be difficult. It's a different matter that there are companies that are working on that, on trying to get the advantages of the assembly line and have flexibility at the same time. That's kind of pushing the boundaries. But in general, if you were to think of an assembly line, it's going to have low flexibility. Product types. Going with flexibility in case of a project, it's going to be a unique product. If you're installing ERP for a customer, you are taking care of their unique needs when you're installing that particular software for that customer. It's going to be very unique for that customer. On the other hand, on the other end of the spectrum, if you look at the assembly line, there are going to be few product types that are going to be made from that particular assembly line. The reason you have it in the assembly line is because these are products that require very similar activities being done in exactly the same sequence and in very similar ways. In a continuous flow kind of process, the product type is going to be one product that's going to be made from one process that has been set up for that particular product. Next, expansion. If you're talking about the project type of process configuration. Again, think of a wedding that is being planned or an ERP installation or taking care or developing a prototype for an airplane. The expansion of the activity is going to be gradual in the sense that you can add more resources little by little. You can add one more person. If there's more work that needs to be done for that wedding or that software implementation. You can bring in an extra expert when you need for developing that aircraft that you're trying to develop. On the other hand, when you think of the assembly line, the other extreme of this, expansion for an assembly line usually happens in chunks. If an assembly line is setup to make 10,000 parts a day. Going from 10,000 parts a day to 11,000 parts a day is going to be tough. You're not going to be able to add a little bit of capacity. The way that assembly line is going to be built, you might be able to go from 10,000 to maybe 15,000 or 20,000. It's going to be in chunks. Similarly, if you think about a continuous flow process, an oil refinery, or a company that's making fertilizer. The expansion has to be done in chunks. It's not going to be the addition of that little two percent extra that you want to get out of it. Let's take a look at the human skills that are needed for each of these different process types. In a project, you might have people who know different aspects of the project. You might need people with broad human skills, with broad skills that are dealing with what the project is doing. Or you might have very specialized skills and you might just bring them in for that particular activity and for their particular expertise that is going to have an impact on that activity. If you're talking about a prototype for a plane, you bring in an expert on the equipment that is being used for navigation. Then they do their job based on their expertise and they don't really pay attention to any of the other aspects of building the aircraft or the prototype for the aircraft. That would be a very specialized kind of skill. Or you might need some broad project management skills for the project manager who is managing the project, who has some sense of all the activities that are needed. Once you move on beyond that, again, it becomes a set of competencies going from broad to specialized. In a job shop, you'll need people who have broader skills. That's the advantage of a job shop that people are able to go through different departments and get things done. They are able to fill in when there are different needs for the different departments in a process, different activities in a process. On the other hand, if you're talking about an assembly line, you might think of a person who is specialized in doing that little task. If you are familiar with, for example, the movie Modern Times in which there was Charlie Chaplin. You're talking about Charlie Chaplin working on a very specific part of that assembly line. He's an expert in doing only that part and doesn't even know anything about what the next task is or the previous task is doing. That would be the extreme of specialization in terms of an assembly line configuration. You have very specialized skills. They may be very skills that do not need too much training when you're talking, when assembly line. For a continuous flow, you might have specialized skills that we specialize in a different sense. You might need experts who know how to assess if there's something that's going wrong with that petroleum refinery. You need specialized skills, but specialized from the point of view of being very educated in a particular area. It's less physical, more kind of intellectual skills that are being needed for a continuous flow kind of environment. Finally, volume, this should be an easy one to look at implications because the project is built. A project type of process configuration is put in place for making one unit at a time versus when you're talking about a assembly line or a continuous flow. These are meant to be high volume. These are meant to be making many, many products a minute, many, many products an hour, so many, many units of a product an hour. I should say not many products. In fact, they're quite the other extreme, they're making one type of product in very high volumes. An assembly line or a continuous flow is making one type of product in very high volumes.

Lesson 2-1.6: Process-Product Matching



Now let's turn our attention to what all this means in terms of what types of customers are being served. So if you look at a job shop, it's catering to customers that care about high variety and are not looking for too much volume. And on the other extreme, if you're looking at a line, you're looking at customers that do not care too much about variety but one high volume. So here we can build a diagnal that says if you are on this diagnal it's a good fit between what the product market is looking for and what the process arrangement is. And typically we think of a position of the diagonal as a a bad fit. Now what you should think about is that the conventional way of thinking that going off the diagnosed as a bad fit. You can take a different perspective of of this idea of going off the diagonal and say that what if we could use a line environment and at the same time produce high variety at a high volume and be able to give the customer what they want. So we're moving away from the diagonal in the sense of well, it should have been a job shop from the point of view of high variety. But what if we could get both of those advantages. Take that compromise away, take that trade off a way based on process configurations. So I want I want you to think about is is although this is a conventional way of thinking, you might want to be thinking about pushing the envelope and trying to go to that other side of making that compromise and saying why should we have that compromise? We might be able to get some kind of a cumulative capability in which we can we are able to offer the customer both these aspects, they can get high variety at the same time they can get the advantages of high volume through lower costs.

PROCESS ARRANGEMENT COMBINATIONS

Exclusive process:

Hospital specializing in one procedure, e.g., Shouldice

(shouldice.com, n.d.)

So just to give you some practical examples, some examples of processes out there where they had these different kinds of combinations. So the first example that you're seeing over here is of a specialized hospital. So this hospital is following the conventional diagonal that you saw earlier which is it saying that we're going to focus on high volume of a particular kind of procedure. So this is shouldice hospital that deals with a hernia repairs. So it deals with one kind of ailment and it focuses on a certain type of hernia repairs. So it's even more specialized than looking at different types of hernia repairs as focuses on one. The idea being that it gets the same types of patients. It has the same types of of procedures that are needed, generally speaking for all its patients and it's able to do it very efficiently. Customers are happy, they're in and out very quickly, patients are happy they're in and out quickly and they are able to to achieve all of this at a low cost. So that's an example of having a process that is built exactly for what the requirements of the customers are.

PROCESS ARRANGEMENT COMBINATIONS

Exclusive process:
- Hospital specializing in one procedure, e.g., Shouldice

Multiple process arrangements:
- Bakery making breads, pastries, and sandwiches, e.g., Au Bon Pain

(aubonpain.com, n.d.)

You can think of businesses that require different process arrangements under the same roof. So the best example for you to think about in my opinion would be a bakery. A bakery that makes breads but also makes pastries and also gives sandwiches to customers. So when you think of that kind of a bakery, and you think of the process arrangements that they might have if they are making their own bread and it's it's bread that is produced that is demanded at high volumes. They might be making it on an assembly line, on a line process. May not be an assembly line but a line process where it's dope getting in from one end of the process at the start of the process and getting converted into bread. And getting packed into polyethylene bags that are going to customers. So it's almost like a continuous process that we're talking about for making breads. And then you're talking about pastries that might be more of a job shop process or a batch process or a combination of those two. You might make the base for the same types of pastries from a more of a batch process. And then maybe if there are pastries that each one of them is being worked on, that might be more of a job shop process. Similarly with cakes, those are going to be from a job shop process, because you have to customize them based on the message that a customer might want on on the cake that their purchasing from you. Sandwiches would also be similarly a job shop process. So what you have is under the same roof multiple process arrangements.

PROCESS ARRANGEMENT COMBINATIONS

Exclusive process:
- Hospital specializing in one procedure, e.g., Shouldice

Multiple process arrangements:
- Bakery making breads, pastries, and sandwiches, e.g., Au Bon Pain

Split process:
- Monogrammed shirts, e.g., Polo Ralph Lauren

(polo.com, n.d.)

Now, you can also have this this idea of offering high volume to a customer and at the same time customization by having a split process. So Ralph Lauren shirts, they make their shirts, they stitch their shirts to a basic shirt from a line process from a high volume line process. And then they customize it based on monograms and the type of polo monogram that you want on it. And and if you want your initials on it, those parts get customized right at the end. So it's a combination of a line and a job shop process.

PROCESS ARRANGEMENT COMBINATIONS

Exclusive process:
- Hospital specializing in one procedure, e.g., Shouldice

Multiple process arrangements:
- Bakery making breads, pastries, and sandwiches, e.g., Au Bon Pain

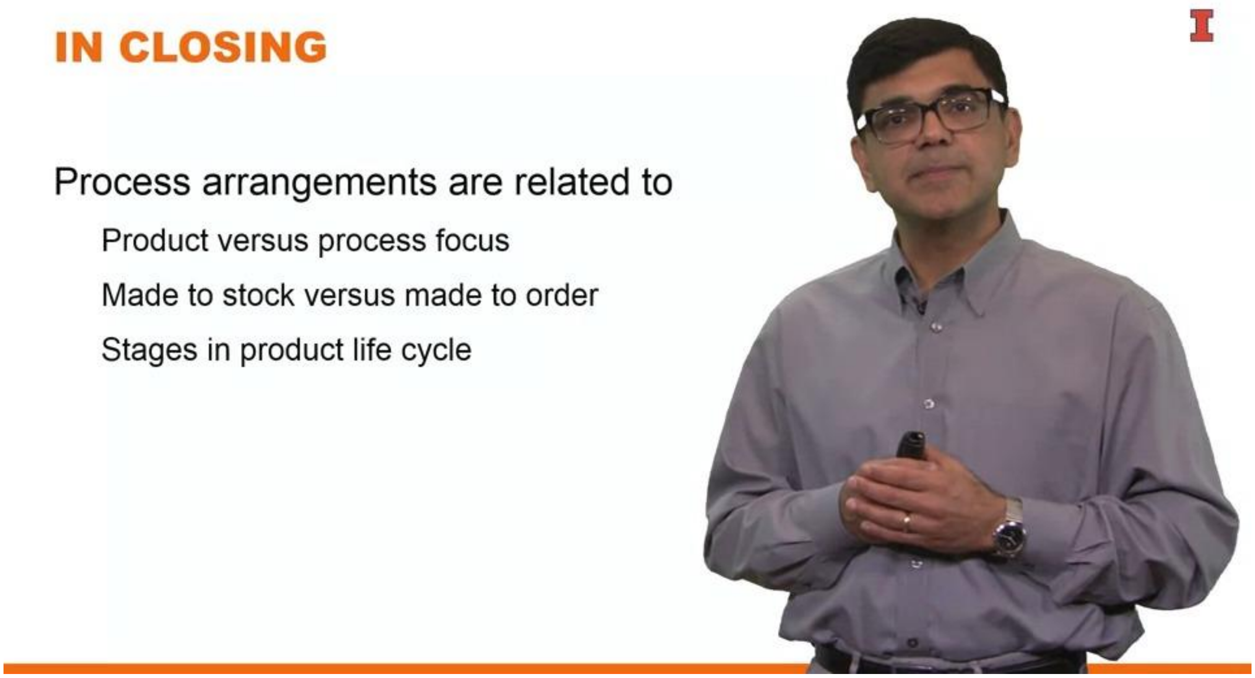
Split process:
- Monogrammed shirts, e.g., Polo Ralph Lauren

Distinct processes:
- Customized and standard motorcycles, e.g., Harley Davidson

(harley-davidson.com, n.d.)

Another example of a company that uses two different types of processes for the same product. So this is Harley Davidson motorcycles. What Harley Davidson does is they make motorcycles that are sold to you in the store where you can go and pick up a motorcycle, but they also make customized motorcycles. The customized motorcycles are made using a job shop kind of an arrangement. So it's one person who is dedicated to making a particular motorcycle and takes that particular motorcycle through the different departments to get the motorcycle completed and then puts his or her signature on it as being assembled by that particular individual. So that's your customized motorcycle from Harley Davidson and under the same roof they have the standard motorcycles that are made that are being assembled on an assembly line. So that's where you have the standard motorcycles that you see in the showroom. So what you see here is examples of using different types of processes based on what kind of competency the company is trying to achieve, which is based on what they are trying to offer to customers in terms of what the customers might desire in terms of how can you win their orders based on what they need.

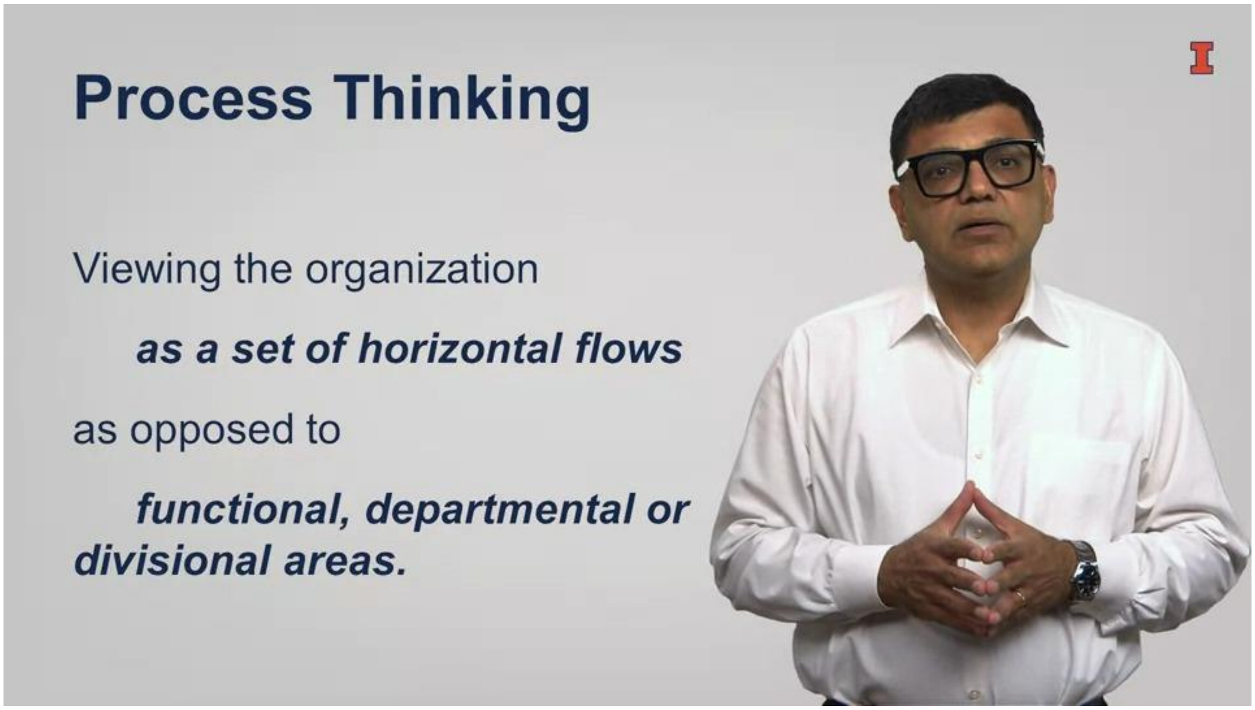
Lesson 2-1.7: Selecting a Process Configuration



So in closing, you can think of process arrangements from three main perspectives. One is if you're thinking about a job shop kind of environment, it's focusing more on the processes. It's focusing more on the activities within the process that are being arranged. So it's by arrangement of the activities, by arrangement of the processes. If you're thinking about a a line kind of arrangement or a continuous kind of arrangement that is focusing more on the product. You're saying each product is going to be made on a different process arrangement and so that's more of a product focus. Second, you could be thinking from the perspective of do we make products that are customized for customers or so they are made to order? The made to order products are typically going to come from more of a job shop kind of environment. Or maybe a small batch kind of environment, because you need to customize product for whatever customer needs are. On the other hand, if it's a standard product and you can make it to stock, then you're going to use more of a linear kind of a process. So you're going to go more towards that end of the spectrum. It's going to be more linear. If you think about stages in the life cycle of products, you might start off with a new product not having enough volume to be able to justify a dedicated line for producing that product, right? So, initially you might start off with with a job shop kind of environment, move towards a line when you get into high volume. And then once the product matures in its life cycle, and it's demand starts to decline in that particular version, you might relegate it back to a job or a batch kind of environment. So that's how you can think about different process types. Other than thinking about it from what does the customer want, you can think about it in these kinds of dichotomies as well.

Lesson 2-2: Process Mapping

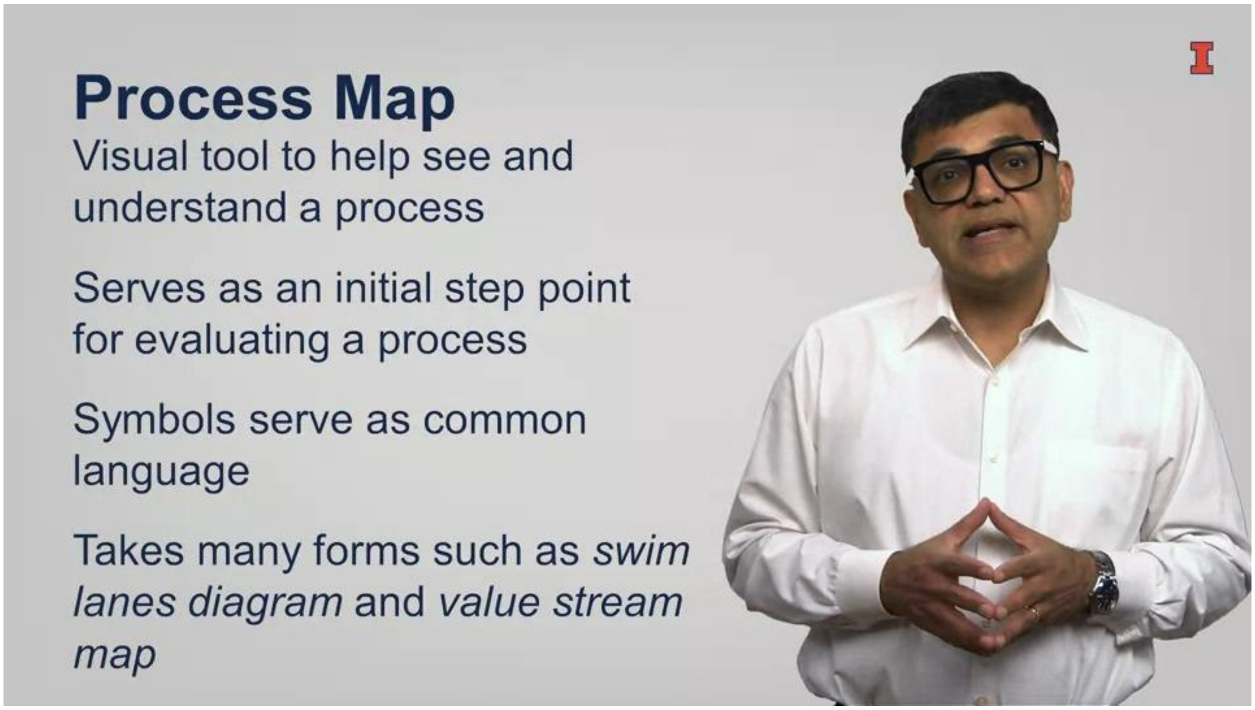
Lesson 2-2.1: Process Mapping



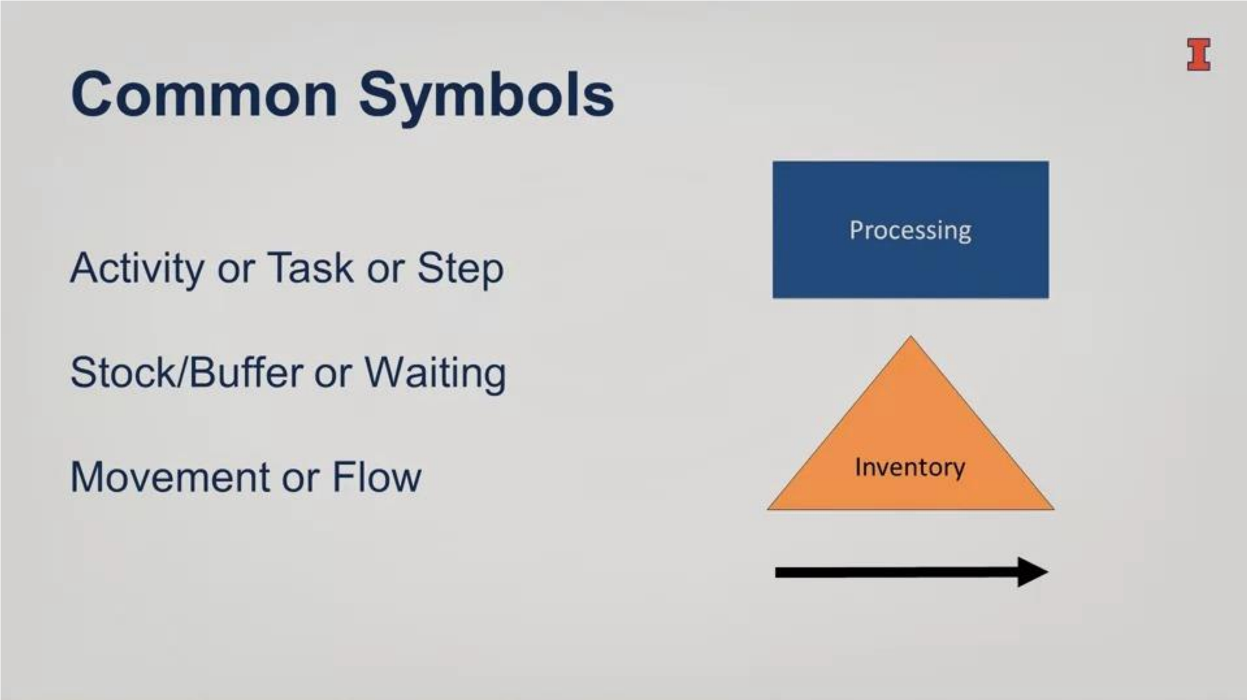
What is process thinking? Process thinking is viewing and planning organizations in the way that work is done. The way workflows horizontally from one activity to another, from one department or function to another. In this way, process thinking is different from focusing on the vertical departments and functions like marketing, analytics, purchasing, finance, HR management, operations, accounting, etc. The horizontal processes cut across the verticals in an organization.

Now, take a few examples of processes here at Gies. Admitting students requires steps or activities from providing information about admission requirements, accepting applications, assessing the applications, and then sending out the decision letters. Scheduling classrooms requires steps of collecting information about room capacities, getting requirements from different departments, allocating the rooms and the times. Applying to the business accelerator program iVenture requires similar to Gies admissions, inviting applications, getting expert entrepreneurs to assess the applications, and then providing decisions.

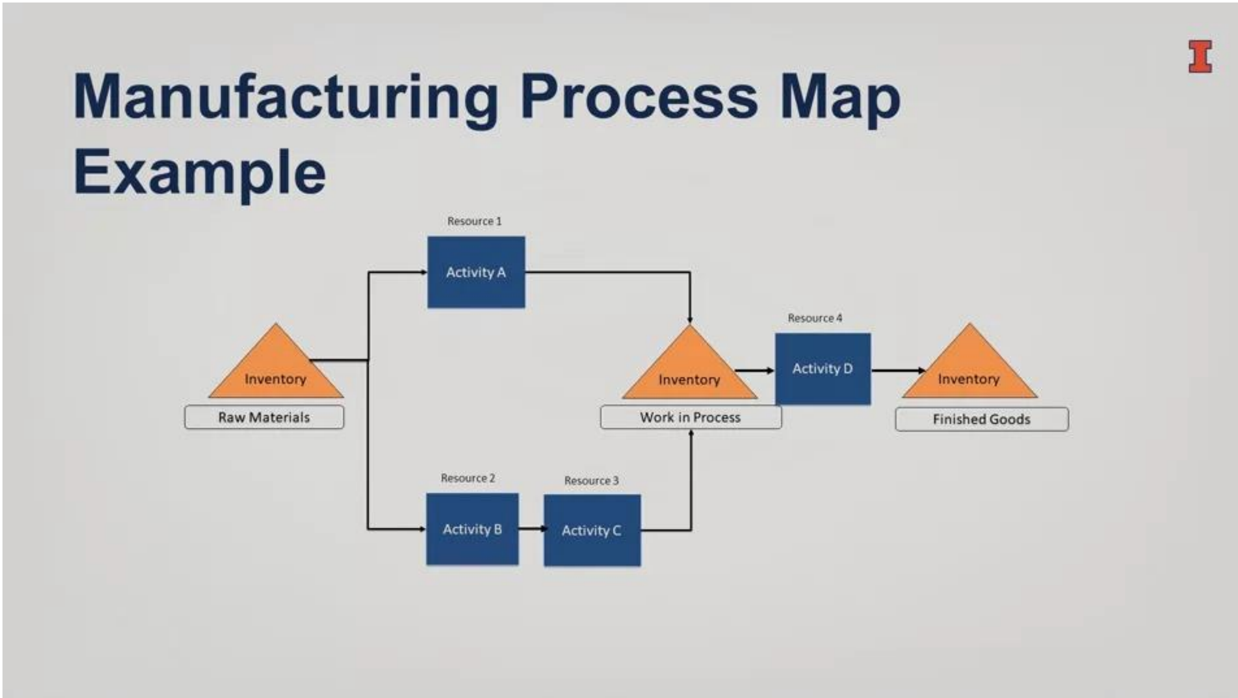
In any business for that matter, any organization, there are processes for doing work. Hiring employees requires creating job descriptions involving HR, and the department which is looking to hire that person. It requires screening, interviews, offers, negotiations, contracts, onboarding. Manufacturers that make products such as cars or medical equipment may need to recall products due to defects and have a process that involves regulators such as the National Highway Traffic Safety Administration or the FDA, Food and Drug Administration, and internal departments including Legal and R&D. Similarly, preparing financial reports such as quarterly statements, calls for steps or activities for collecting the information, verifying, finalizing the reports that can be used either for reporting or for analysis. Overall, any work requires a set of activities, a process, and processes are all around us.



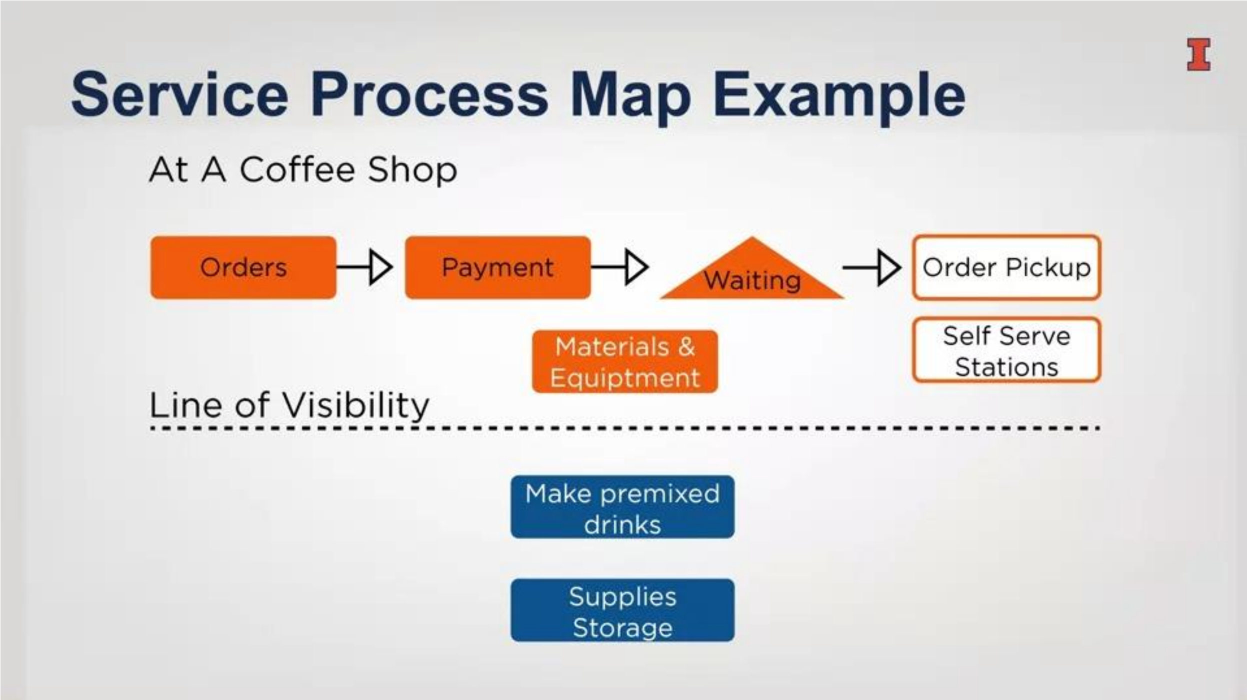
A process map is a schematic, it's a visual, it's a drawing, a graphic, a diagram, or a chart. It depicts the activities in a process or the steps in a process. Once you see how you can do it, it can serve as a starting point of discussion. Does someone else see differently? Should the process be run differently? Are there improvements that we can make to the process? There are many templates for process maps. Organizations adopt these templates so that there is a common language. Some popular examples of such templates are swim lane diagrams, value stream maps. Now such templates may have different focuses. The swim lane focuses, for example, on showing hand-offs, and the value stream focuses on flow of the product and on value added at each step. Another type of process map that is popular are flowcharts that are used for programming purposes.



Although there are many templates for process maps, some symbols are common. Activities are usually depicted in rectangular boxes, stocks of inventory, or people waiting in line are depicted as triangles. Sometimes the triangle is upright, sometimes it's reversed, and arrows typically depict the direction of flow of the product or customers if you're talking about a service process.



Here is an example, a made-up process for manufacturing goods, where you can see the triangles are showing stocks or inventories at three stages. Now, these inventories could be raw materials, work in process, and finished goods. There are four activities at different stages of this process, and it's also showing you the product flow. Now here we see that there are two parallel sets of activities. One has only activity A, and one path has activity B, and activity C. This shows that B and C are being done in parallel while A is being done, and then activity D combines what comes from the two paths.

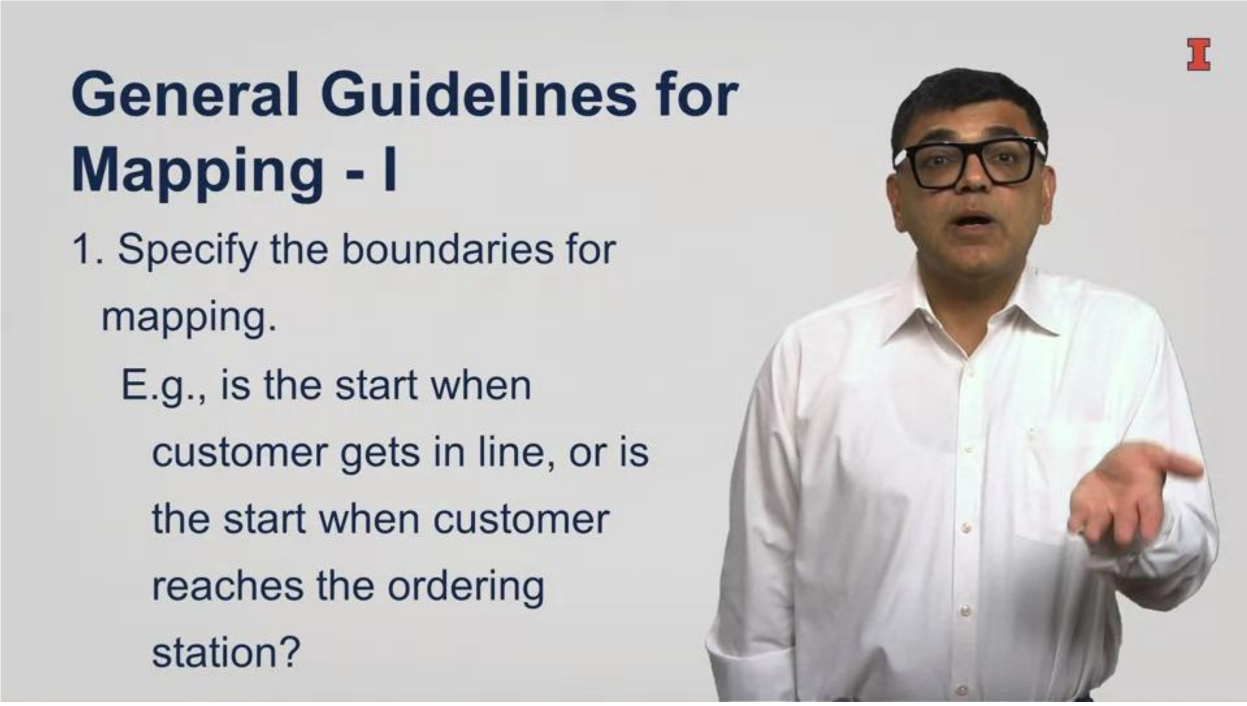


Here is an example of a service process. This shows the steps and also it separates the customer facing steps and the backroom steps in a coffee shop.

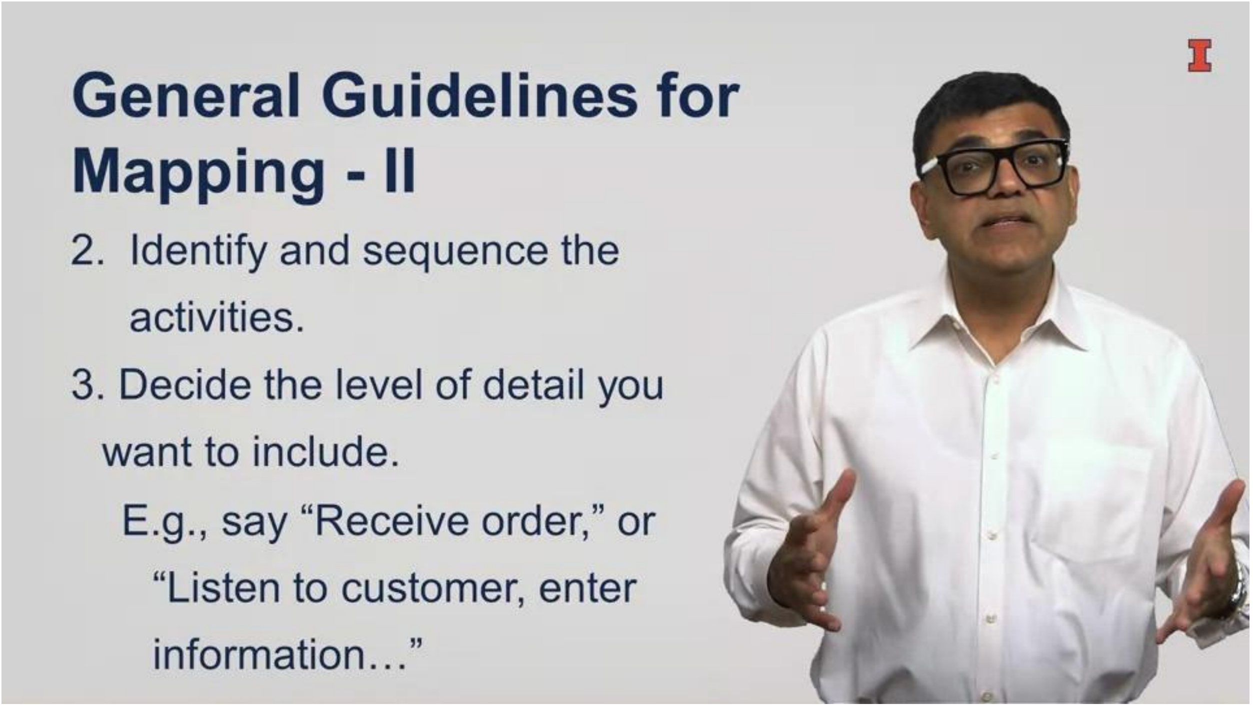
Let's try our hand at mapping a process that we can all relate to, a drive through window at a fast food restaurant. Now, visualize the activities from the perspective of the restaurant. We'll start from when a customer drives up to the window to when the customer leaves with the order.

First, the customer enters the line, the queue, then reaches the kiosk, which has the menu and the microphone and speaker. The employee greets the customer, employee receives the order, confirms the order, and the amount, asks that you drive up to the pickup window. The food and drinks are being prepared in the background while another employee takes your payment. Next, you wait a minute or two, and then the employee gives you your food and drinks, and then the customer leaves. Now, in a service process, the line of visibility depicts the customer facing and the backroom parts of the process.

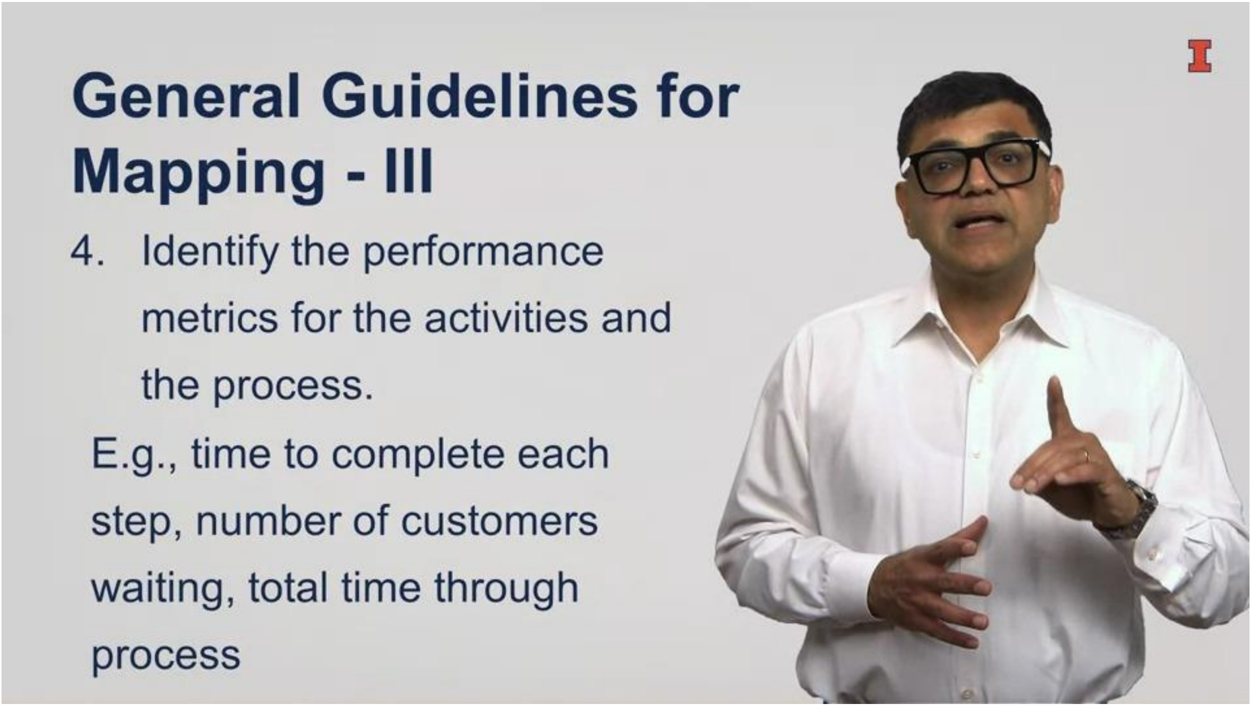
Drawing this process map has hopefully given you an idea of how to draw such a map. It must have also raised some questions in your mind, no doubt. How detailed should this be? Can I add data about times? How do I handle it when there are different types of customers who want different things? What happens when there are errors in the process, when somebody has given me the wrong order and I have to go back? These are all good questions that a process map is meant to bring out, it's meant to evoke those questions. A process map is a good starting point for analyzing a process.



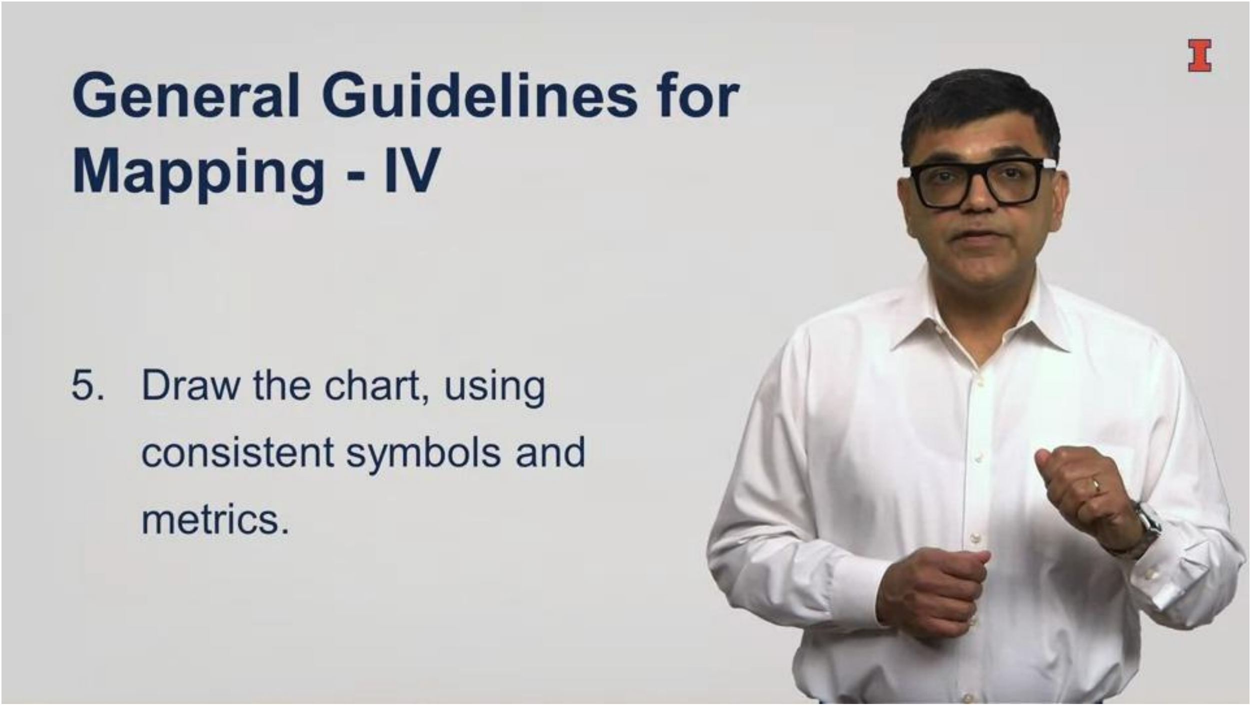
Some things to think about before you map a process. First, decide where does the process start and end? Be specific in terms of whether it is starting when the customer enters the store, or gets in line, or when the customer reaches a register. Now you can decide based on your purpose of that mapping exercise. For a product, it could be from when a customer placed an order, or it could be starting from when the production process started.



Second, identify and sequence the activities, depicting the parallel ones in a separate sequence. Third, decide how detailed you want the map to be. You can combine or breakdown activities based on how granular you want your process analysis to be.



Fourth, plan for the process metrics you want to measure.



Fifth, draw the process map or the chart based on what you have decided for the level of details and the level of the metrics.

Processes, Flow Units, End Points

Process	Flow Unit	Start / End
Order fulfillment	Orders	Order received / Product delivered
Customer service	Complaints	Phone call received / Issue resolved
New product development	Products	Need recognized / Prototype readied
Cash-to-cash cycle	Cash	Expenses incurred / Revenue collected

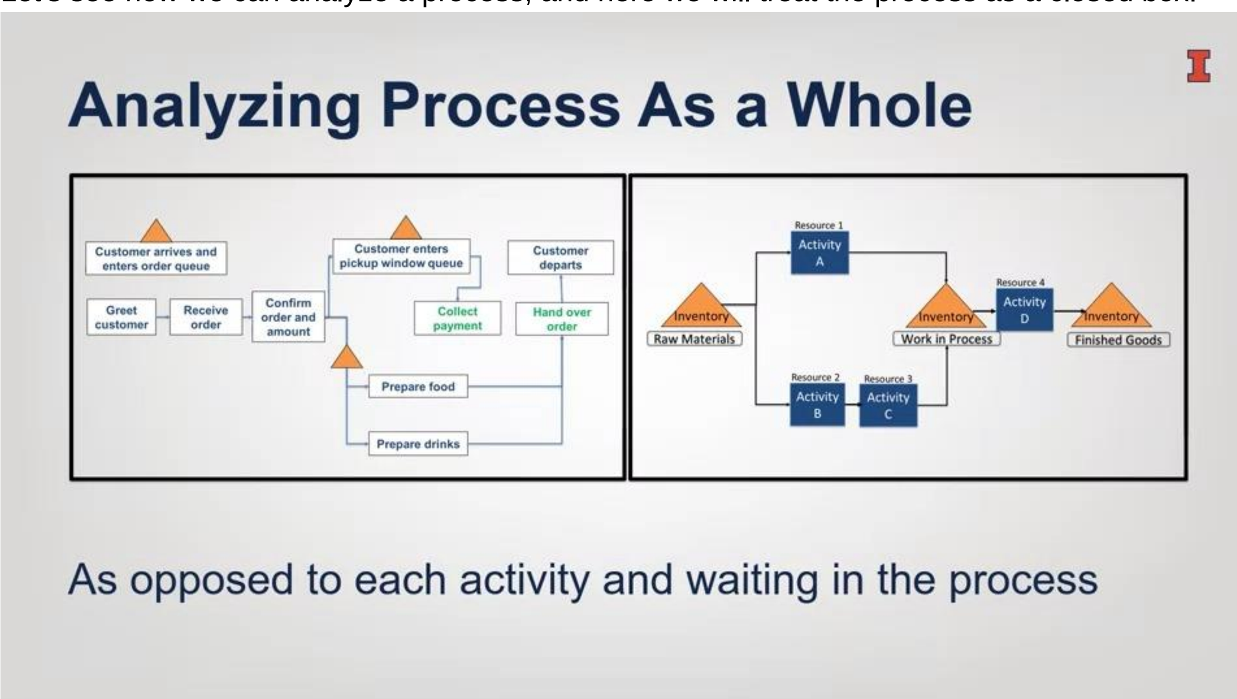
Now here are some examples of processes that also include what is the flow unit? The flow unit is the thing that we are tracking through a process. It's the unit that is flowing from start to end, and the starting and the ending points. First, orders being received and product delivered. Second example, customer complaint received and issue resolved hopefully to the satisfaction of the customer. Third, is a new product development process, starting from the product need being recognized by the customer to a prototype being created by the company. Fourth, it could be cash, that is from expenses to receipt. You spend the money and then you receive the money, you spend the money to make the product and then you received it from the customer.

Now these are examples with different flow units and specific start and endpoints. In closing, processes are everywhere around us and every process can be improved.

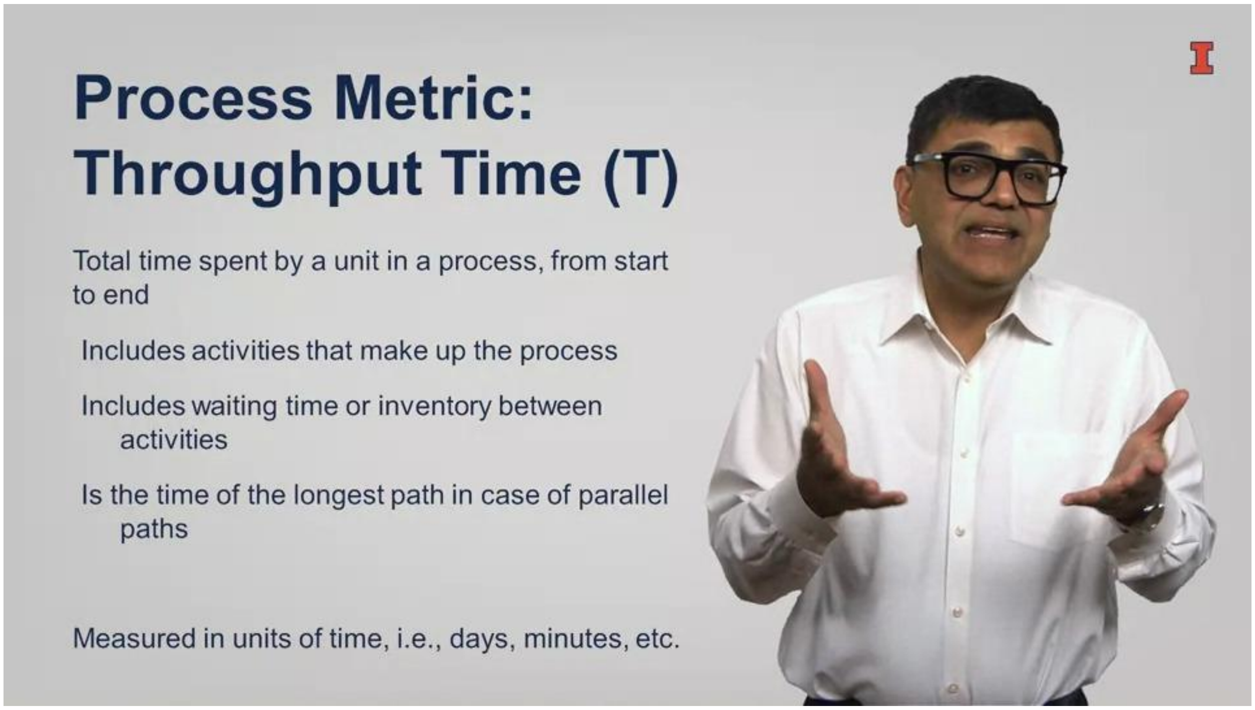
Lesson 2-3: Metrics to Assess Performance

[Lesson 2-3.1: Metrics to Assess Performance]

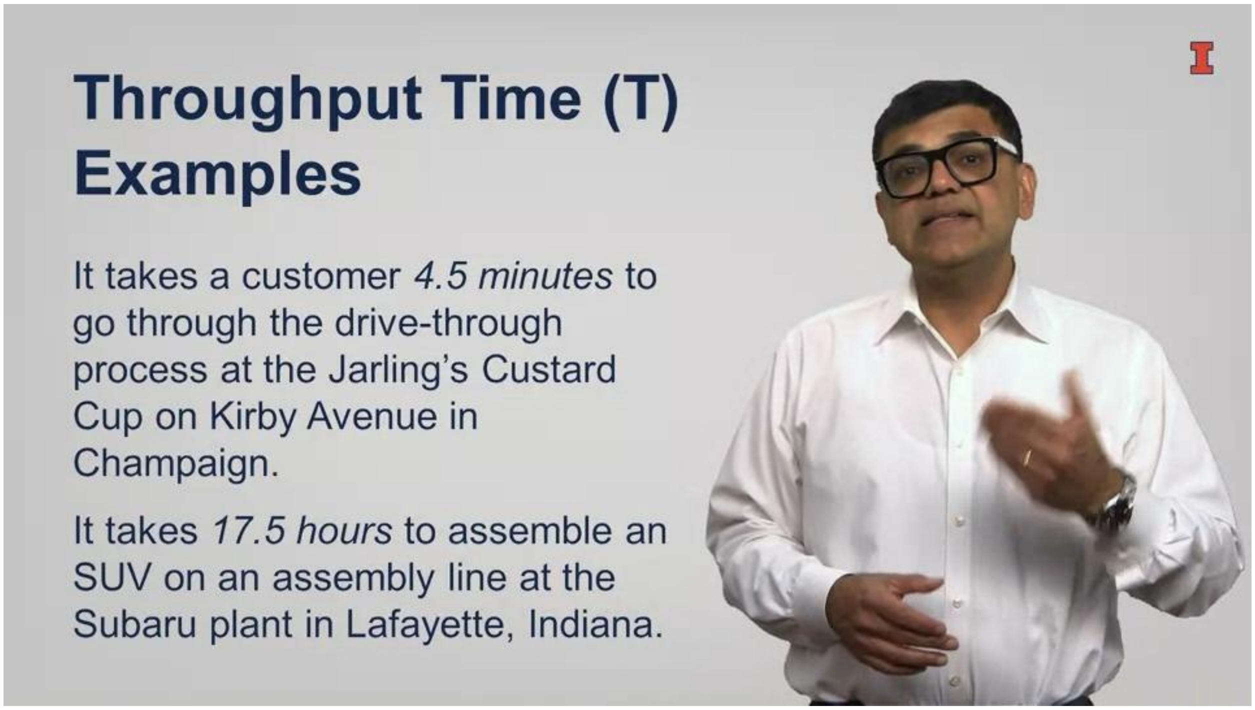
Let's see how we can analyze a process, and here we will treat the process as a closed box.



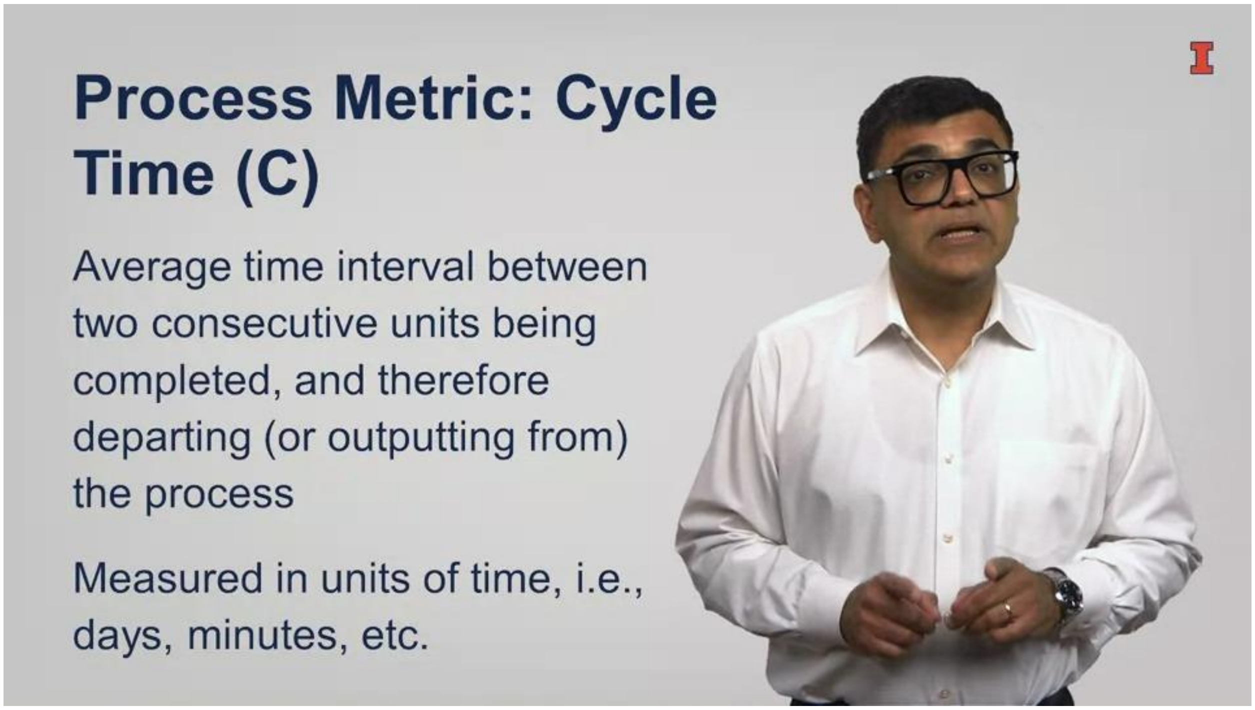
We will analyze the entire process as a whole, and analyzing a process requires using a set of process measurements.



Throughput time is a metric that can best be described as starting your stopwatch when a unit starts in the process and stopping your stopwatch, the unit exits the process. Throughput time does includes when something is happening to the unit. For example, a cookie that is being manufactured or a customer that is placing an order, and it also includes when cookies or customers are waiting between activities. When there are parallel paths like when the top and bottom cookie for a sandwich cookie are being baked while in parallel, the vanilla cream that will be sandwiched as being made. The longer of the two will impact the throughput time. Throughput time is measured in seconds and minutes for short or high-speed processes, and it could be measured in days and even months for longer processes.

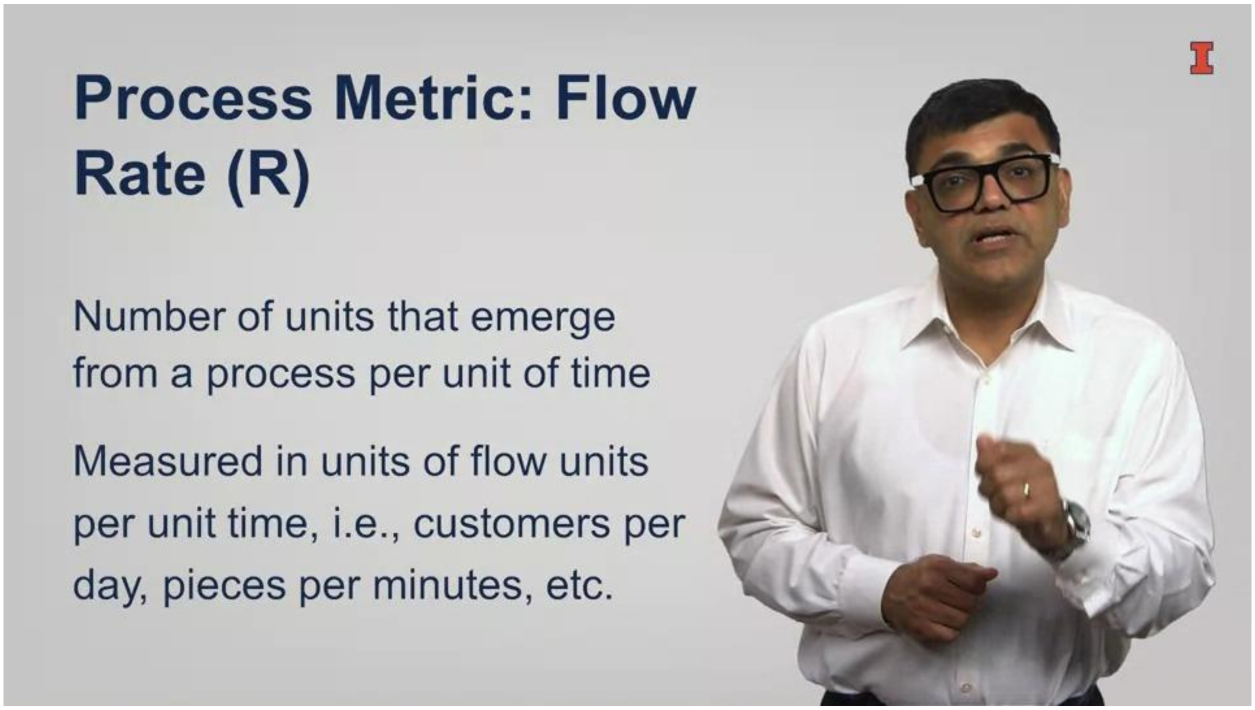


Here are two examples of throughput time, and you can use these to visualize its measurement. Now, let's say you're standing outside the Jarling's Frozen Custard Shop on Kirby Avenue, not far from the Gies College of Business. You can visualize using a stopwatch to measure the start and end time of a car entering the drive-through and the car leaving the drive-through. In this example, that is 4.5 minutes. Similarly, starting the assembly of a Subaru SUV, timing the assembly line from task 1 to when the finished SUV rolled off the assembly line is 17.5 hours.

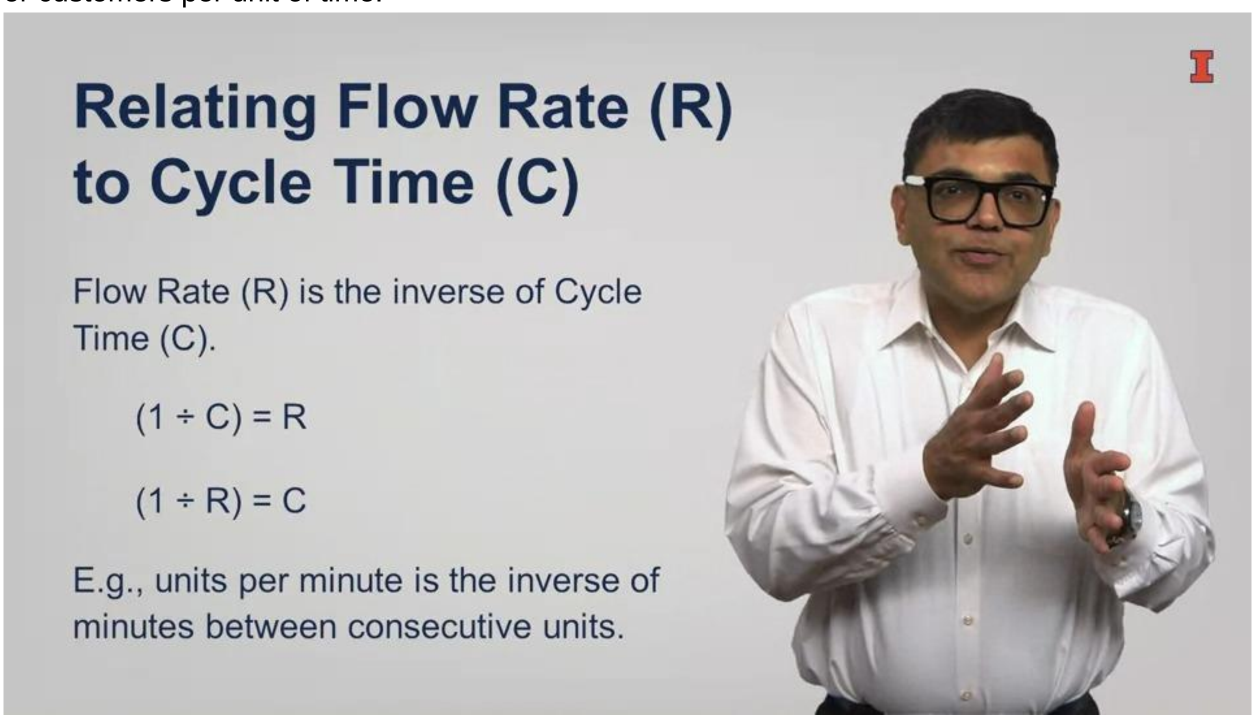


Metric of cycle time can be visualized as standing at the end of the process and using a stopwatch to measure the time between Unit 1 and Unit 2 or Customer 1 and Customer 2 exiting from the process. Now, this is a time interval, so unit of measurement is still days, hours, minutes, or seconds. The definition says average cycle time here because this time is calculated based on one or more units getting through the process together. For example, two cars from two lines at the drive-through or five assembly lines outputting five cars at a time. The metric of cycle time accounts for such multiple units and takes the average time. In fact, most commonly, process metrics are calculated based on averaging. First to allow for multiple units together, and second, to allow for variation. Cycle time of one minute and three minutes will average to two minutes.

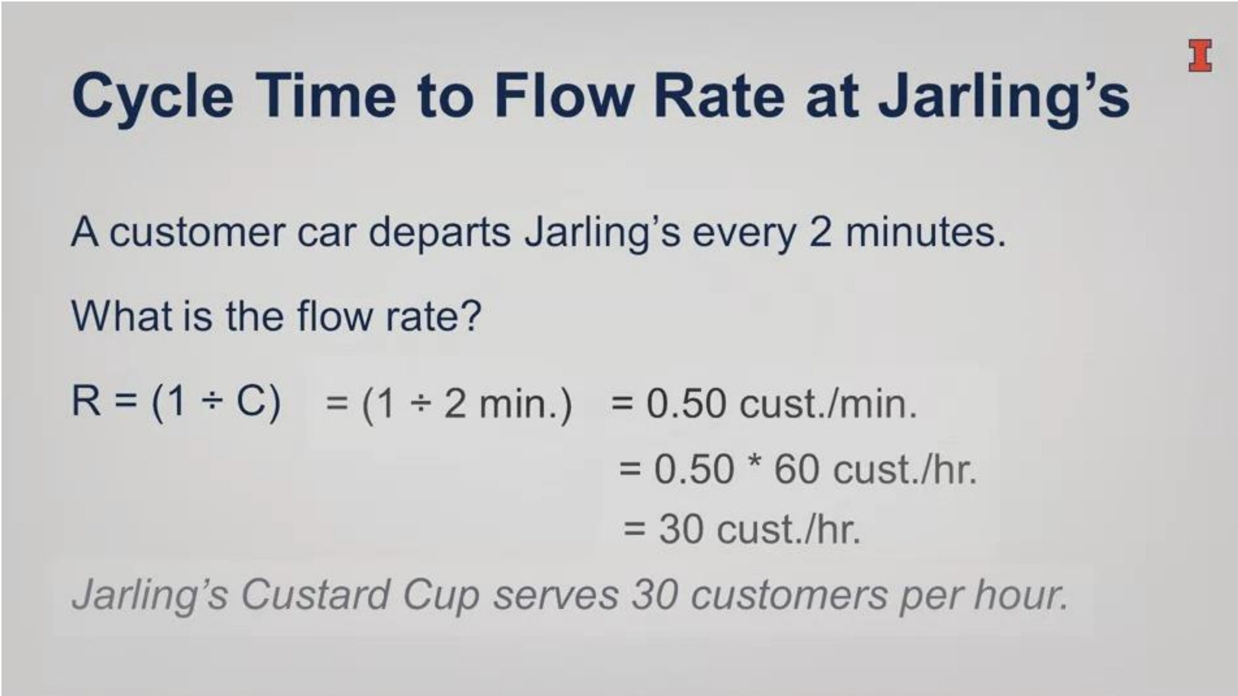
To help clarify the meaning of cycle time, imagine that you assess the time between two cars leaving the drive-through of the ice cream shop to be 2 minutes, and the time between two finished SUVs exiting the Subaru plant to be 1.5 minutes, 90 seconds. Now, here it can help to note that a Subaru SUV coming off of the line every 90 seconds is not indicating how long it takes for the SUV to get assembled. It takes much longer to assemble that SUV. There will be many SUVs at various steps, various activities in the process at any given point in time, and it just so happens that in SUV is coming off the line every 90 seconds.



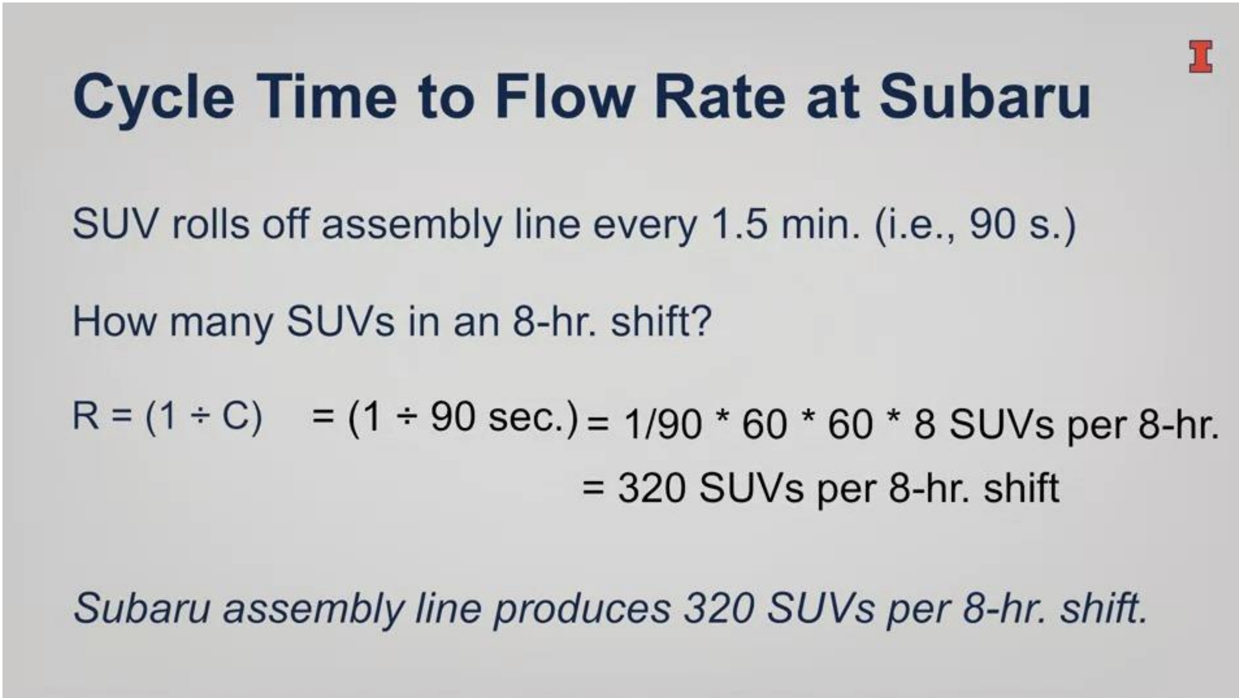
Flow rate. Flow rate is the rate at which units emerge. It is a rate measured as units of product or customers per unit of time.



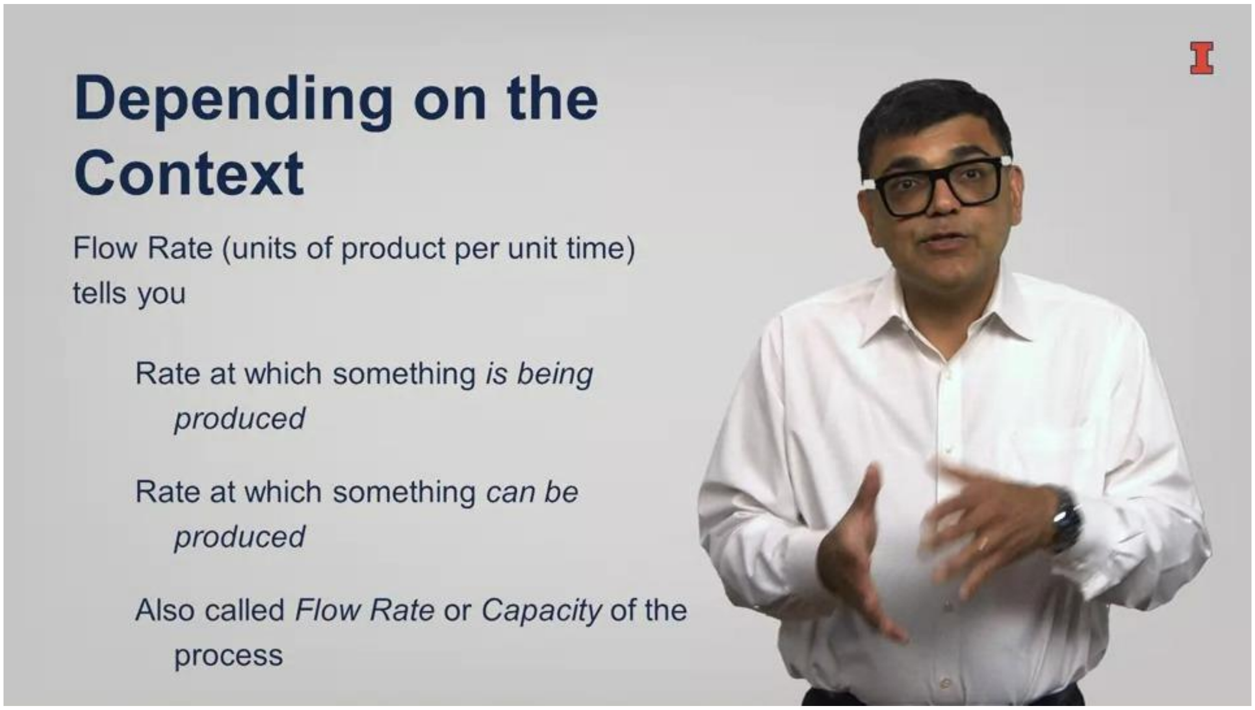
You must be thinking flow rate is related to the metric of cycle time, and you would be right, they are both the reciprocal or the inverse of each other. Cycle time is time between units of products or between customers, and flow rate is units of product or customer per unit of time. Inverse of cycle time is flow rate. Inverse of flow rate is cycle time.



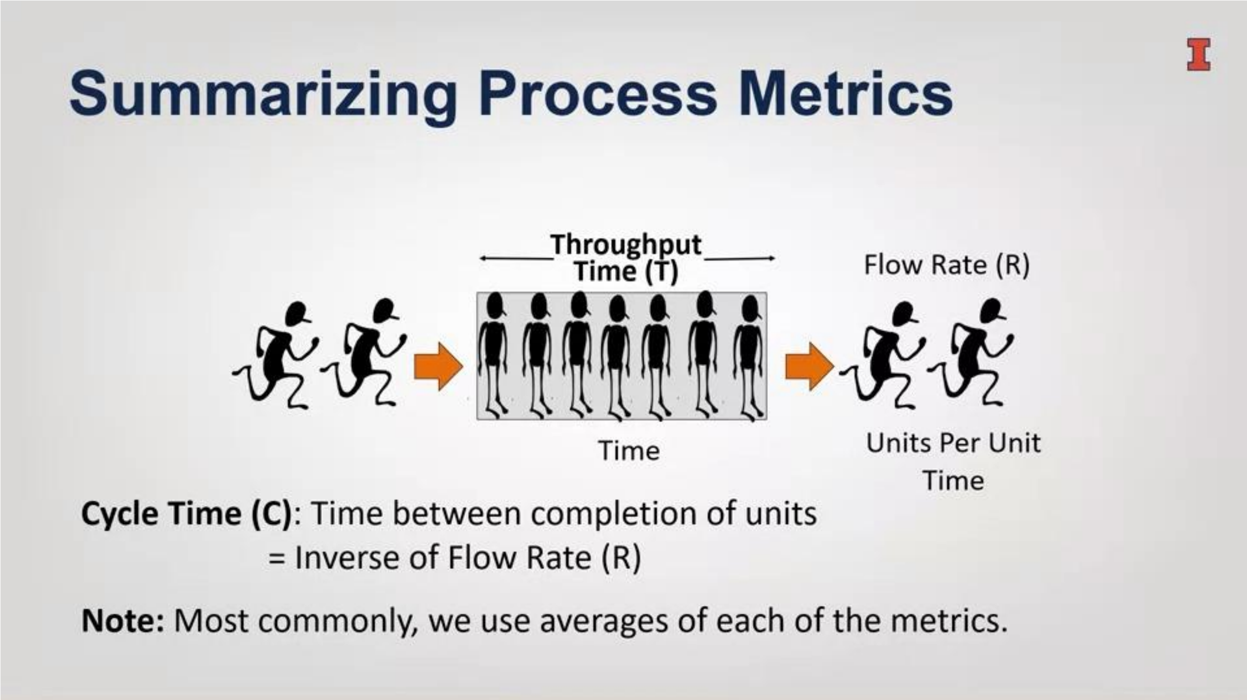
In this example, the cycle time for customers at Jarling's Frozen Custard is 2 minutes. The flow rate is 1 divided by 2, which is 0.5 customers per minute. Now, you multiply by 60 to convert to customers per hour, and it gives you 60 per hour. The flow rate at Jarling's is 30 customers per hour.



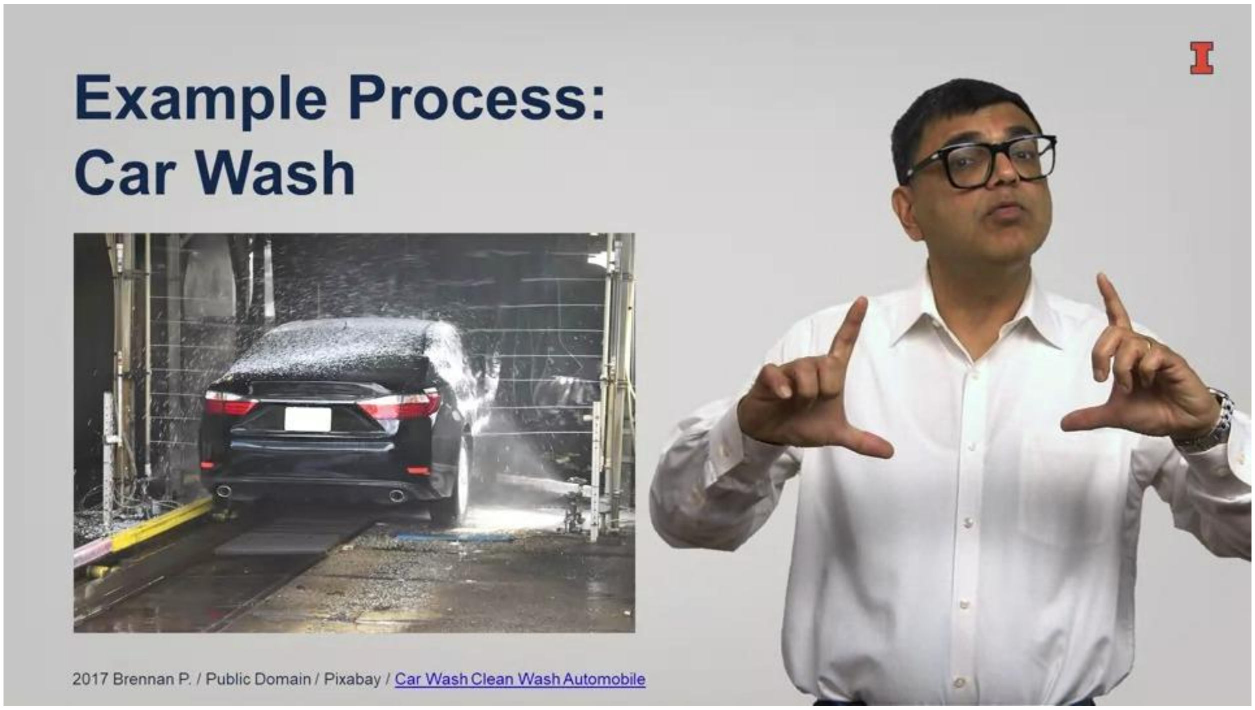
In this example, the cycle time for SUVs is 1.5 minutes or 90 seconds, and the question is, what is the flow rate? How many SUVs every shift, with the shift being eight hours. 1 divided by 90 seconds multiplying by 60 times 60 because we want to convert to hourly and then by 8 because we want to convert to per shift. You get 320 SUVs per eight-hour shift, and that is the flow rate. We can say that the Subaru assembly line produces 320 SUVs per shift.



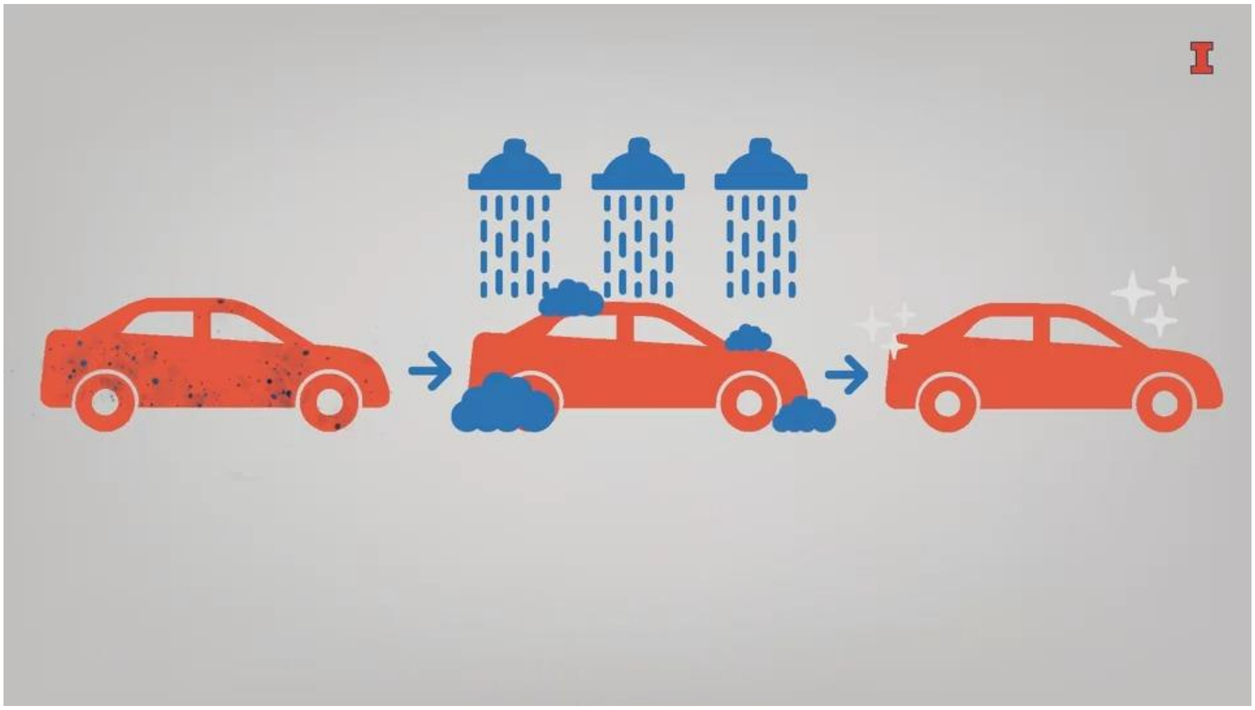
The metric of flow rate is something that we all use commonly, perhaps without calling it flow rate. You can think of flow rate as how much is being produced per unit time, or in terms of how much can be produced per unit time. Think of it as observed capacity or potential capacity of a process. Flow rate is analogous to capacity.



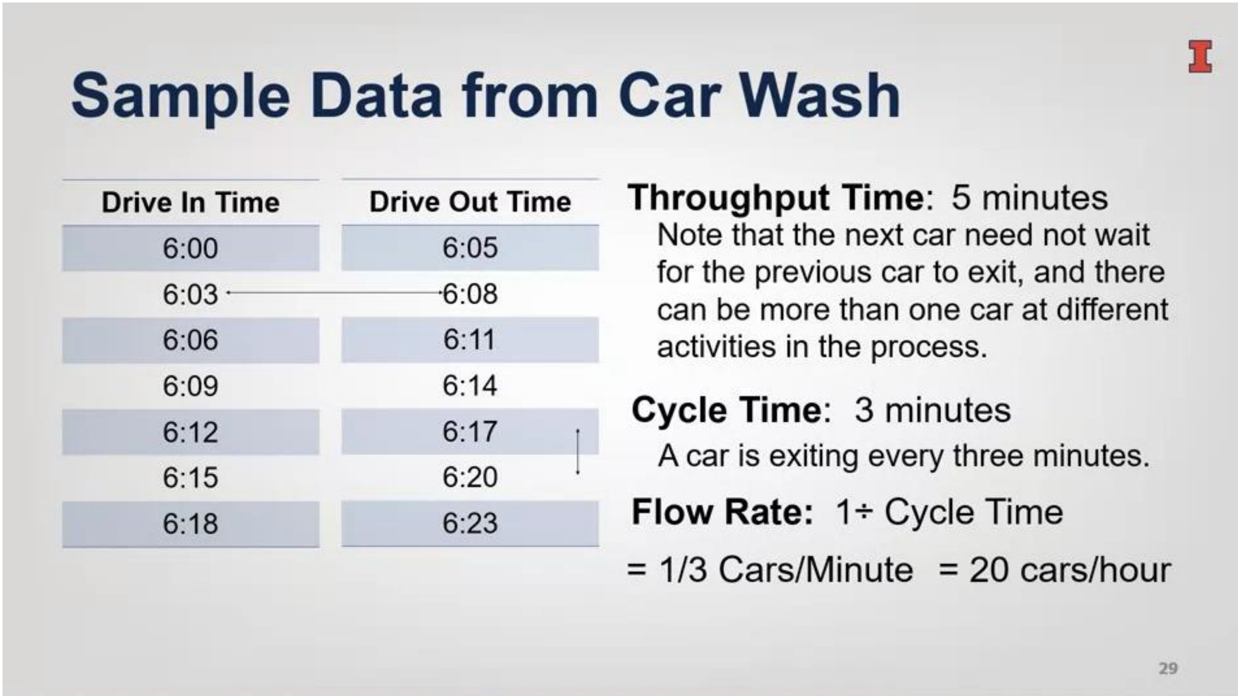
Putting the three metrics together for the process, treating the process as a box, putting them together, throughput time is total time elapsed from start to end. Flow rate is units per unit time. Cycle time is time between units. It's the inverse of flow rate. Most commonly, all these metrics are used in terms of their averages.



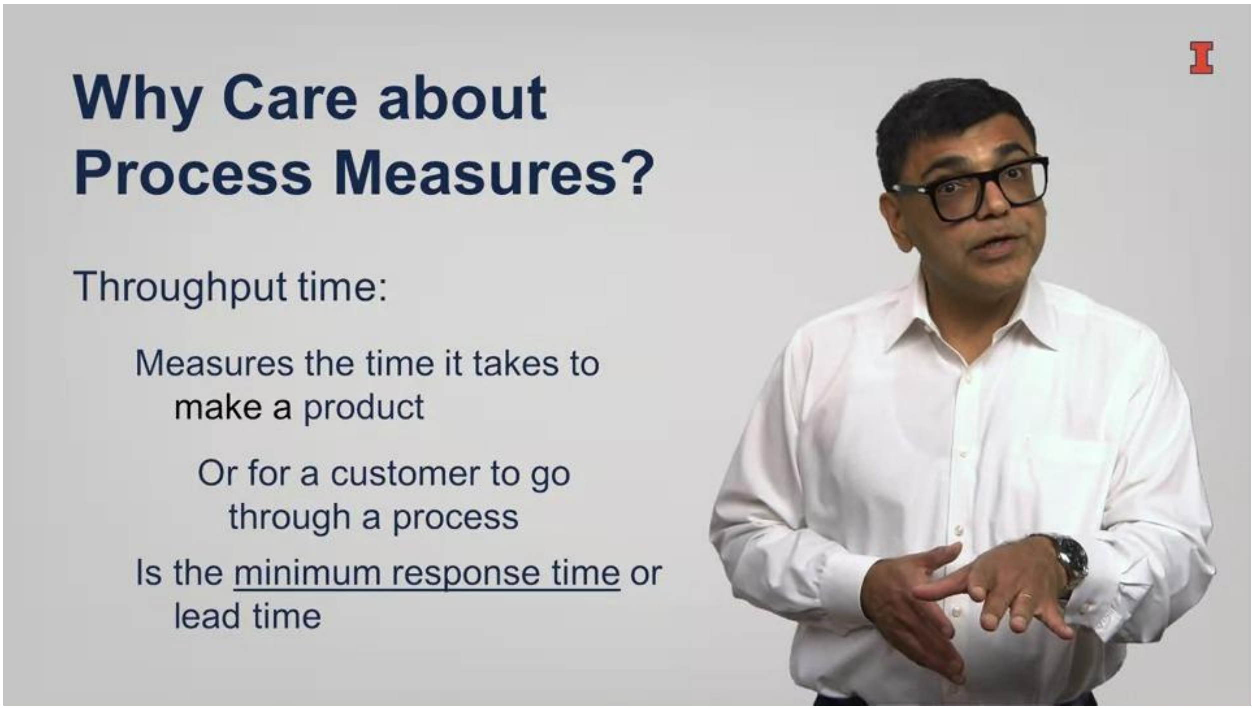
To give another example of a car wash, we are treating the different steps in the car wash. The pre-wash, the soap application, the water runs, the drying of the car, all the steps. We're treating them as one overall process. It's a box process.



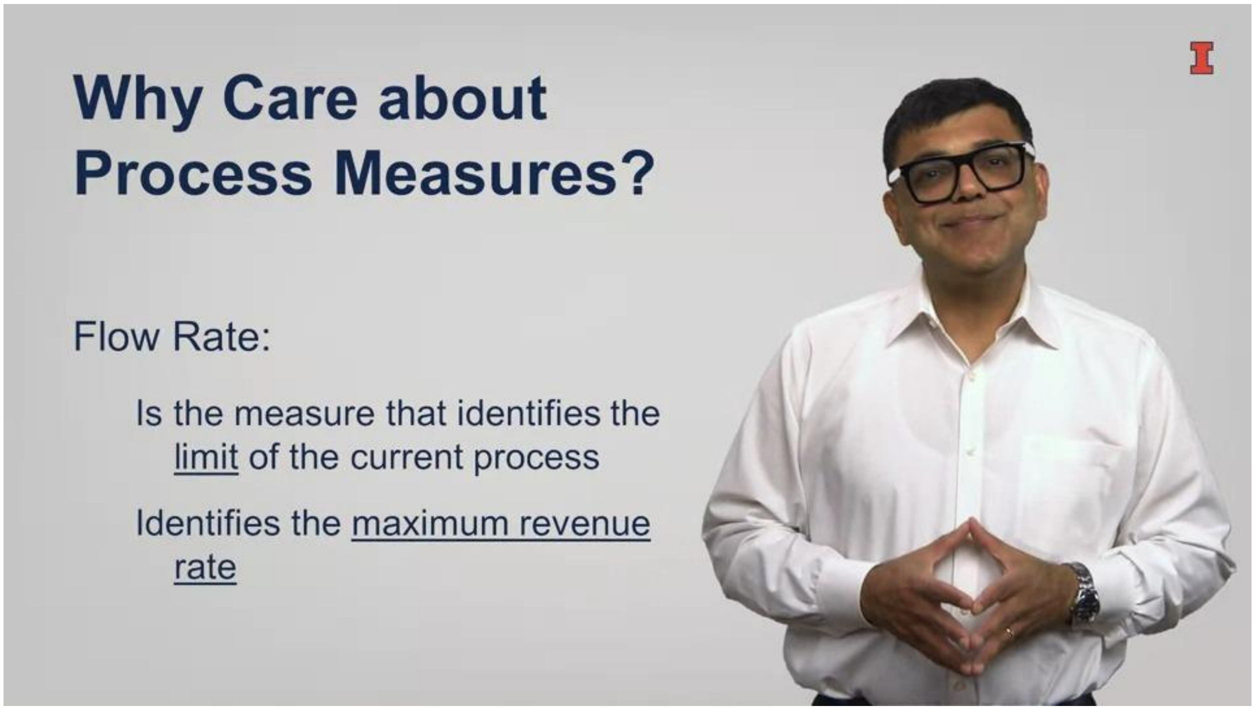
You can visualize the process in this way.



Turning to the process metrics for this car wash process, the throughput time, time from coming into going out is 5 minutes. Now, here it is important to observe that we can have multiple cars in the car wash. They can be at different activities, one can be at the pre-wash stage, another car maybe add the rinsing stage, and a third car may be at the drying stage. Regardless, the entire process for a single car takes five minutes. That's the throughput time. Next, the time between two cars exiting this car wash. Now, here that's the difference between any two consecutive cars, and to drive-out times that you want to take from this table. The difference is 3 minutes. This is the cycle time, time between two units. Now, note that in this car wash, this time is constant. That is, all the times between cars are 3 minutes. It does not always have to be the case, and that is why we say average cycle time, which would be averaging of all the times between exiting cars in a sample of observations. Again, here a car is exiting every three minutes. The flow rate is going to be the reciprocal of the cycle time. That is 1 divided by the cycle time, 1 divided by 3 minutes gives us 1/3 car per minute. Multiplying 1/3 by 60 gives us 20 cars per hour. The flow rate is 20 cars per hour.



Now, the question you might be asking is, why are these process measurements important? How are these metrics even relevant? Throughput time is relevant because it tells us how much time from start to finish. Also commonly thought of from a customer perspective as lead time. You can tell a customer that they should expect to take that much time to go through the process or that their order for a product, will take that much time once they place an order.

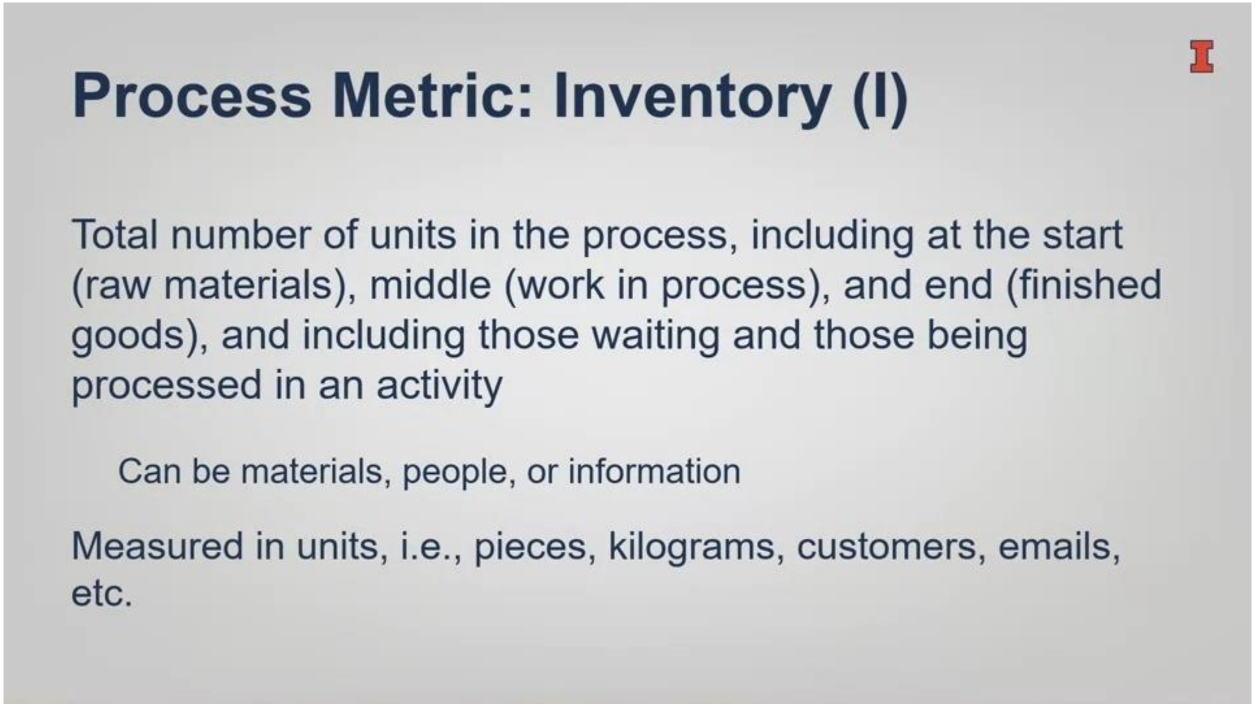


Flow rate is commonly the capacity. It identifies how much the process can output, which will dictate how much you can make and sell, how much revenue your business can make every hour or day, or month.

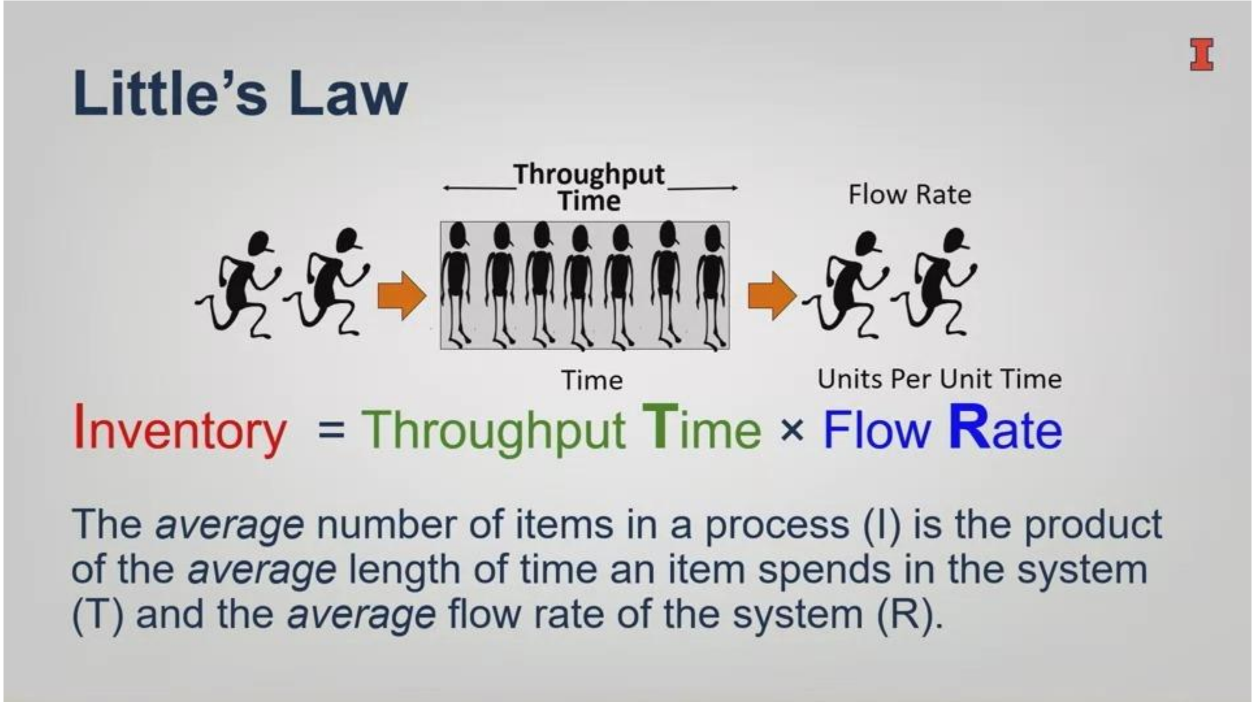
Lesson 2-4: Little's Law

Lesson 2-4.1: Little's Law

Let's start with defining the metric of inventory as it relates to a process.



Inventory is the total number of units through the process at any stage before or in the first activity of the process, in the second, or third activity, or as a finished product at the end of the process. It includes raw materials that are considered to be within the process boundary, works in progress that are anywhere in the middle of the process and finished products waiting to leave the process. It is measured in whatever the flow unit is. For example, it could be number of cookies. It could be kilograms of breakfast cereal. It could be number of patients in a health clinic, or even the number of emails in your mailbox.



Little's Law relates the throughput time, time that passes from start to end for a unit, and the flow rate, the rate at which units are being processed to the inventory, the number of units in that process. Little's Law is represented by this short formula, inventory in the process, also referred to as commonly as inventory in the system, is throughput times times flow rate. Formally stated, average inventory in a process is the product of average time a unit spends in the process and the average rate of flow for that process.

In order to illustrate Little's Law, we can check the relationships among I, T, and R from this simulation of customers going through a process.

You will need a stopwatch for the simulation that can measure time in seconds, and you will need to observe very carefully and count as I advance the simulation. The first thing you will do is count the seconds that it takes the first customer to go through the process. The second thing is counting how many customers are leaving the process every second.

The process is this gray box.

The position of the start and end points of this box are important as you're going to be timing people going through the process and counting people that are leaving the process, so focus on the start and the end of this gray box. Your first task is going to be counting the number of seconds that it will take for the first customer to go through. You will start the stopwatch when the customer enters the gray box, and stop the stopwatch when the customer leaves that gray box.

Here come the customers who are going to enter the process box. Get ready with your stopwatch. Start the stopwatch when the first customer enters this gray box, stop it when the customer leaves. Now, you should have the throughput time. The time that it took the customer to go through.

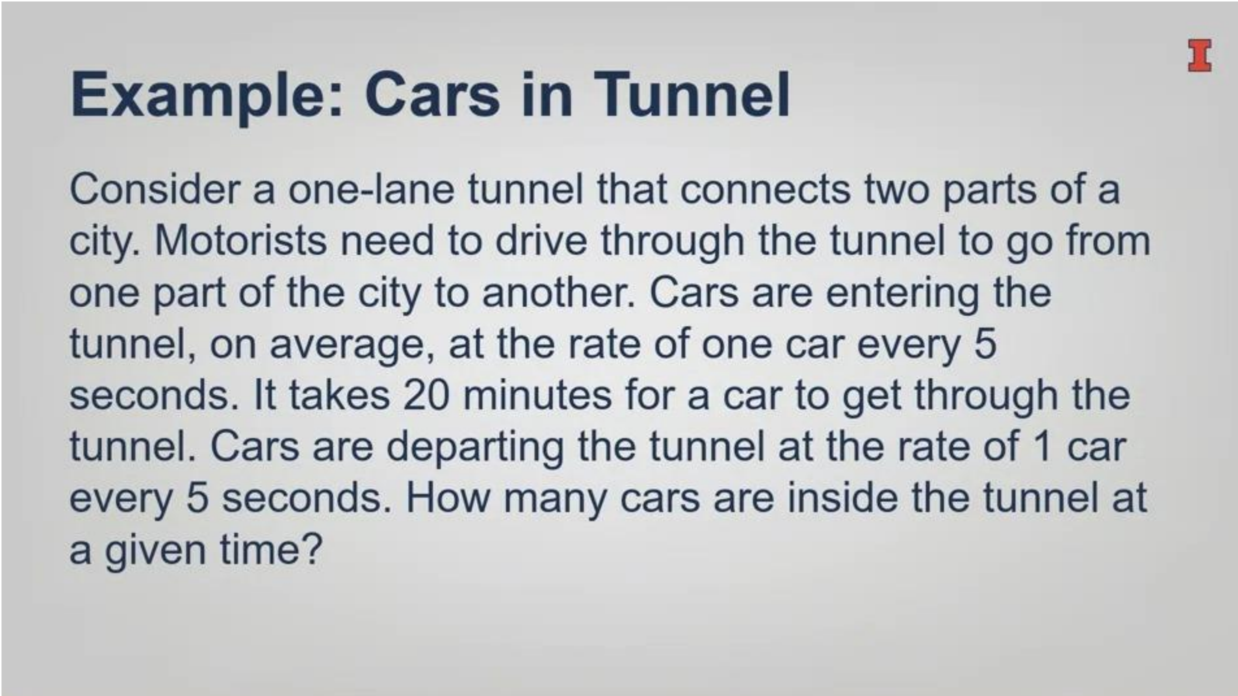
In the next click, when the simulation advances, you can see how many customers are leaving the process in one second. Keep an eye on your stopwatch, and at the same time, count the customers that are leaving.

Now, you should have the flow rate.

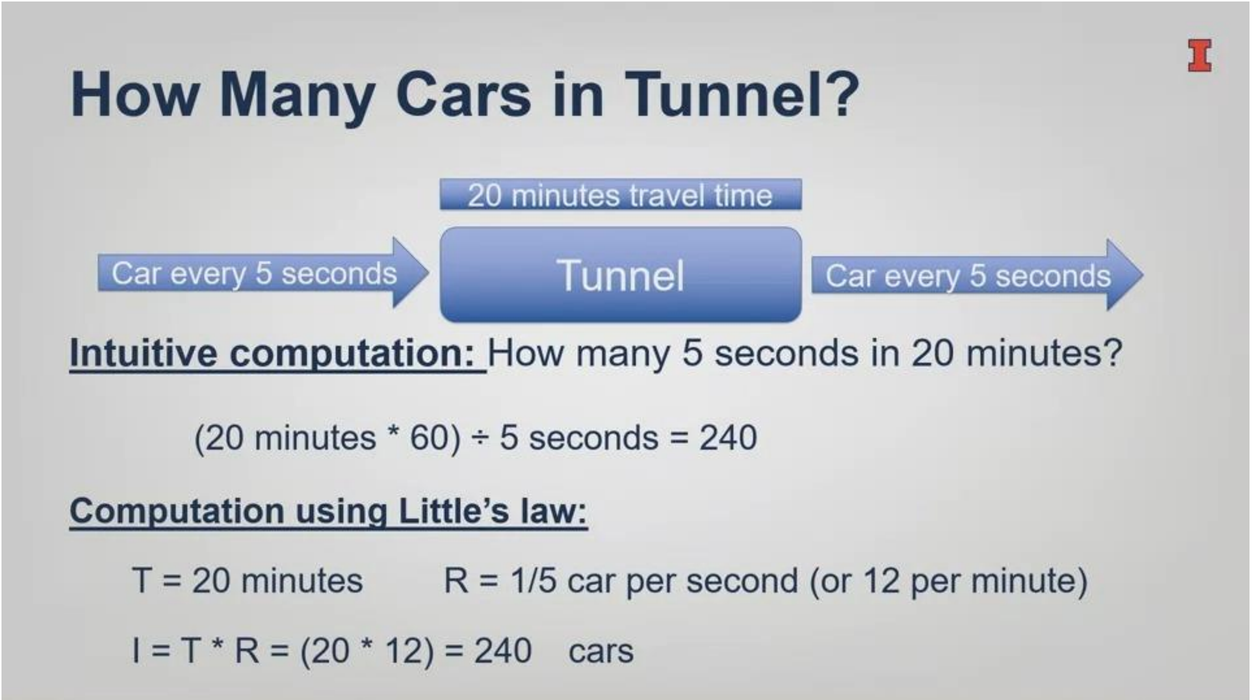
Next, you can observe how many customers appear to be in this box. Count the half at each entry point and the half at the exit point as being one. What is the total number in this process? That will give you the inventory. Now, you have the throughput time, the flow rate and the inventory in this process. You can verify any of these metrics as the simulation advances on the next click.

Now that you have the measurements, here they are, throughput time, three seconds, flow rate, two customers per second, and in-process customers in that gray box is six.

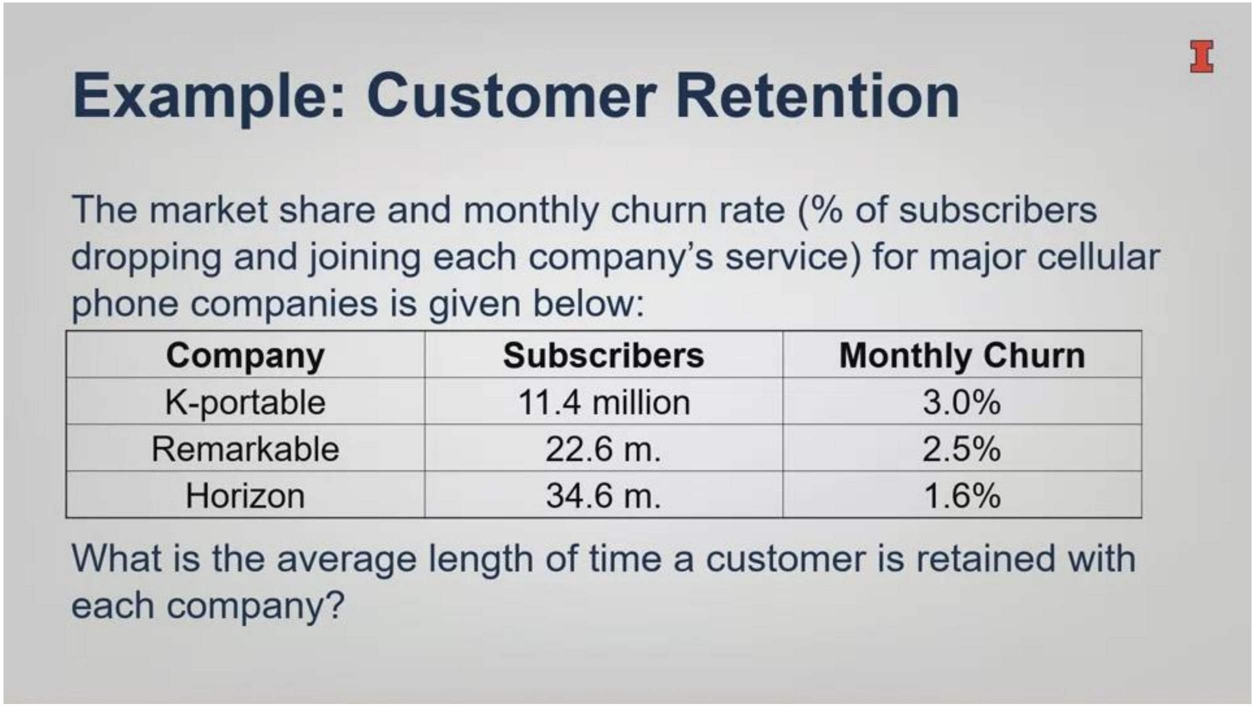
This matches with the relationship that would be predicted by Little's Law. Six customers is equal to 3 seconds multiplied by 2 customers per second.



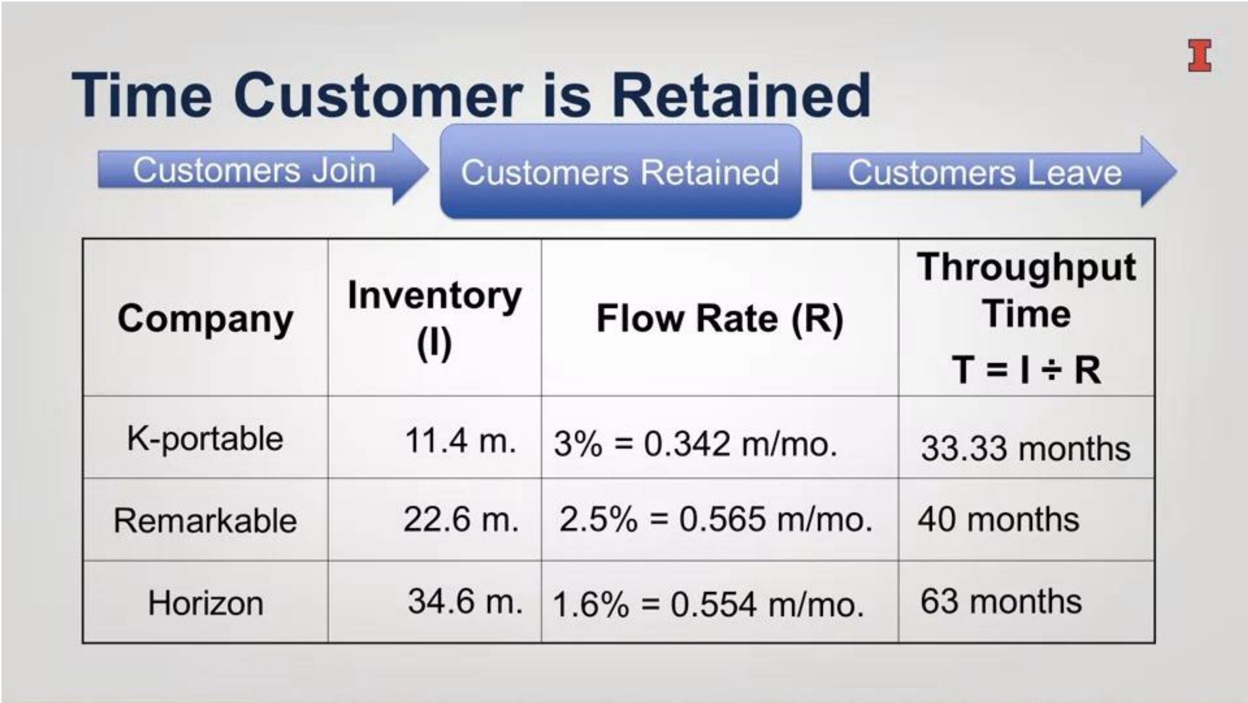
Here's an example to observe the relationships predicted in Little's Law. There is a one lane tunnel. First piece of information is cars enter and leave at one car every five seconds. The second piece of information is it takes 20 minutes for a car to go through the tunnel. The question is, how many cars are in the tunnel at any time? That is, if you were to take a snapshot of that tunnel, pausing the tunnel video so to speak, how many cars would you expect to find in the tunnel?



Here's that scenario depicted in a diagram. Now, the intuitive computation that you might have, even without knowing Little's Law, is how many five seconds are there in 20 minutes? Because a car enters every five seconds, takes five minutes to go through. This calculation works out to 240. Now, based on Little's Law, throughput time, or T is 20 minutes, flow rate, or R is 1/5 of a car every second or 12 cars per minute. Note that we have to have the metrics in matching units. Throughput time was in minutes, and that required that we convert flow rate into cars per minute. Now, using Little's law, inventory, I, is equal to T times R, which also gives 240 cars. Here you can observe the units for each of the metrics, and note that minutes multiplied by cars per minute gives a result that is in cars.

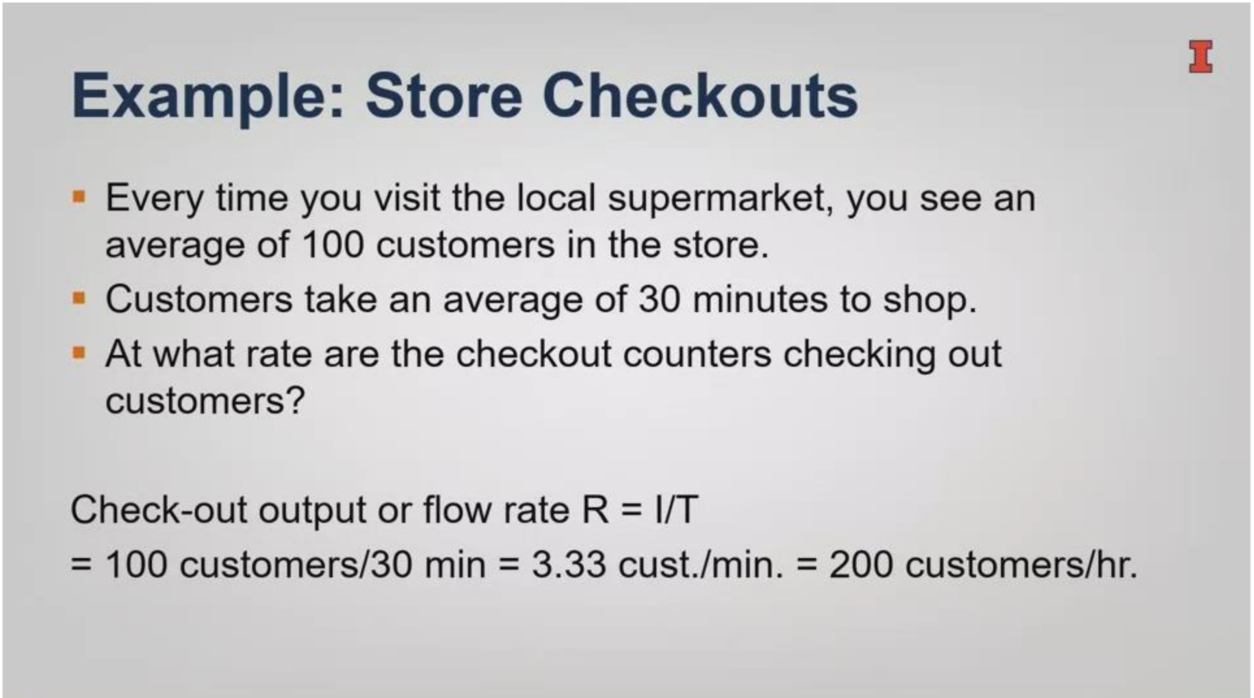


We can apply Little's law to a question of customer retention. Here, the data provided is for three cell phone companies. These are made up names, but they may be similar to some names that you know for cell phone companies. The first company is K-portable, the second one is Remarkable, and the third one is Horizon. We have the size of the market in average number of subscribers, and we have the churn rate. This is a marketing term which is used to calculate the percentage of subscribers joining and leaving that cell phone company each month. The question is, how long does a customer stay with each cell phone company?



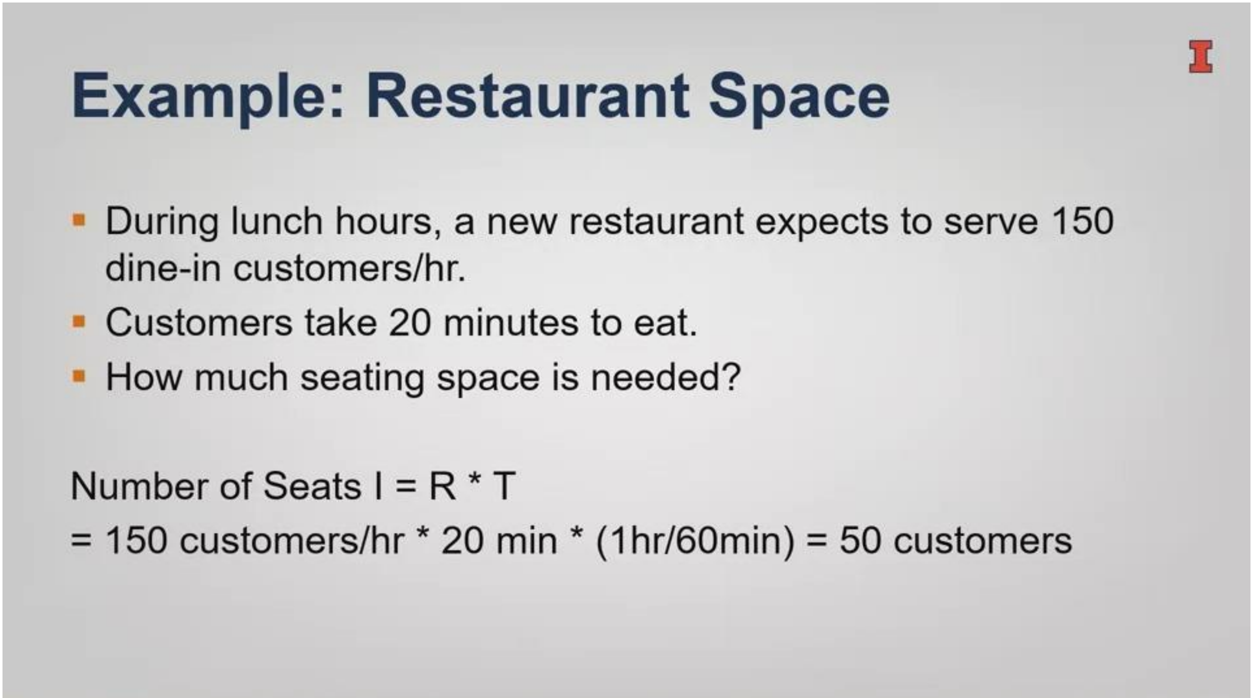
Company	Inventory (I)	Flow Rate (R)	Throughput Time T = I ÷ R
K-portable	11.4 m.	3% = 0.342 m/mo.	33.33 months
Remarkable	22.6 m.	2.5% = 0.565 m/mo.	40 months
Horizon	34.6 m.	1.6% = 0.554 m/mo.	63 months

Here's a visual of the question. Translating this information in terms of inventory, the number of customers, and flow rate, churn rate, which we need to adjust to number of customers per month, so we take three percent of 11.42, that gives us 0.342 million per month, and so on for the other two. We can get the average time and average customer stays with each of the three cellphone providers. We take the formula I equals T times R and calculate for T. T is equal to I divided by R. You can see here that Horizon customers are retained for the longest period of time on average.



We can use Little's law to decide the rate at which customers are checking out from the supermarket. Here, the average customers in the store is 100. Inventory or I is 100 customers. Average time spent by a customer in the grocery store, in the supermarket, is 30 minutes. Throughput time or T is 30 minutes. The rate of checkout is going to be R, which is I divided by T. 100 divided by 30 gives us 3.33 customers per minute, and that is 200 customers per hour.

Little's Law can be used to determine the seating space needed in a restaurant that is based on the number of customers that are in the restaurant if you know the rate at which customers visit the restaurant and the average time a customer spends in the restaurant eating their meals.



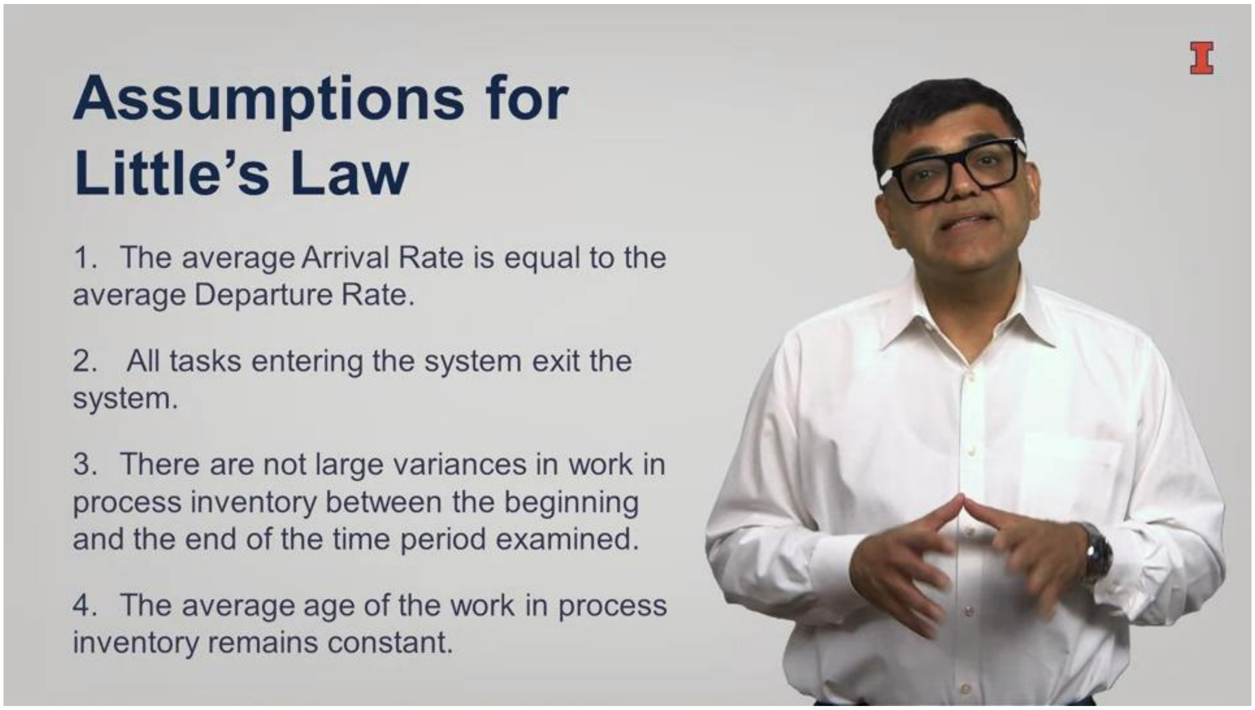
Here, the flow rate is given to us as 150 customers per hour and customers spend on average 20 minutes in that space. How many customers on average in the restaurant? I equals R times T. We convert the 20 minutes to hours by dividing it by 60. This is done to match the units for the flow rate, which is customers per hour. The answer shows us that you need to plan for 50 customers to be seated in the restaurant. If you're planning for how many tables and chairs, you're planning for 50 customers to be seated in the restaurant.

Computing R, I, or T

	Rate	In-queue and in-process	Total time in queue and system
Semiconductor factory	1,000 wafers per day	45,000 wafers	**45 days**
E-mail management	50 messages per day	150 messages	**3 days**
Maternity ward	5 mothers per day	**12.5 mothers**	90% 2 day stays 10% 7 day stays
Toll booths	3,600 vehicles per hour	20 vehicles	**20 seconds**
Real estate	**25/120 houses per day OR 76 per year**	25 on sale	120 days
Doughnut shop	**10/3 cust./min. OR 200 cust./hour**	10 customers	3 minutes
3rd party logistics provider	10,000 toys per day	**50,000 toys**	5 days

Little, J. D. C., & Graves, S. C. (2008). Little's Law. In D. Chhajed & T. J. Lowe (Eds.), *Building Intuition: Insights From Basic Operations Management Models and Principles* (Vol. 115, pp. 81–100). Springer US.

Here are several examples of using Little's law to calculate one of the three components from knowing the other two. You can see the applicability of this calculation in a variety of scenarios with a range of speeds of processing from a fast-moving process in a factory where the flow units are semiconductors to the question of a slower moving rate for sales of houses in a real estate example. The formula for Little's law enables us to calculate the third component from knowing two components.

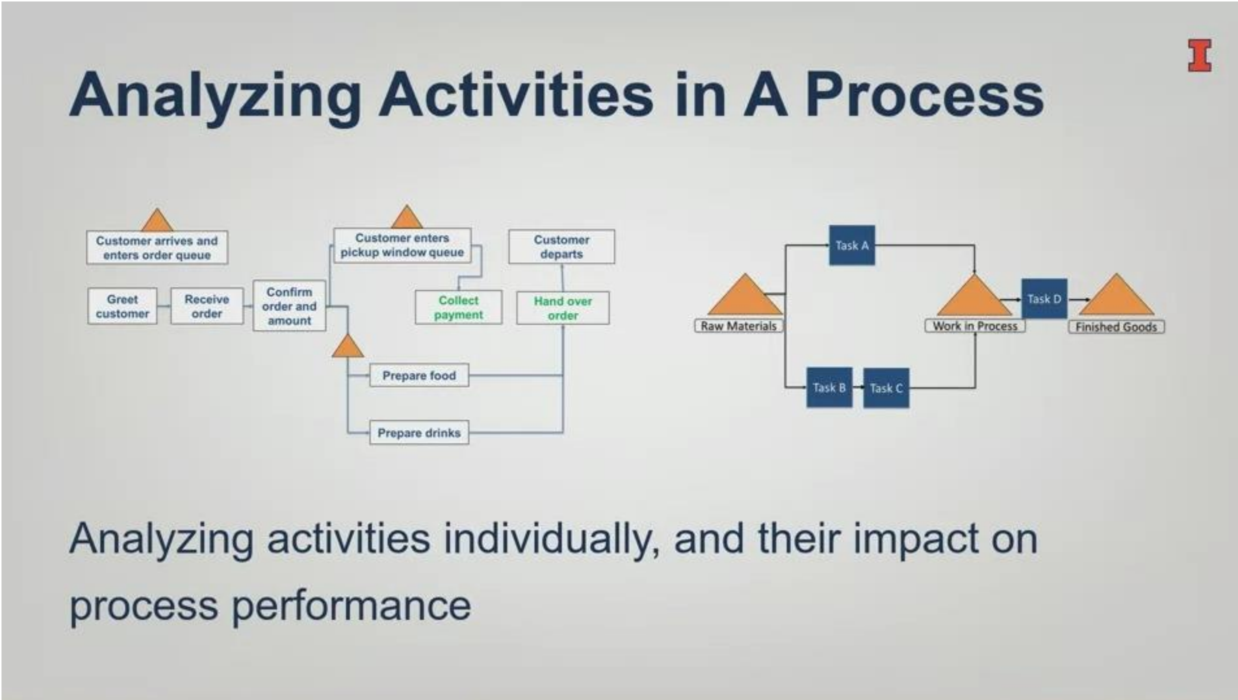


Now, Little's law applies under certain conditions. First, that units arrive and leave at the same rate. The flow rate is input rate as well as the output rate. Second, there's no loss of units in the process. All units that enter the process or the system also leave it. Third, the inventory in the system or in the process is constant. There's little variation in the amount of inventory in the process. Fourth, the age of the inventory, the number of days the units stay in the system, or the number of minutes the units stay in the system or the process does not vary much. Now you might say these assumptions seem restrictive and somewhat unrealistic, but you can take a positive perspective of these assumptions. They provide ideals to aspire to. That is, you want to get as close as possible to making these assumptions hold. Let's take them one at a time. The first one translates to having a smooth flow rate. The second one translates to reducing the waste or the scrap in the system or the process so that you reduce the need to reject and throw away units being produced. That would be a good thing. Third, also has to do with a steady work rate. The fourth assumption, you use first-in, first-out. You prioritize based on time of entry in the process or system. Customer who walks in First is being catered to first, second, second, so on and so forth. In other words, the assumptions for Little's law also provide good target conditions for making process improvements.

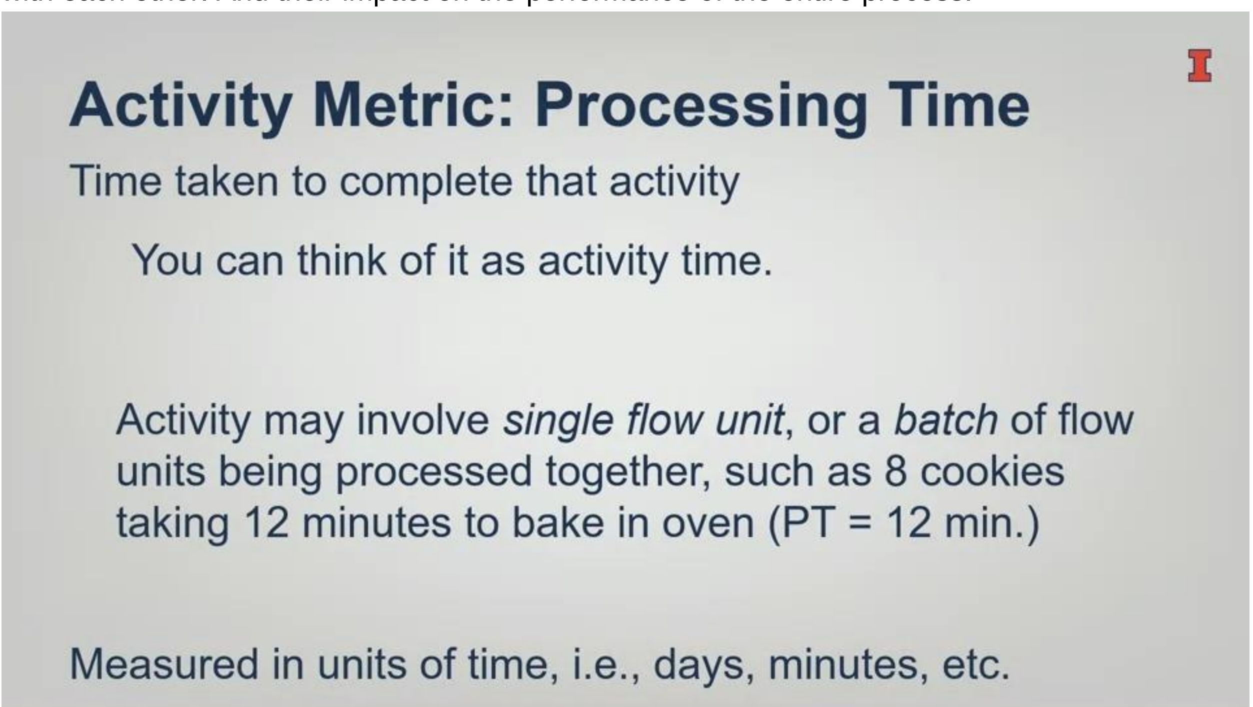
Lesson 2-5: Activities Within Processes

[Lesson 2-5.1: Activities Within Processes]

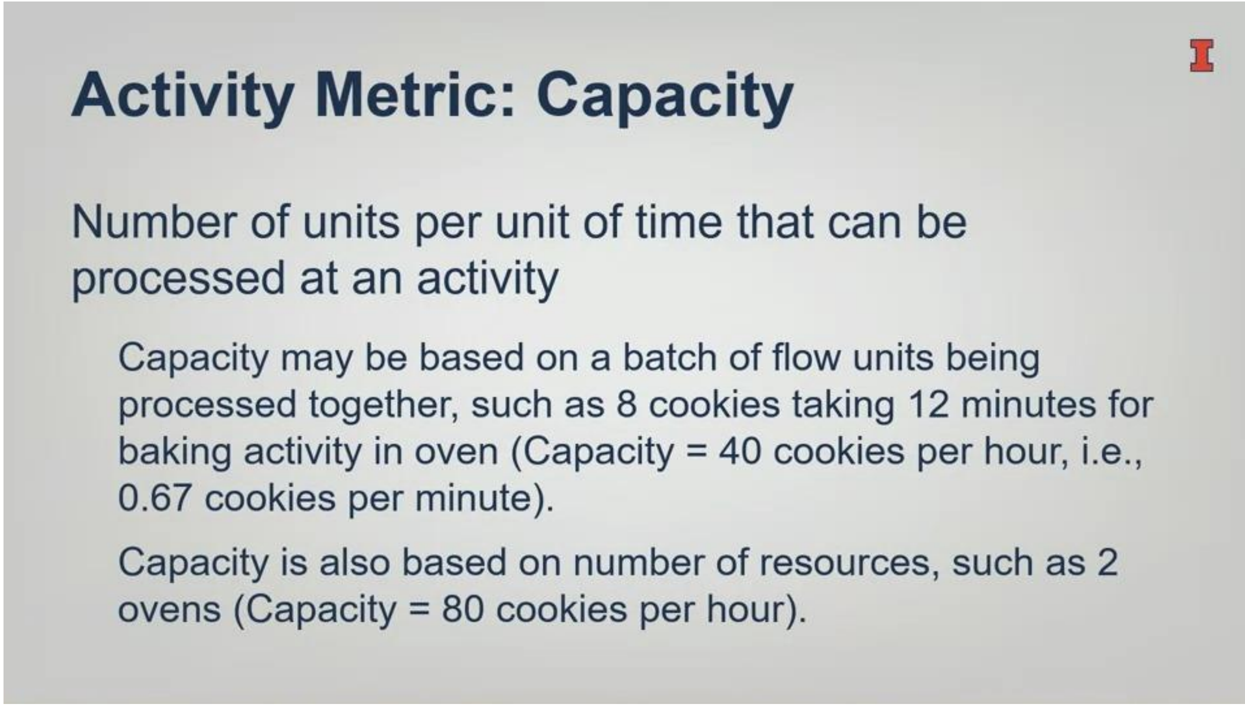
Let's see how we can analyze the process. And here we will focus on not just the entire process, but on the individual activities that are part of the process. The steps that are in the process.



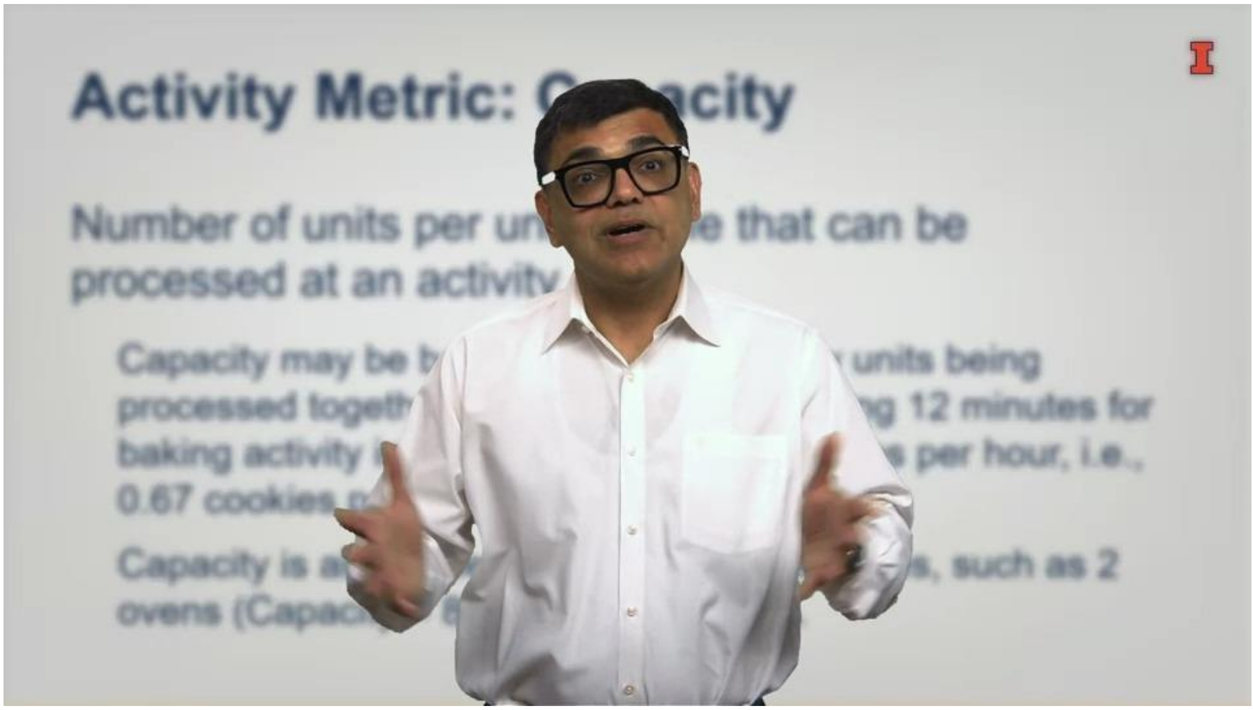
We will use measurements of individual activities and steps, and we will study their relationships with each other. And their impact on the performance of the entire process.



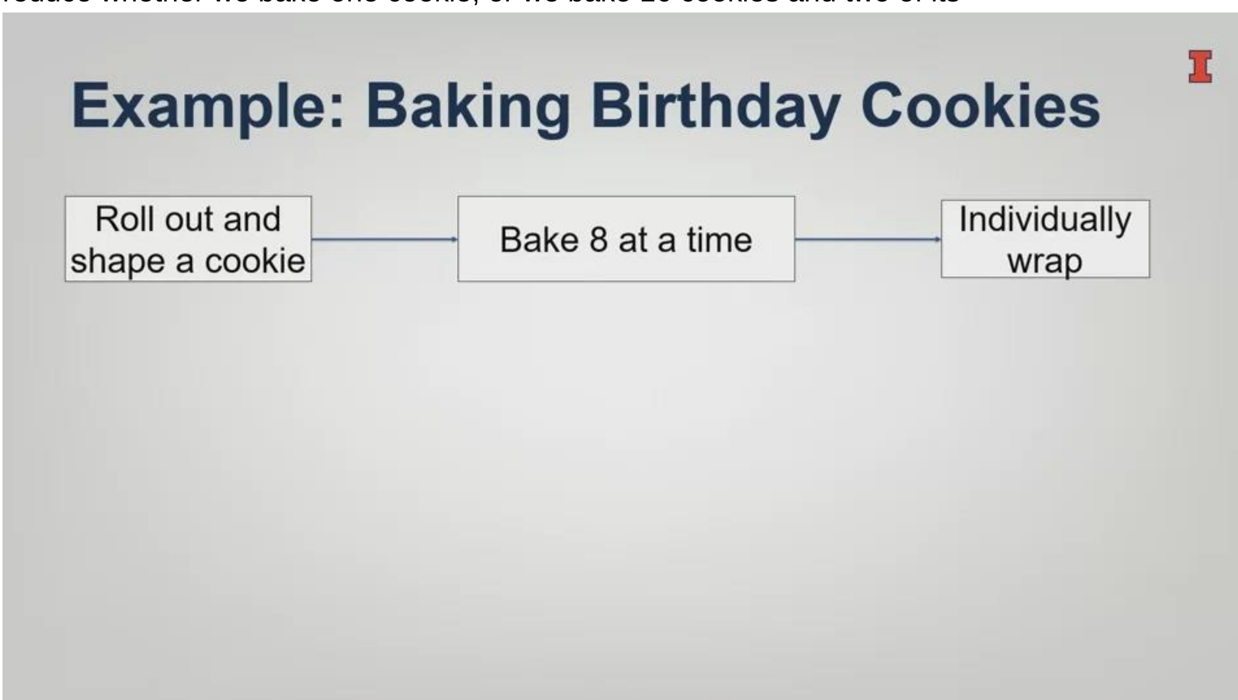
Introducing the first metric for an individual activity, processing time. Processing time is the time it takes to get that activity done. So, it could be for example that I bake cookies in 12 minutes. That's the processing time. Note that it takes 12 minutes to bake a batch of cookies. However, processing time is just that 12 minutes. Whether we bake one cookie, or we bake a batch of any number of cookies that's possible, it's still 12 minutes. It is measured as time, so in minutes, seconds etcetera.



Capacity of an activity is measured as a rate number of units of product, that can be processed per unit of time. Now, this will be affected by the number of units that can be processed simultaneously. So a batch of eight cookies that takes 12 minutes to get done in one oven, gives us a capacity of that baking task to be eight divided by 12. So two third or 0.67 cookie per minute. We multiply by 60, it is 2/3 of 60, so 40 cookies per hour. Now, if we have two ovens that can bake cookies simultaneously, eight in each oven. Then the capacity doubles, it is now 80 cookies per hour.

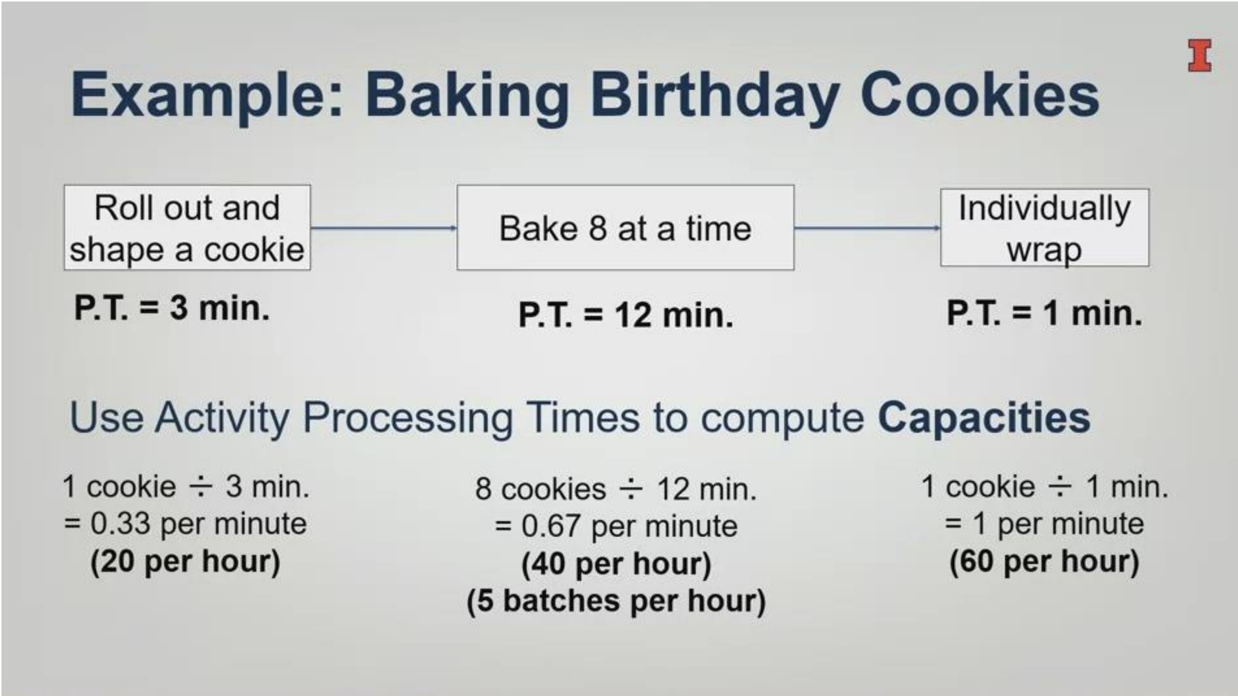


Note here that the processing time for baking remains 12 minutes. The baking time does not reduce whether we bake one cookie, or we bake 16 cookies and two of its

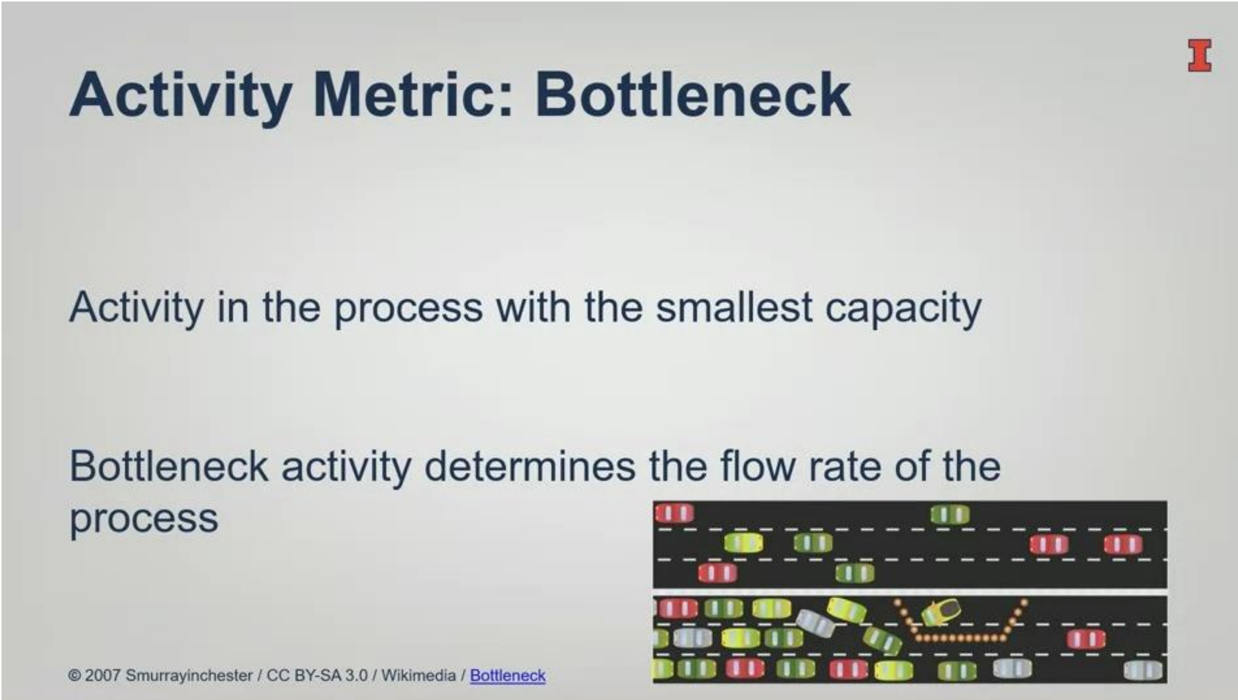


using an example of taking birthday cookies. This process consists of three activities three steps. First, roll out and shape a cookie, second, you bake and this is making eight out of time. Third, we wrap each cookie in an individual rap.

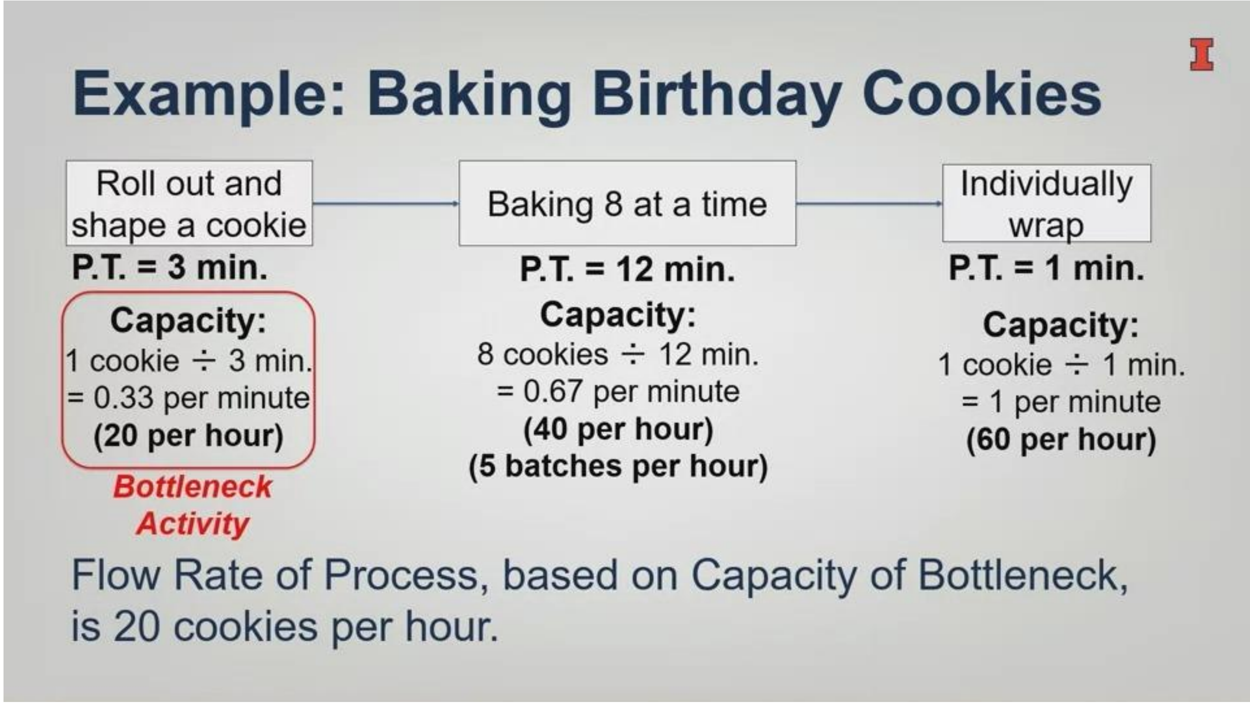
As a side note, this process uses a wrap made of biodegradable paper, that protects the cookie and has minimal impact on the environment. Now let's put processing time for each of the three activities on this process map.



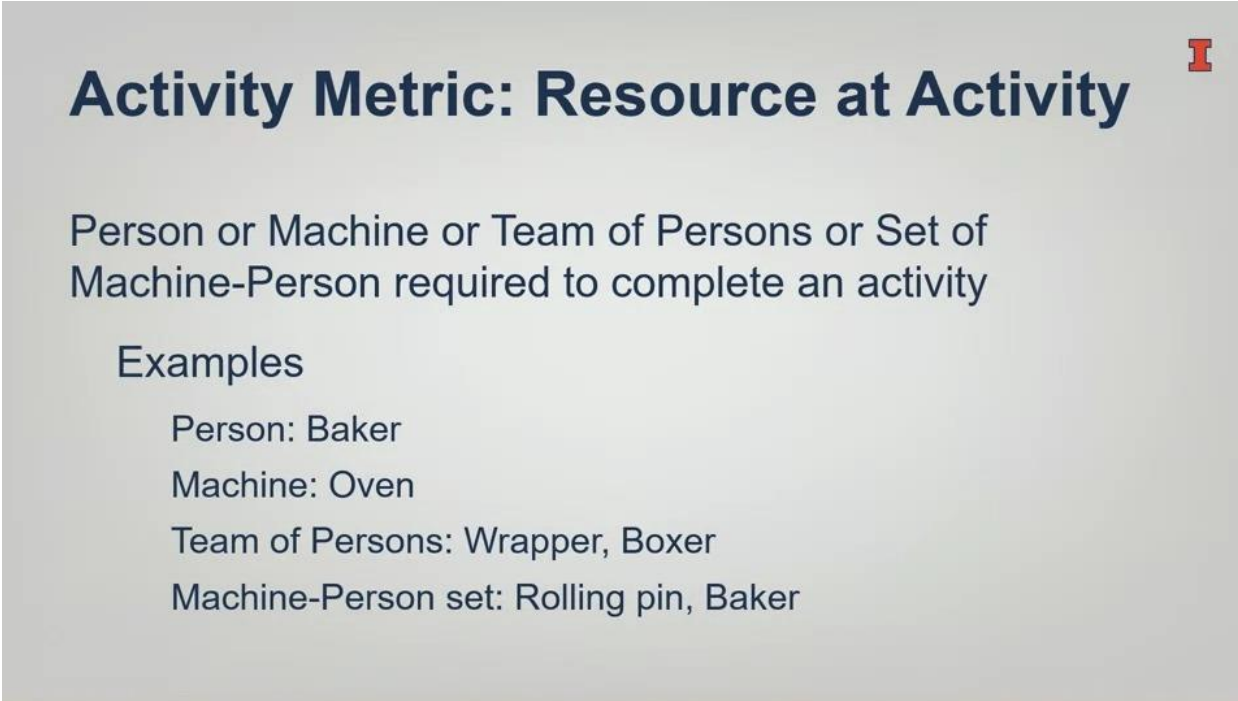
So 3 minutes, 12 minutes and 1 minute. Use these activity processing times to calculate the capacity for each activity. Number of cookies produced simultaneously divided by the processing time. So 1 divided by 3, gives us 1/3 per minute or 20 per hour. 8 divided by 12 gives us 40 per hour, or you can say 5 batches of eight per hour. Wrapping the cookie has a capacity of one per minute, so 60 per hour.



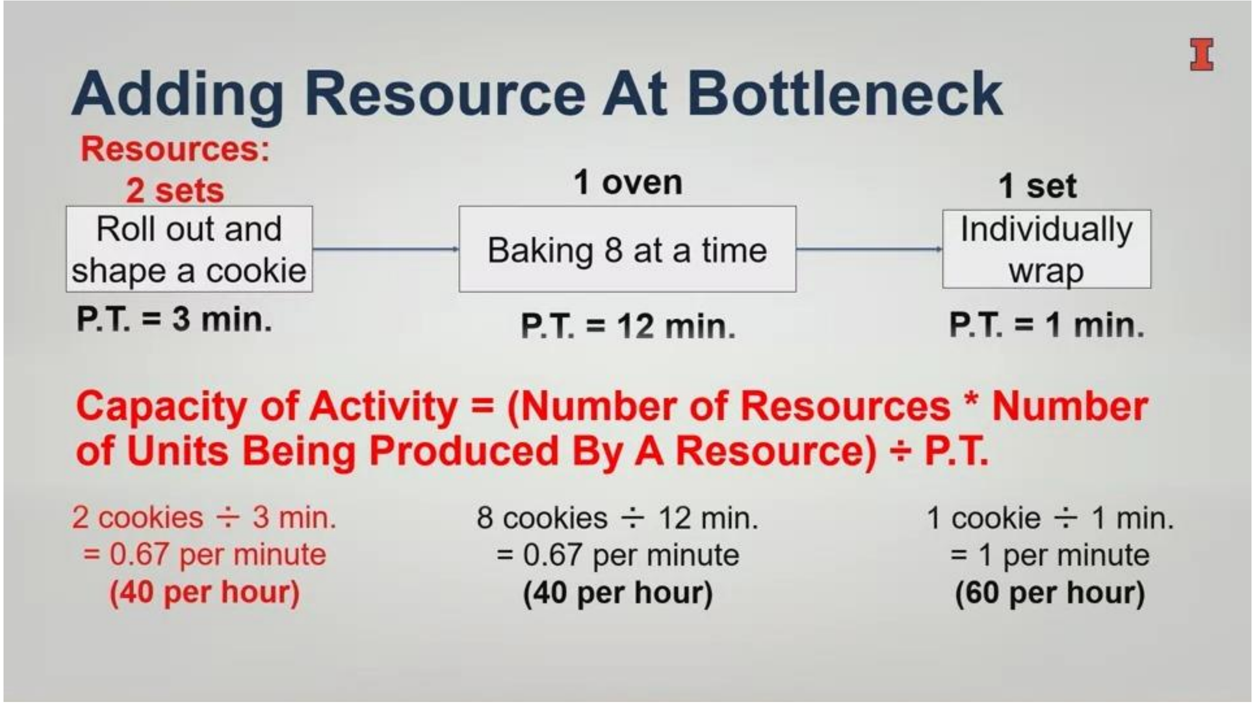
What's the bottleneck? A bottleneck is an activity among activities in the process that has the smallest capacity. The bottleneck or bottlenecks, if there are more than one with that same smallest capacity, determines the flow rate of the entire process. The bottleneck activity in the process, is like two lanes on the street being reduced to one lane, the capacity of that street. How many cars can pass through per hour is going to be based on the one lane portion of that street. It is worth noting here that the bottleneck is based on the lowest capacity activity, and not based on the largest processing time often activity.



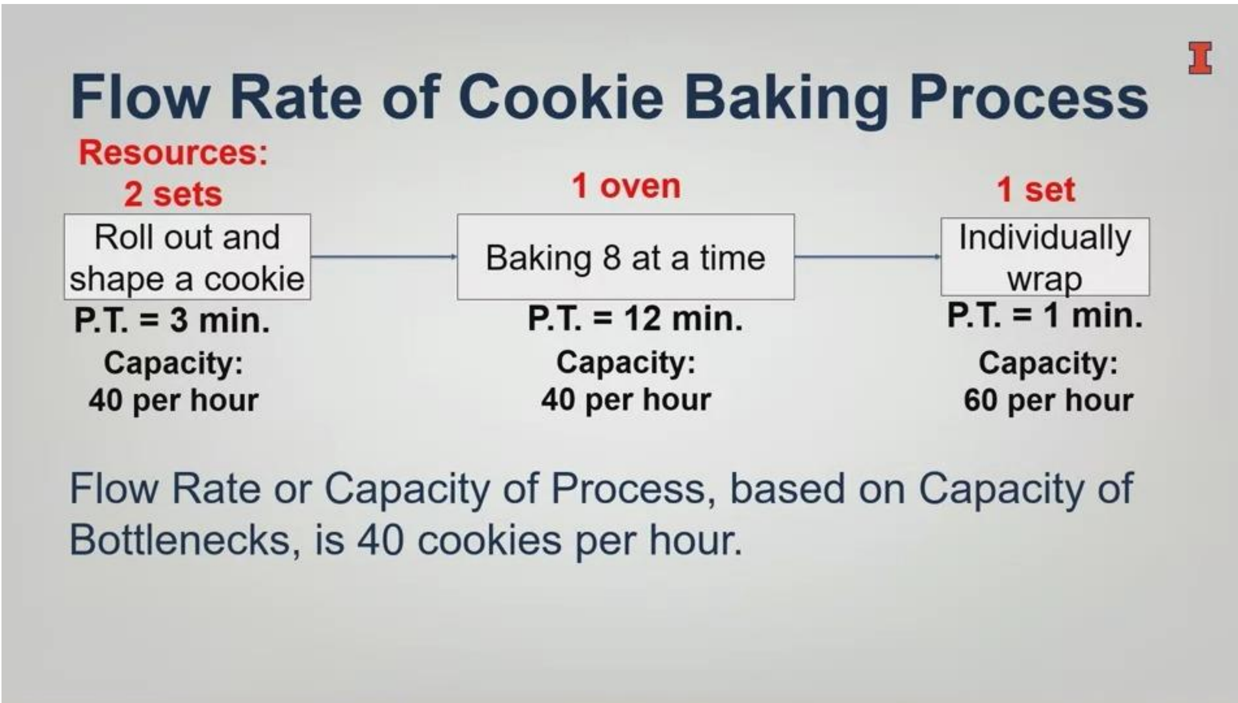
Using an example of making cookies to demonstrate the idea of a bottleneck, you see here three activities with their processing times given. And their capacity is calculated, we can identify the bottleneck activity based on the lowest capacity. So with the capacity of 20 per hour, the first activity of rolling out in shaping cookies, is the bottleneck activity. The flow rate of the entire process is based on the capacity rate of the bottleneck activity. The process can produce cookies at the rate of 20 per hour. It's worth noting here that comparing processing times, you can see that baking has the largest processing time, and here it is not the bottleneck.



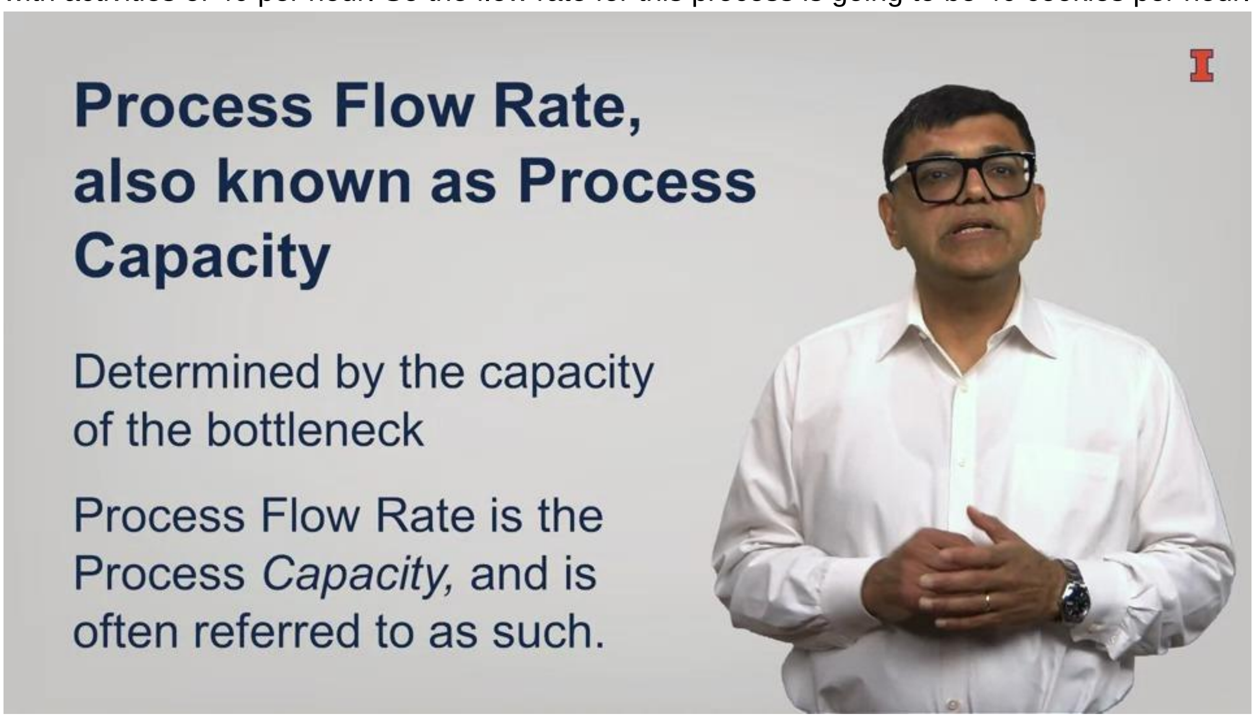
How many people or machines or people machine combinations or teams we have at each activity. That is what we can define as the number of resources at each activity. For a cookie baking process, we can observe the different employees baker rapper, anyone else. The equipment, the oven, the rolling pins and these types of things as resources.



Let's see the impact of changing the number of resources. Here we're adding a resource at the bottom like activity which is the first activity in this process. So let's say we install another station and hire an employee and provide a rolling pin and cookie cutters etcetera. The other activities still have one resource each. To generalize the calculation as a formula, the capacity of each activity is the number of resources. Multiplied by the number of units being worked on simultaneously by a single resource. And then we divide that product by the processing time. So here for activity one that is 40 per hour, for activities two and three using the same formula, we get 40 per hour and 60 per hour.



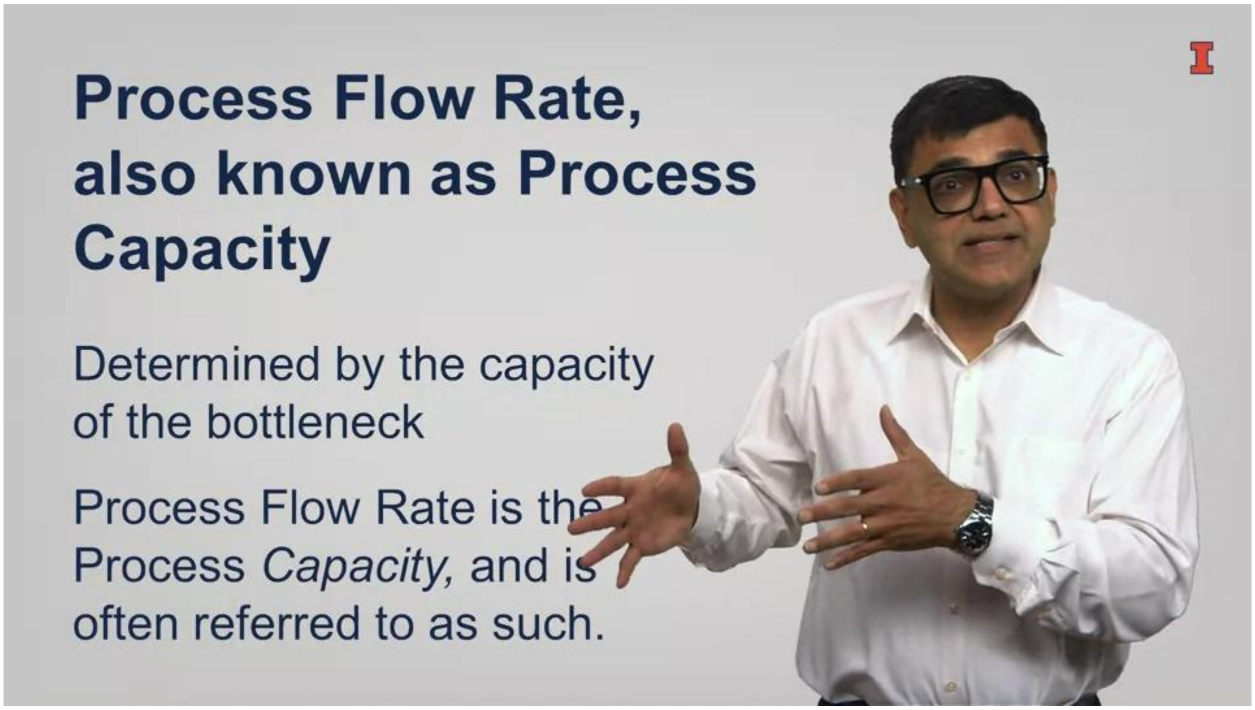
What is the flow rate of this three activity or three step process? We need to identify the bottleneck that is based on the lowest capacity, here we have activities one and to both of them, with activities of 40 per hour. So the flow rate for this process is going to be 40 cookies per hour.



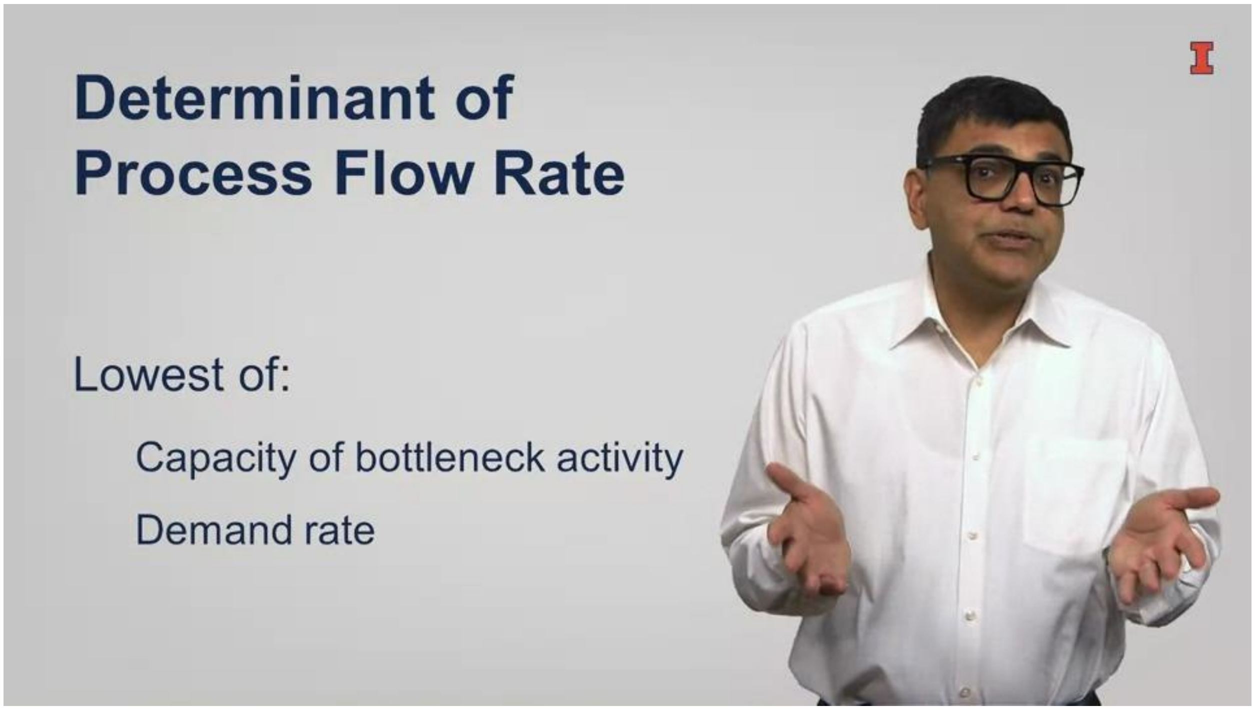
The process flow rate calculated based on the capacity of the bottleneck activity, basically gives us the process capacity. Absent of any other information, we can say that process can produce at this rate per unit time, so cookies per hour or cookies per day etc.

Lesson 2-6: Capacity Utilization

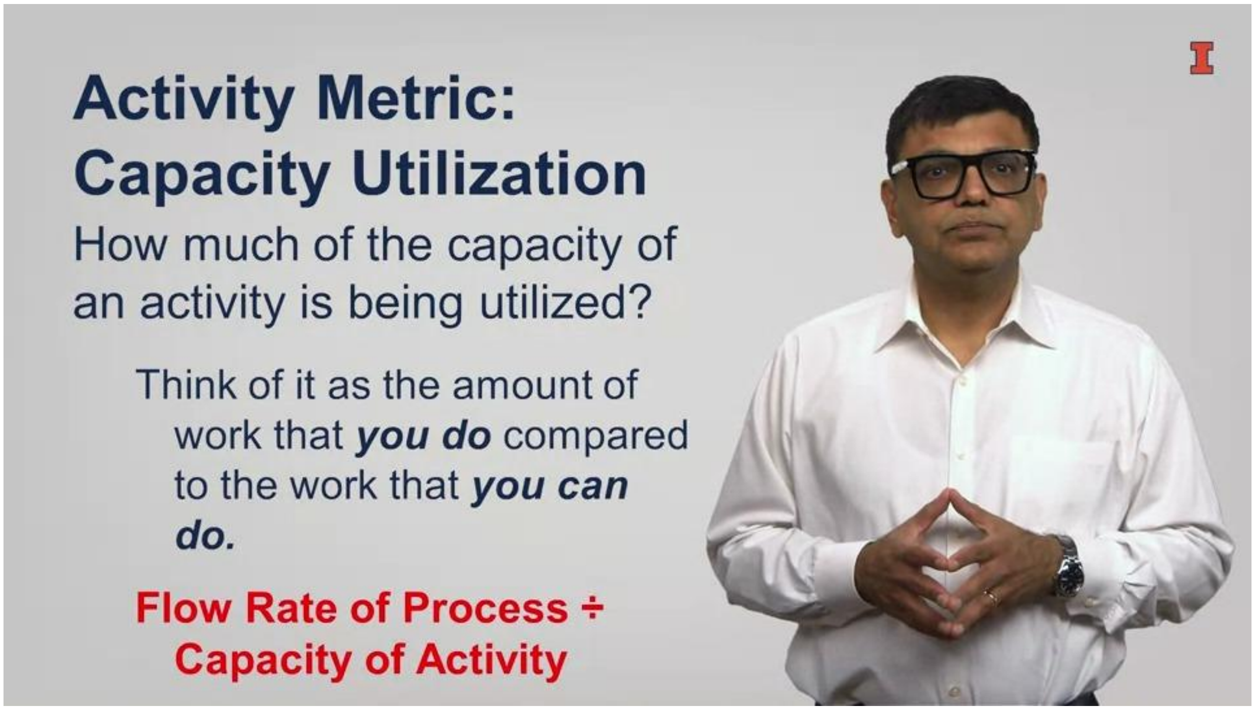
Lesson 2-6.1: Capacity Utilization



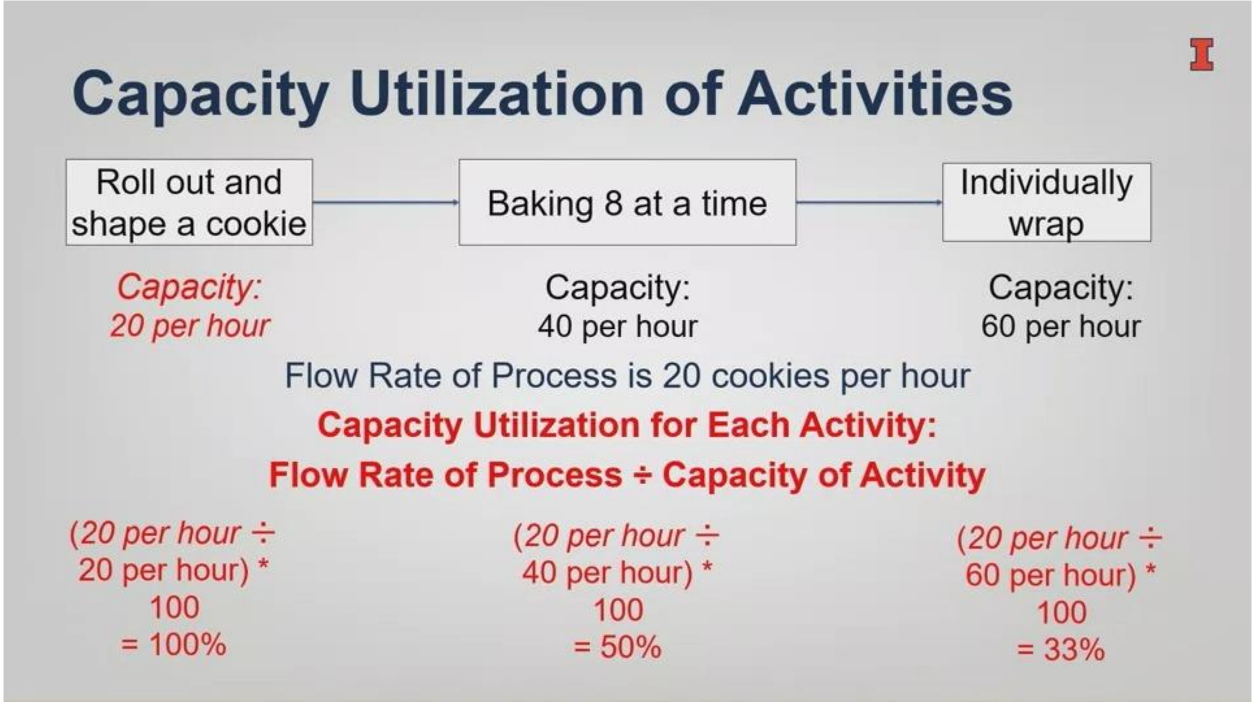
The metric of demand rate is based on the demand which comes from outside the process, demand comes from the customer of the process. Now the customer of the process can be an external customer, the final customer for your product or it can be an internal customer. The next process in the production of the goods or services.



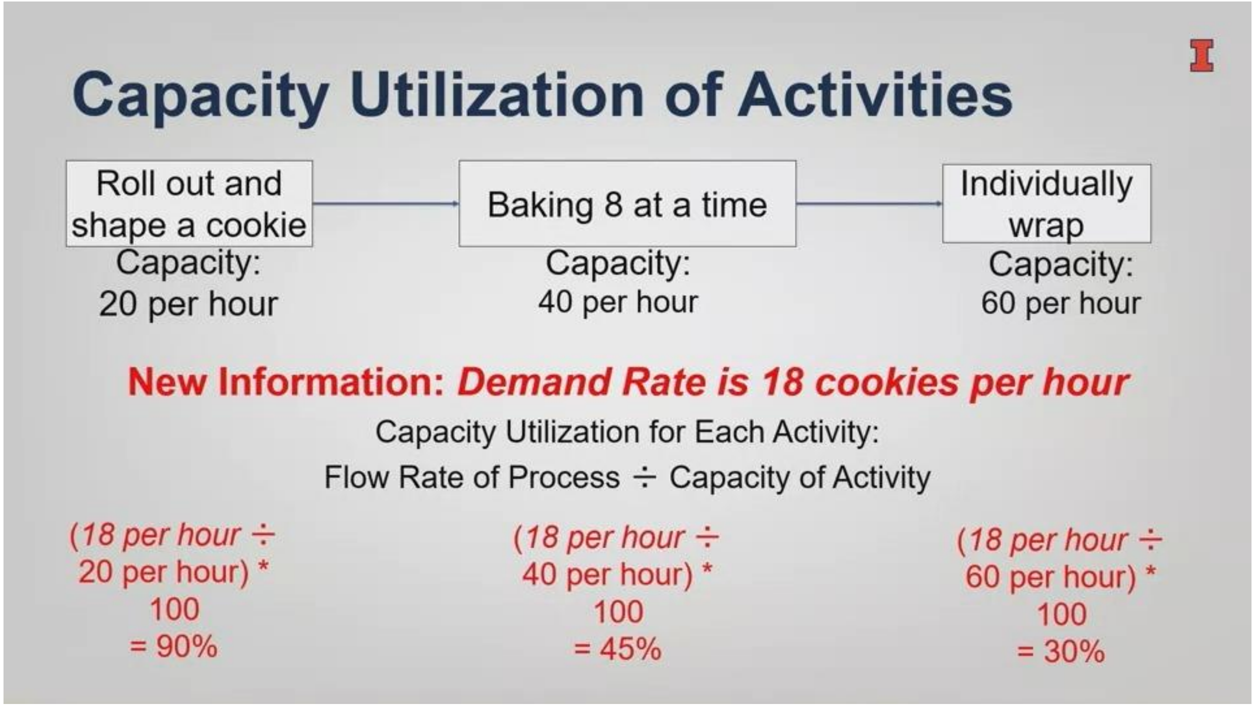
When we have information on the demand rate, we can say that the process will flow at the rate that is the lower of the two, the capacity of the bottleneck activity and the demand rate. Basically what we're saying is that in cases where the demand is lower than what the product process can produce, the process is not going to produce at a faster rate than the demand rate.



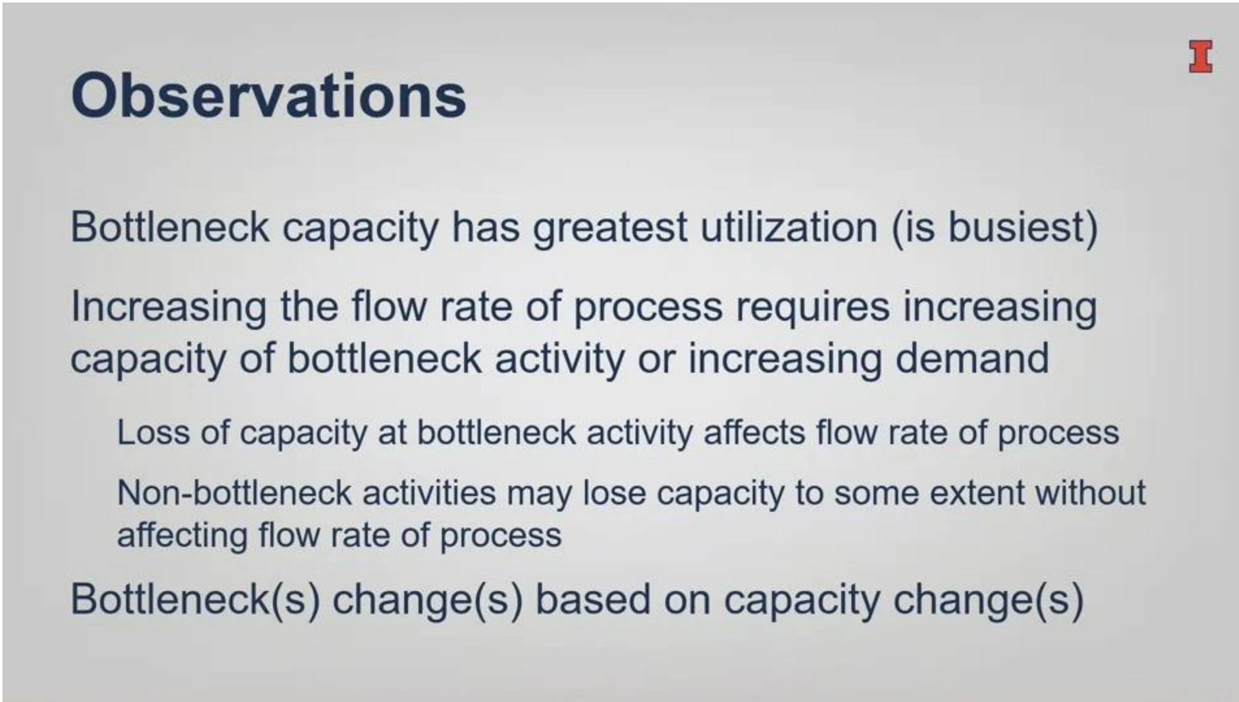
The metric of capacity utilization can be understood based on the intuition that utilization is the ratio of what a process is doing to what a process can do. So in short doing divided by can do. More formally the capacity utilization is the flow rate of the process divided by the capacity of the process.



In order to calculate the capacity utilization of this three activity process, we first identify the bottleneck activity. The flow rate for the process based on this activity is 20 per hour. Now we can calculate the capacity utilization for each of the activities. Again, the flow rate of the process is 20 per hour, because we are basing this calculation of the capacity utilization on the bottleneck. We are basing it on the fact that the bottleneck is a 100% utilized. Activity two, 50% utilized and activity three, 33% utilized.



Now here is the three activity process with processing times and resources. The additional information here is that the demand rate is 18 units per hour, customers are demanding this product at 18 units per hour. What is the capacity utilization for each activity? Because the demand rate is lower than the flow rate of the bottleneck, the demand rate becomes the flow rate for the process. Here, the utilization is going to be the flow rate of the process divided by the capacity of the activity. So activity one, 90% and activities two and three, 45% and 30%. The activity with the lowest flow rate has the highest utilization. The bottleneck has the highest utilization.



Some general observations about utilization of activities in the process. The bottleneck, the activity with the lowest flow rate has the highest utilization. Increasing the flow rate for the entire process requires to increase the flow rate also known as capacity of that bottleneck activity or the demand rate, whichever of the two is lower. Because the bottleneck constraints the process, it is important to get production to the extent of its potential. As long as an activity is a non bottleneck activity, losing some capacity at that activity will not affect the process capacity unless and until that activity capacity falls to the level at or below the bottleneck capacity. Capacity changes may cause the bottleneck to shift, may cause it to change.

Capacity utilization can get impacted by any reduction in the realization of the capacity because of stoppages or errors. Now, stoppages can be for changing over from making one product to another, or they can be for things like machine breakdowns. Capacity utilization is also impacted by the errors, by creation of product that has to be scrapped by time taken by the errors that had to be corrected. Capacity utilization is also impacted by variation in the performance of machines and the performance of employees that are working on the activities.