MITOCW | Ses. 3-6: Six Sigma Basics

PROFESSOR: OK, so we're going to talk about Six Sigma. Now, if you've seen, the course is heavily weighted towards Lean with a little bit of Six Sigma. And we think that's the appropriate place to start. But we need to get you started on Six Sigma. And so learning objectives here are that Six Sigma is a valuable approach for improving process quality. OK? And we'll try to explain a little bit more about that.

We're going to have you be able to interpret a basic statistical process control chart. That's what the active learning experiment's about. We're going to talk about the difference between process control limits and specified control limits. And you'll be able to describe what a capable process is.

OK, so Six Sigma is a strategy to improve process quality by identifying and eliminating defects, and defects in the broadest possible sense, not just defects in the size of a hole being drilled, but defect in something that you want to deliver your customers, not what they want. That's a defect. OK? It's a very data-driven approach.

So if you've seen Lean-- in fact, one of the comments we got back on the feedback sheet is it's kind of a lot of touchy-feely stuff you're covering. And Lean is, in some ways, a lot of touchy-feely stuff, because of the importance of people. Six Sigma, if you read the literature on Six Sigma, at least the literature I've read, people are never mentioned. It's about a problem-solving process. And that's important, but it has its limitations.

And the important thing is to know when to use it and how it fits in with a more holistic Lean approach. And it's a very structured implementation approach with certified experts. You probably have heard of black belts and green belts, and things like that, OK. So Six Sigma has this hierarchy of experts.

And that's really not the mindset of Lean. The mindset of Lean is the experts, the coach, not the person who knows the most. It's the person who gets the most out of the people there. So there's some big cultural differences between Six Sigma and Lean. But they've come together, and the important thing is to try to understand that.

Now, where does the word sigma come from? Well, this is a pretty analytical group, so you probably all know this. But a normal distribution, something like what you just saw with the M&M's-- although that wasn't quite normal, but it was somewhat close to that-- is defined by the standard deviation, which is sigma. And in this chart-- so this is one standard deviation from the mean, two standard deviations, and three. And Six Sigma would be six standard deviations.

And just keep this in mind. We're going to deal with some Three Sigma in a little bit, coming up here. Three Sigma is 99.73% of the area under a normal distribution, would be within a Three Sigma band.

OK. An important part of Six Sigma is defects. Because the goal of Six Sigma is to reduce the number of defects per million opportunities. And a defect is defined as any process output that does not meet the customer specifications, as I mentioned earlier, in a very broad sense. OK? And so you've got two things here. You've got opportunities and defects.

So you want to reduce the defects, but you also, in many ways, you want to reduce the number of opportunities to have defects. OK, so reducing the number of hand-offs-- Sue mentioned the baton. Hand-offs between people are always a potential source of mistakes or errors or misunderstandings. Just think about how many miscommunications have you had with your boyfriend or girlfriend or parents or best friends. So hand-offs of any kind are something that you want to minimize.

I just read some literature I'm going to share this with you, since we're in the aviation field-- I'm in the aviation field. The data from last year's commercial air transport travel in the US was there was 0.02 fatalities for every million boardings, 0.02. I think that's a nine sigma. Yeah, OK. So that gives you kind of a benchmark of something being really good.

But how good is good? Some people say, you know, 99% is good. I mean, If my car starts 99% of the time, and it's an old car, that's good. But that's three days out of the year, I'm not going to get out of my garage, and I'm going to miss getting to my appointment. OK, that's not so good.

So 99% you might think is good. But that's 20,000 lost article of mail per hour; unsafe drinking water for 15 minutes a day; in this audience, 5,000 incorrect surgical operations per week; two short or long landings at a major airport each day; 200,000 wrong drug prescriptions a year. That's not really very good, 99%. This is much better, Six Sigma. This is what you're looking for. OK? 1.7 incorrect operations per week-- even that's too much. But boy, that's a lot better than 5,000. If you're one of those 1.7 people, you don't care what sigma it is. You just got--

[LAUGHTER]

Same here. And as I mentioned, airline travel is nine sigma for safety. OK, so a basic tool in Six Sigma is called the statistical process control chart. So a chart shows-- so it's a sequence. This is a time chart. And we're going to build one just shortly. It's time, and this is some measurement. And this shows how stable it is, how much it's tending to be around the center of the chart.

It's a very common chart. And in both fields, if you go into a production facility, an engineering, production facility, now the operator will be showing you their control chart. I couldn't believe, when I first went in and saw the machinist proudly or the machine operators showing me their control chart. I see control charts all through health care.

So let's make a control chart. OK, so we're going to do a little experiment, a little thing here. We're going to put it in the framework of a pharmacy. For those of you who are not in the framework of health care, you could think of another application where you're getting something.

But our pharmacy here dispenses a medicine called a White Bean Medicine. And we get it in bulk from two different suppliers. This is our brand name supplier, Goya. And it appears to come from Spain. It's a little hard to tell what the original source is here. But at the end of it, there's some Spanish, and so I presume it comes from Spain.

And this is our generic supplier, [? Shaw's. ?] So we get these two suppliers. And if you read the back of the [? Shaw's-- ?] well, you can read the back of the label, if you need to, later. So our pharmacy gets it and puts it in these bins. And then they've decided to measure dosages by volume.

Now, usually a dosage is by weight. OK? But it's much easier just to scoop this up and fill it than to scoop it up and fill it and weigh it, and so on. So we're doing it by volume. And what we want to do is to track our pharmacy dispensary, to be sure that we're getting consistent weight. And so our pharmacy-- this is not a critical medicine, but it's widely used in our facility. So we dispense a lot of it each day.

And so what we've done in our pharmacy is our pharmacy is going to take three samples of this medicine each day and weigh it. And the next day, it will take three more samples and weigh it. And we're going to build this chart to see what it's like.

And the pharmacy has been very cooperative. They've given us 20 samples, that are already on your table. OK? And then I'm going to tell you what to do. We're going to enter this data.

So we've got a three-cup sample. We're going to enter data into control charts-- one for the average weight and one for the range of the weight of the three cups. And we're going to use it for 20 days to establish our process capability. So we're going to measure for 20 days, and then that's going to tell us, do we have a stable process? And we can monitor after that. And so that's what we're going to do.

So our first phase is now each of you are going to weigh this. You each have four days. In the center of your table, you have 12 cups. And the cups, there are three cups for each day. It says right on there, this is day 16. There are three day 16 cups.

And you have a sheet. And your sheet says, here's day 16. So you measure cup A, B, C. You compute the average-- we can get some calculators, if you need it-- the max and the min and then the range, which is the max minus the min.

And then you bring that up here to data central. And we'll record it. And you have a scale. And you want to use grams. This is in pounds and kilograms. You want to use the kilograms scale to get it in grams.

And don't use this now. But when we're all finished, we'll dump the beans in there. But don't do it now, because we may need to go back and do some second measurements. OK, so please now start at your tables measuring these samples, filling out the chart, and bringing it up here.

[INTERPOSING VOICES]

AUDIENCE: 98.

AUDIENCE: Oh, my goodness.

AUDIENCE: Excellent. Very [? well done. ?]

PROFESSOR: OK. So we have all the data. And my helper over here is going to enter it day by day, so it unfolds like you would see a normal control chart, if you're watching it day by day. So he's now on day five.

Now, what we have-- this is the mean average. This is the average, and this is the range. And this is the mean of the average, and this is the mean of the range. OK? And then what we have here are these red lines are the Three Sigma lines. Remember, on a normal distribution, I said Three Sigma.

So the way these control charts work is you get this data. And it's been established that the processes-- you look at a three sigma deviation. And as long as you're within that three sigma deviation, your process is under control. OK, that's just sort of what's evolved.

And of course, these red lines will change as he enters the data, because he's getting more and more samples. So this is like watching the election returns on election eve.

[LAUGHTER]

AUDIENCE: We're all [? down here. ?]

PROFESSOR: OK.

AUDIENCE: [INAUDIBLE]

PROFESSOR: So we're up to day 10.

AUDIENCE: [INAUDIBLE]

PROFESSOR: OK, and what's going on in the background-- one of our colleagues at Cal Poly put this spreadsheet together. So this shows the [? app, ?] the mean, what's called x bar. This is x bar, and this is r bar. X is the average, and r is the range. And then we've got the upper and lower control limits. These are called upper control limits and lower control limits. We've got the upper and lower control limits for the average and for the range.

And usually, the way this field works is 20 samples is considered a good enough baseline to establish the process capability. So oh.

AUDIENCE: Oh-oh.

PROFESSOR: [INAUDIBLE]

AUDIENCE: I'm double-checking the data.

PROFESSOR: Can you double-check that?

AUDIENCE: Yeah, I'm double-checking. [INAUDIBLE] what's on the sheet? We may have to go [INAUDIBLE].

PROFESSOR: OK, well, let's finish it off. Let's keep going.

AUDIENCE: OK, so that's it for 20 data points.

PROFESSOR: OK, so something's obviously funny with day 15. So when you have some funny data, what do you do?

[INTERPOSING VOICES]

PROFESSOR: Go to the [? gemba. ?] So who has 15? OK, so let's go take a look at 15. What's going on here?

AUDIENCE: [INAUDIBLE] Which sample is that one?

PROFESSOR: Can you weigh it again?

AUDIENCE: It's cup C.

PROFESSOR: It doesn't look quite full, does it? Why don't you put some more beans in there.

[LAUGHTER]

Just fill it up kind of like the rest of these.

[INTERPOSING VOICES]

PROFESSOR: What's now?

AUDIENCE: 73.

PROFESSOR: OK, so now, on day 15, something happened in the pharmacy. And all three cops are shy by 1/4 inch, 1/8 inch, something like that. So what we would probably do is go back to the pharmacy records and see what happened. And we might find out, for example, that some employee had been ill that day, and they'd hired a temp. Or a fill-in wasn't cross-trained properly, and they thought this was a full cup, a full dosage.

So we can eliminate. Let's delete that point. We know that that point is no good, because for certain-- we can see it. We can verify it's no good. So--

AUDIENCE: What happens if I [? blank it? ?]

PROFESSOR: OK, that's fine.

AUDIENCE: Going to zero?

PROFESSOR: OK.

AUDIENCE: Is it going to go to zero?

PROFESSOR: No, that's fine.

AUDIENCE: [INAUDIBLE]

PROFESSOR: No, no, that's fine. It's fine. Yeah. Thank you, sir.

AUDIENCE: All right.

PROFESSOR: Yep. OK, so now we've got our process capability established. We've got 20 days minus the 1 bogus day. And our upper and lower control limits are-- we know now, for our process, it's 75 and 69. And we got them for the range. OK? So good. Thank you.

So that's how we would build a control chart. So now we're going to do a little bit more slides. And then we're going to come back to see how we use this control chart. So I'm going to change now from the basic control-charting to a little bit about the basic Six Sigma method, called DMAIC.

And DMAIC is another Deming cycle. It's like plan, do, study, act, except it's slightly different. It's called Define, Measure, Analyze, Improve, and Control. And so DMAIC is the easy thing to remember.

So if you're doing a Six Sigma intervention, like in our pharmacy, we would have to define, who are the customers? And what are their requirements? So in the case of the pharmacy, the customers would be whoever has ordered the medicine, and they have some requirements.

And then we want to know what the key characteristics are important to the customer. Well, the customer for medication is really interested in weight. They don't care too much what it looks like. They really don't care how it's packed in the cup, things like that. But they're really interested in weight. And of course, we're using volume, because it's a little quicker, but they're interested in weight.

So OK, then you measure. So once we know the key characteristics, then what are the key input and output characteristics? And you want to verify the measurement system. So here are output characteristics, is the weight of the cup. That's what we're measuring.

Later on, we might get more sophisticated and measure the input characteristics. Like, we might weigh these two samples, or something like that. But right now, we're just focused on the output characteristics.

And we collect the data and establish the baseline performance. That's what we've done. OK, and then we've done that so far. Then we're going to look at the raw data. We convert the raw data information and get insights into the process.

Well, we already found out we had something wrong with poor Molly. On day 15, she got the flu. And we had a good temp, but we didn't train the temp. So we've learned now that training is important so we don't dispense the wrong medication.

OK, so we've improved. We've developed a solution. And now we want to put our process under process control. I [? mean, ?] under process control, we're going to now monitor day by day the medication dispensing and see if it stays within control. That's DMAIC.

So here's a simple example. You have a process. So you have a defined process with an input and an output. You measure the weight with a scale. You analyze the data with the control chart.

Then you want to improve the process. We just talked about training is one improvement. And then you put it under process control. So that's the basic Six Sigma cycle.

This is one area where I said, in Lean, when you came out of this course, you could probably pick up any book in Lean, and you could go for it. If you pick up Six Sigma books, they do a deep dive into a lot of math. So it's a lot of statistical mathematics. So you may need more than what we've taught you, because we're not focusing on math. OK.

It's easy to see in a process control application like this. It may get more complicated if you're looking at something that's not quite so visual. But anyway, that's the way it is.

OK, now there are certain kind of variation in the process. And actually, our control chart was a good example of that. There's what's called Common Cause Variation. And this is just the sort of randomness in the system, the things that affect all the samples.

And then you have Special Cause Variation. And we just had an example of that. Common Cause was the different variations of 19 of the 20 days. And then we had one case which was a Special Cause Variation. We sort of went out of bounds. In that, we could go in, and we could intervene fairly quickly and correct.

To get our Comma Cause Variation down, we're going to have to do something different here. We're going to have to be much more careful about how we fill the cups, and stuff like that. We might have to have more careful procedures. But the Special Cause Variation, we want to drive out of the system.

And the control charts give you a way to quickly see the differences between these two. So let's look at an example. This is actual data for patient falls. I've forgotten the facility. Anyway, the reference is just off the back of the bottom of the screen here. But this is patient falls.

And we've heard sue mention this morning how patient falls are-- you had it on a slide. It was something about there being a source of waste, or something.

AUDIENCE: [? Patient ?] falls are considered [? to have ?] never have been something [INAUDIBLE].

PROFESSOR: [? They've ?] never [INAUDIBLE]. Great-- never [? met, ?] OK. And here we've got, in this facility, this is by month. And we got an average of about six patient falls a month. And they've been charting it. And we have an upper control limit of about eight and a lower control limit of about four. Now, how many patient falls would you want?

AUDIENCE: [INAUDIBLE]

PROFESSOR: None. OK, that's a customer-specified limit. There's a difference between your process limit. This is your as is process. In this case, your process is not very capable in the eyes of the customer.

So we're going to get into this towards the back end of the module about the difference between the process capability, the upper and lower control limits, and the upper and lower specified limits. So I just introduce it here as a teaser so you don't fall asleep.

OK, so now, in this facility, they tracked it for 20 days. And then they kept tracking it. And then something starts going kind of bad here towards the end of the around 28th month. We've got something that's kind of getting up to the control limits. And then we've got something that's going outside the control limits.

And this is when the red flags start saying, OK, we're outside the normal bounds we consider acceptable. We better go investigate what's happening here. And that's what we did with our pharmacy thing.

So now what we're going to do is continue our exercise. And the first thing I'd like you to do is take the cups. And there's a white tray in here. And dump all the beans that you have into there. And just nest the cups back together.

And then the pharmacy's going to bring you a new batch of cups. So let's get these out of the way first. OK, so while we're getting some help here, what's going to happen is, each of the stations on their easel has a chart for the average and the range. And what I want you to do is to come put a scale on this where you're going to put the--

OK, the upper control limits, we don't have to be accurate to the second decimal place here. It's about 75.4 and 69.5. So we want to do something like this. First of all, let's get the mean. I'll just do one, and I'll let the other tables do theirs.

So this is 72.5. That's the mean. And then the upper control limit is about 75.4. So we'll just put that here. And the lower control limit is 69.5.

OK, so you're going to want to finish that. This is for the average, and this is for the range. And I'll let each team finish their own. And you can come up here and get the data if you need to. And then--

AUDIENCE: [INAUDIBLE]

PROFESSOR: So we want to draw the control limits on our chart. That's now fixed. That's our process capability. And now we're going to start moderating it for days 21, 22, 23, 24, but you're each going to do it. You're going to do 21, 22, 23, 24. You're going to do 21, 22, 23, 24. OK?

And you're going to measure three samples each day and plot the data on your control charts. So whatever the data is for the average on day 21, you put here in the range. On day 21, you put here. OK? And you're going to look at it. And you're going to see whether your process stays under control or whether it-- is it doing this, or is it doing that, or that, or something else?

And if it starts going out of control, once you've decided it's out of control-- you may have to watch a little bit-- then it's time to stop to investigate in what the root cause is. Just like we did here, we went to the table and found out the root cause was it wasn't filled.

But we want you to do this in a structured way. OK? The tendency you're all going to have is to say that I know what the root cause is. Somebody didn't fill it. But maybe or maybe not.

So we're going to ask you to use a fishbone diagram that Analisa just told you about. And that's on the second page. And start thinking about all the reasons that the behavior you're observing might be happening.

For instance, could it be that Aubrey, who was thinking about something else, didn't weigh it right? Maybe it's a measurement thing, so that would be a personnel. Or maybe you got a crummy weighing scale. That's a machine.

So start filling out all the things you can. And then, when you get those filled out, then start looking at them systematically. Which one do you think is most likely? OK? So it's a detective operation.

So now you're going to actually do a root cause analysis. OK? OK. Does anybody have any questions about-- yeah?

AUDIENCE: So the upper and lower limit and the average that we're using are from our first sample?

PROFESSOR: We've established our baseline, yeah. So that's not going to change [? anymore. ?]

AUDIENCE: Do we all use the same one?

PROFESSOR: You all use the same one. Would it help if I write down those numbers?

AUDIENCE: Yes, especially there on the left [? in the screen. ?]

PROFESSOR: Yeah. Can you see them?

AUDIENCE: Yeah, there it is.

AUDIENCE: 75.4 and 69.5.

PROFESSOR: Yeah. Oh, you've got good eyes. OK, it's nice to be with young people.

[INTERPOSING VOICES]

And then now, you just operate on your own. You're all independent. Think of yourself as the independent measurement quality control group of a pharmacy. OK?

AUDIENCE: [INAUDIBLE] for A.

AUDIENCE: 0 to 7 and 1/2.

AUDIENCE: 74. [INAUDIBLE] There's a rock in mine. [? Turn ?] [? it ?] around.

AUDIENCE: Yeah, [INAUDIBLE] [? wrong ?] with it. [INAUDIBLE]

AUDIENCE: Average is going to be [INAUDIBLE].

[INTERPOSING VOICES]

AUDIENCE: So it will be [INAUDIBLE] 16.

AUDIENCE: [? RG ?] is-- OK.

AUDIENCE: [? And ?] are the machines that you use for calculating [INAUDIBLE]

[INTERPOSING VOICES]

AUDIENCE: So let's talk about how those might have been issues.

AUDIENCE: OK. [INAUDIBLE] materials.

AUDIENCE: The cup itself?

AUDIENCE: Yes, sir.

[INTERPOSING VOICES]

AUDIENCE: You want to write those down?

AUDIENCE: Quality of [? scale? ?]

AUDIENCE: Yeah, quality of [? scale ?] [INAUDIBLE] machine [INAUDIBLE].

[INTERPOSING VOICES]

AUDIENCE: It could be not leaving it long enough on the scale.

AUDIENCE: Well, I just sampled three different ones.

[LAUGHTER]

AUDIENCE: [INAUDIBLE]

AUDIENCE: So bean variations.

[INTERPOSING VOICES]

AUDIENCE: I think it's pretty full.

PROFESSOR: OK, well let's see.

AUDIENCE: [? If ?] we dump it out?

AUDIENCE: Well, I'll try dumping it out and see [INAUDIBLE].

[INTERPOSING VOICES]

PROFESSOR: [INAUDIBLE] [? It's ?] [INAUDIBLE].

AUDIENCE: Why are they [INAUDIBLE].

AUDIENCE: Oh. Look at that.

PROFESSOR: OK, so going around the room, we had a range of a root cause analysis things, ranging from-- this table just said, we think this is the cause. And they tested it, and that was the cause. So they just jumped right to a conclusion. We had a very structured process over here.

But this is a way to make it visible. If you go into a facility that's under statistical process control, the employees are trained on this. And they're trained to recognize this kind of deviation. And then they do something about it.

OK, here's a chart for resident falls in a long-term care facility, control chart. And here's their 20 days. And this was their control. Now, in this case, they were intervening to try to reduce patient falls. So this is not now just doing nothing. They're doing a bunch of interventions. And these are different interventions.

Actually, what they did here was-- it's not on the chart, but what they did was they just simply identified the patients in this long-term care facility who were susceptible to falling. And they put stickers on their wheelchairs or their walkers in their room and on their charts. And they picked stickers that were so interesting, that the residents who weren't in danger wanted the stickers, too.

But just being conscious of-- those were at-- the at-risk patients started to drop it. And you can see their interventions lowered the mean and lowered the control limits and lowered them again. And this was a process improvement study that I actually heard at the last IHI meeting.

OK, so now our last topic-- this is Process Capability. Process Capability is defined as the ability of a process to meet the customer expectations. And what we have here is we know what the capability is, but we don't know whether it meets the customer expectations. And to get the customer expectations on there, we have to find out what they want.

HUGH MCMANUS: The customer-determined limit, the spec limits, are essentially what the customer wants. The upper and lower values between which a process must be controlled-- that's what the customer wants. The bounds in which we choose to control the process, or which we try to control the process, are the upper and lower control limits of the process.

So how do we measure, given those two definitions, the process capability? One way to do it is to think about the process. And again, this is an approximation. But it's a pretty good one, under a lot of circumstances.

The process is having a normally distributed behavior. So if we collect some data, we can assume a normal distribution, do some statistics using our statistical tools, and decide how good or bad the process is. And if we have a normally distributed process, its behavior is going to be characterized by its standard deviation, sigma.

And if we draw our spec limits around that normal distribution-- here is our lower spec limit, and here's our upper spec limit-- we can define a quantity CP, the process capability, which is essentially this distance here, the upper limit less this lower spec limit-- so that the range which is acceptable divided by the Six Sigma of the process. And if we have, say, a CP of 2, that's a very tight. Basically, the spec limits are twice Six Sigma of the process.

Then it's a very tight distribution inside the spec limits. And the chance of something bad happening are very, very small, the chance of going out. So a CP of 2 is a very good process. That, in fact--

AUDIENCE: [INAUDIBLE] Six Sigma is [INAUDIBLE]--

HUGH MCMANUS: Six Sigma--

AUDIENCE: --standard deviations [INAUDIBLE].

HUGH MCMANUS: That's right-- six standard deviations on either side of the mean, right. So a CP of 2 would be a Six Sigma process. In that sense, it would be a very good one. And just graphically, you can just see there's basically no tail sticking out of the bad zone.

CP of 1 means you've got three sigma on each side. Three sigma, you've got 97 point whatever percent of the process falling in that range. So the chance of something falling outside the range is quite small. But it's not 0. We can see a little bit of ink here outside of the acceptable range. And once we get below 1, it starts getting ugly. We really don't want to even talk about that-- so from a statistical process control point of view.

Another issue which one can ignore is the fact that we may not be centered. And we can actually redefine our process capability using a metric called CPK, which takes into a fact that we may drift off mean. And it's defined this way. It's basically the distance to the closer boundary from where we are divided by three sigma. And it's whichever one of those is worse.

And those same curves shifted over 1 and 1/2 sigma look a lot less pretty. Our former Six Sigma process now has a CPK at 1.5. But it's still OK. There's a tiny, tiny-- there's a couple, like two pixels worth of ink sticking out there. The chance of a defect is still very, very small.

But our formally OK-looking CP of 1 process now has quite a bad-looking tail. And our process that was bad is now horrible, our relatively uncontrolled process. So that's a different way of measuring process capability, which takes into account the fact that the mean may not be on the center.

What we do with these two measures is different. Here we have a archery example. This is a classic statistically characterize-able process. We have shots that are both widely dispersed and off-center. So how would we characterize that? It's basically low on both metrics, right? It's widely dispersed, and it's off-center.

Here's another archer. It has a tight distribution, but it's way off-center.

AUDIENCE: So CP is high.

HUGH MCMANUS: So CP is high, and CPK is low. That's right. So that's the difference between those metrics. On this metric, it looks great. On that metric, it does not. And this, of course, is what we want.

If you're an archer or any other person who needs to control their process, what do you do first? Yeah, I'm cheating a little bit on this one. I do archery sometimes, not very much. But you have to do this first, actually. You have to get your process repeatable, even if the meat is way off.

Because if you're correcting every time, then it just goes all over the place. But if you just go, OK, same thing every time, OK. Five times in a row, I've hit up and to the right. Now I'm going to adjust. So often, you concentrate on knocking your CP down first, to understand your process, to see where the mean is. Because you can't really measure the mean in a situation like-- you can statistically, but it's hard.

OK, enough of that. This actually-- remember we said we would-- I'd tell you where the definition of Six Sigma comes from. Interestingly, it comes from a process with a mean shift of 1 and 1/2, which would give you three defects per million opportunities. So if you have a very good process, but you still don't control your mean to more than 1 and 1/2 sigma, you still have a very low defects per million.

That's where that idea comes from. Those are some of the concepts that we use to get processes under control and keep them there. And Six Sigma, as an overall method, is very useful for taking variation down, especially in critical applications like large-scale manufacturing or health care, where you want your defects to be very low, your variation to be very low.

We've talked to you about control charts, which is a great place to start. It's not the end. And we've glossed over all the statistical tools you need to really understand the numbers. But the visual is very powerful in and of itself. Even if you don't do the statistics, having the visual evidence of what your process can do and whether it's deviating is very powerful. And once we understand what our process can do, we can compare that to what the customer wants and understand the capabilities of our process and whether they're acceptable or not.