Six Sigma
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Module No. # 01
Lecture No. # 35
The Journey to Six Sigma

Good after we resume again the our lecture series on Six Sigma. We have 2 sessions planned this afternoon for you. The first is going to be a journey.

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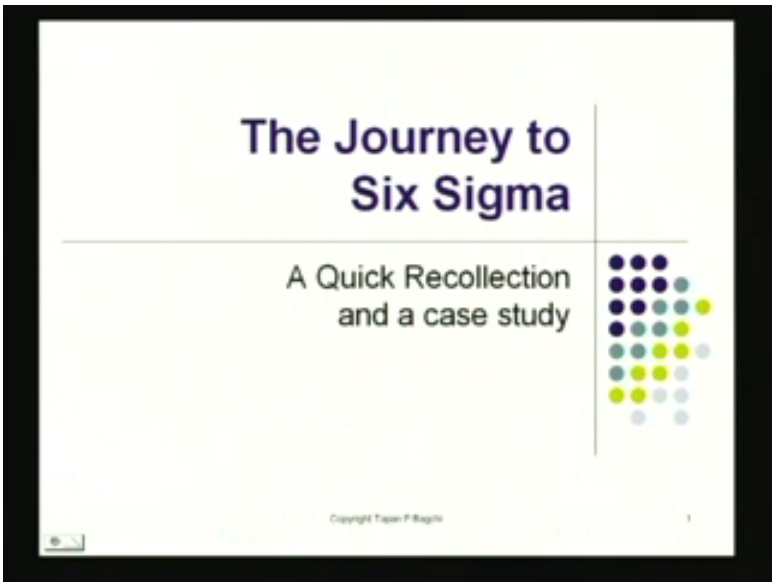

So, we are going to recapitulate some of the material that we have been discussing so far. That will be like the first part of the, to our session. And the second half I will try to illustrate the methodology using a case study, a live case study that was conducted under the Dmaic framework. This is what we will be doing.

Starting out we obviously have going to be we we will be doing the quick recollection first.

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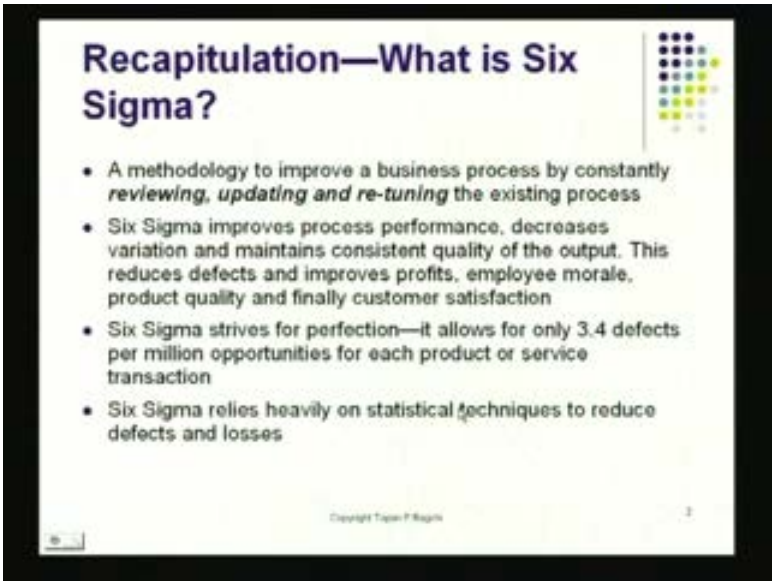

Then of course, the 6, the Six sigma case study is going to follow. From that, let us try to recapitulate, let us try to recall what actually is Six sigma. It is a method to improve business processes and this is done by constantly reviewing and updating and also retuning process which are there. These could be existing processes or in need of improvement and so on so forth. So, that is what provides the motivation for doing this. What does a Six sigma achieve? First of all it will improve process. Process performance is going to be improved by Six sigma. It is going to decrease variation and it is also going to may help maintain consistent quality of the output.

These are some of the accomplishments of Six Sigma. When you when you complete the project successfully this effort is going to reduce defects and also improve profits in the end because there will be fewer losses. It is going to raise employee morale because they will be working with the process that has got good quality coming out of the system. So, product quality would be impacted and finally, of course customer satisfaction is going to go up. These are some of the benefits of Six Sigma. Six Sigma actually strives for perfection. It allows only three or four defects per million opportunities where you could make a mistake, where you make a make an error. It tries to minimize that. It tries to bring it down to the level of three or four parts per million opportunities. And of course, to be able to do that it relies very heavily on statistical methods in particular design of experiment. That is like something it cannot really do without.

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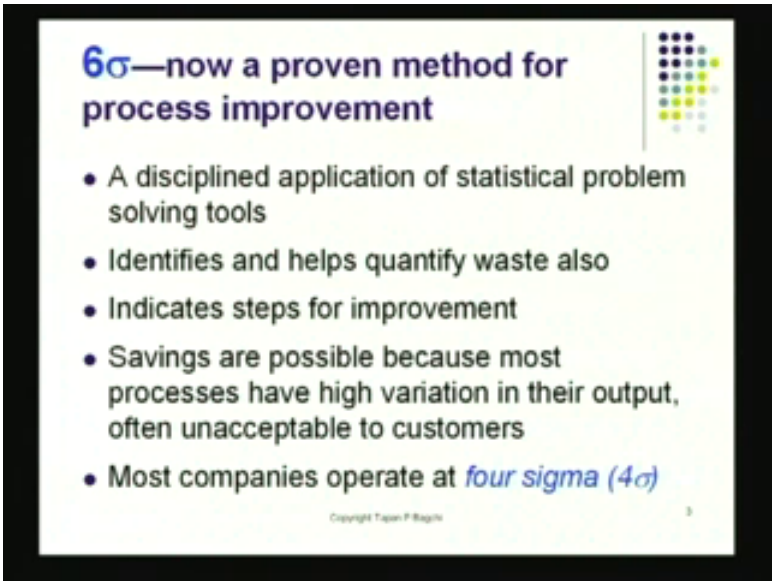

It is a proven method now. It has been proven many, many times and Motorola saved billions of dollars something in the order of seventeen or eighteen billion dollars. Motorola ended up saving once they adopted this Six Sigma approach. It is a disciplined approach. It is an application of statistical problem solving tools in a disciplined way. It identifies and helps to quantify wastes also. If there are wastes in the process, if there are waste in the as the as a as a byproduct of the process itself. It tries to minimize that it tries to basically reduce them to 0. It also indicate steps for improvement are required that is done by the process as the process moves along. As as you move along the Six Sigma path, you locate many opportunities wherein improvements could be made. Savings are actually possible because many natural processes, many processes that have not been worked upon those actually demonstrate high variation in their output and that is sector gives us the opportunity to be able do that. If you for example, if you look at a process that is an existing process most companies today they are operating around three or 4 sigma by the sigma metric. So, in fact there is a large opportunity to go to go from there to the Six Sigma level. There is a large opportunity there. The gap is pretty wide which should mean the a lot of customers who are not satisfied with the products we provide or the services that we provide them. They are really not satisfied.

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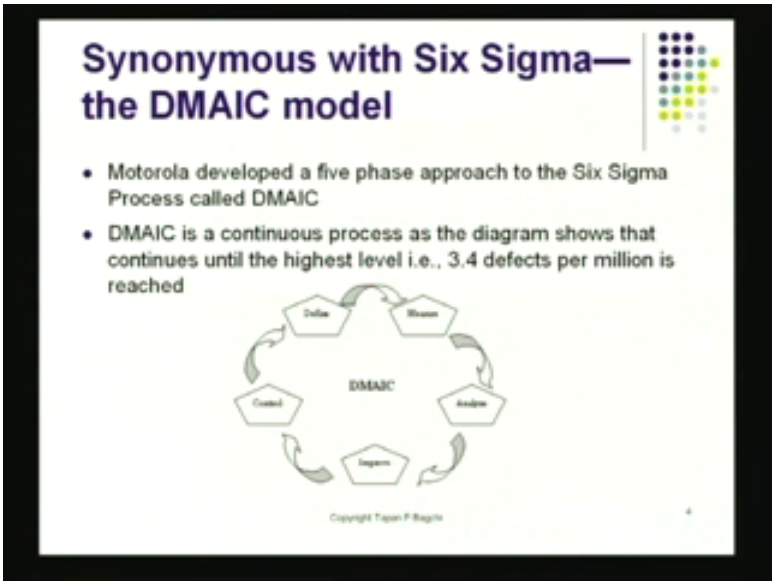

If you look at the process, if you look at the process the Six Sigma approach is pretty well synonymous with the DMAIC model. And DMAIC, as we are going to be discussing in this session here and we have already done that in the past, it comprises five steps. You define the issue you define the quality issue that is there, you measure the the extant of that performance, you try to find out what current performances. Then you go through an analysis which is the analysis steps of step of DMAIC. And once you are done the analysis, you identify certain actions which might move the process towards an improved state. And that would be done under the the step called improve in DMAIC and this is where you will be utilizing statistical method such as such as for example, design of experiment that could be one of the methods you would be using. There could be many other methods also that you utilize. Quite often actually you if you start recording data and if you start plotting the data and so on and so forth lot of problems become visible. Let us say you come up with the process which if of which is one that is nowhere near this Six Sigma level of operation. It is probably near two sigma or three sigma. You will find it quite easy in fact to do some trials and tests and so on provided you use the framework of DMAIC that you achieve an improvement and that is going to be really the new level of performance. Once you identify that your job is going to be to control the process to keep there. So in fact the five steps are going to be define, measure, analyze, improve and then control. This is what DMAIC comprises. And that process has become that that method actually has become synonymous with any Six Sigma program that we talk about.

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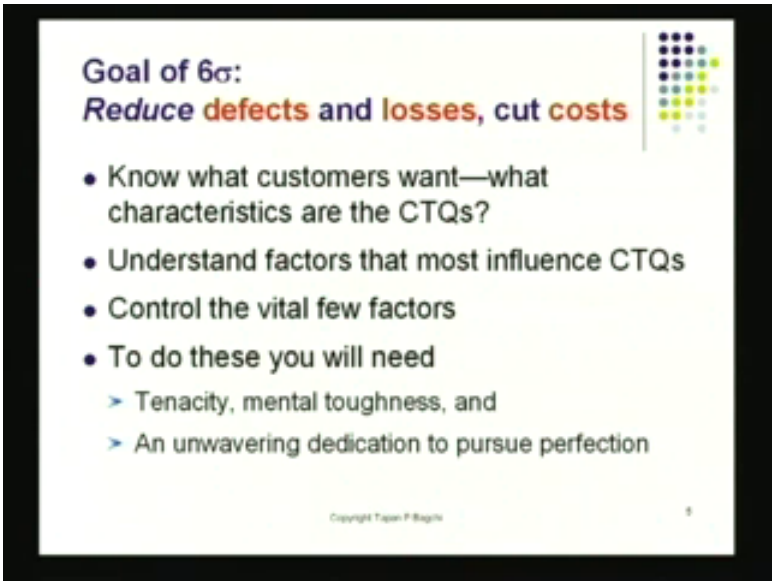

What is the goal of Six Sigma? The goals are pretty straightforward. Six Sigma basically aims at reducing defects and and losses and it tries to cut cost and thereby tries to improve profits. In fact, the starting point really is to try to find out what the C T Q's are. What are those quality characteristics that customers would like to have? This is something that is the starting point of a Six Sigma program program or Six Sigma project. Then the second thing is to try to understand factors they impact the C T Q's. This is something that you'd like to identify because you would like to have some actions to follow through the project. If a if I found out what the problem is and if I found out it is it is reasons it is causes then of course, you get something to act on that is going to one of your steps control. Now you try to control the vital few factors that have the largest impact on the C T Q's those characters takes that are critical to quality as far as the customer is concerned. To be able do these things of course, you need some percent quality and these are these are required by the members of the team, members of the Six Sigma who really take care of the project, you got to have tenacity; you should not give up you should have mental toughness. There may many situations that will be tough for you to handle. You must be that tough to be able to go go through it and of course, you must have unwavering dedication to pursue perfection. In fact this is something that you really require. You must seek perfection at almost any equals. That is something if you show that drive there there is going opportunities when you you might actually have second thoughts and so on and so forth. But, stick by it and you'll end up delivering the, what we call a better process.

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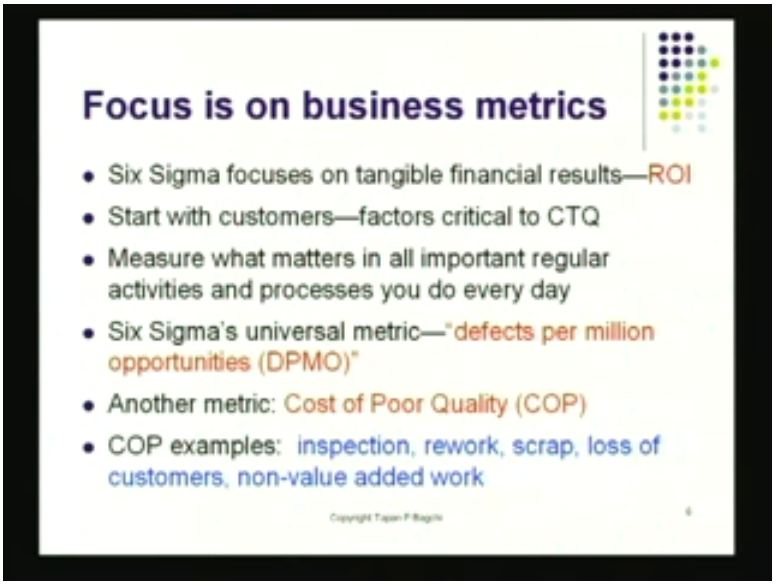

We would start the starter point is going to be focus, by focusing on business matrix. Now, I should just recall here. Remember the old method for managing quality was to do T Q M, total quality management. And there are five pillars on which T Q M was founded. Top managements, direct involvement that is that like came even without saying unless top management grows quality or the machine to try to satisfy customers. It just would not happen. The second thing was strong customer orientation. That was the second facet of total quality management, T Q M. The third was applying statistical methods. When you have problems, your actions should be data-driven and the signs for handling data are basically statistics so that is why the methods that you will be utilizing as per the recommendation of T Q M is statistical method. The fourth item is going to be everyone will participate. This is also the main thing that is required. You cannot just say that the quality control department or the production department, they are going to be in charge of quality. Nobody has anything to do with it. That is certainly not true if assume T Q M to be guiding your company. And the fifth and the last one is continuous improvement. These are the, they are the five pillars. They are the five pillars of total quality management.

What is missing unfortunately in this and that is why many people had second thoughts when they launched T Q M program. They did all the training and everything and results were not there. The problem with T Q M is it does not really show any incentives for making improvement. There are no dollar incentives as the bottom line of total quality

management. It is to be taken on faith because it works. If you ask people why should I do T Q M they will probably end up responding because it works, because it has an impact on quality. When unfortunately that dollar or the money power of the incentive or the bottom line or return on investment now none of these financial considerations are there when people talk T Q M. The result is this this was actually when people had management in particular wanted to get something on which they could hold on to and that was actually if they had a project that showed an R O I in the end. So, this was like one of the key things that were utilized that was incorporated in Six Sigma project. No Six Sigma project can be launched unless the project can project to to to achieve a certain level of level of R O I for the for the investments and for the resources that is expending on that improvement project. So, every Six Sigma in improvement project must produce an R O I. Without that you cannot really justify any activity. It is not going to be any different from your general management of quality. So, Six Sigma is quite distinct that way. It must have, it must be able project that I am going to be producing so much of R O I.

The next thing is you have got do, you got to start with customers. Find out what these critical to quality factors are, what the C T Q's are. That is going to be very important. You got to be able to measure them and the ultimate goal of Six Sigma of course, is to look at to measure your performance on this universal metric called D P M O or defects per million opportunities. Six Sigma reaches the level of three or four parts per million. If you have done it right you will end up with a process that is very consistent and you will produce defects which are like products that are not acceptable to customers only to the extent of three of four parts for a million parts. Another metric that is also utilized in Six Sigma particularly when you are looking for a project is to look at your data on cost of poor quality and then of course, there are four components of that; there is the appraisal cost in cost of quality, then there is there are the external failure cost in cost of quality and this we have covered in the earlier lectures. Then you got internal failure cost which will comprise scrap, rework those sorts of things. And the last one that really pays is prevention cost. If you increase prevention cost that is like taking proactive actions that will, that is like assuring quality and with that your appraisal is going to come down, appraisal cost is going to come down. External failure cost is going to come down; internal failure cost is going to come down. So, it is not that all cost of quality are bad, prevention cost in particular are quite good. In fact they produce the R O I.

The prevention cost they often get into Six Sigma program and they are the ones that really help you produce the produce the return that you looking for from a project. So as far as cost of poor quality is concerned you could look at the external inspection that is going on, the amount of rework that is going on, the amount of scarp that is going on, loses caused to customers that is existing right now, non-value added work, these are the the roots for losses in the company. These are various examples of the cost of poor quality. These would give you places to look at whereby you can just buy a Six Sigma project. So, in fact the focus is going to be then business metrics.

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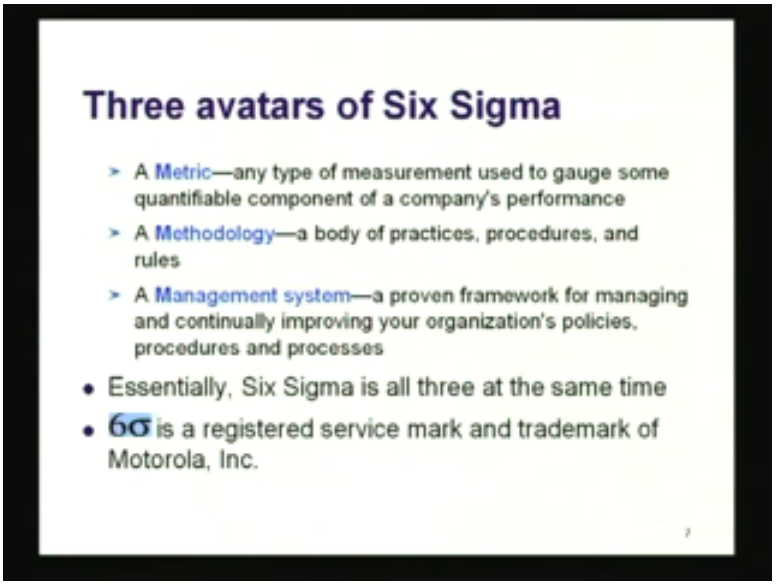

Six Sigma exists in three avatars. There three incarnations of Six Sigma. And the first one of course, is the metric Six Sigma is a metric it is a a metric is any type of measurement that is used to guage some performance, some quantifiable component of the company's performance. That is like something that a metric would perform. It would indicate the second thing that also is synonymous with Six Sigma is the DMAIC methodology. So, methodologies are also kind of unique in Six Sigma and Six Sigma does provide a unique body of practices and procedures and rules. These are clopped under this dmaic DMAIC procedure. Then of course, the third thing that Six Sigma also brings forth is the management system, which a proven framework for managing and continually improving your performances. And these could be actuated through policies procedures and of course, the processes that you run. So in fact may having a metric having special methods and having a management system, these are going to be the

basically the arms and ammunition for Six Sigma. Essentially Six Sigma does all three of these at the same time. You would not be able to say I am not doing, I am now doing management or I am I am doing DMAIC or I am measuring performance. It is all being done together you know Six Sigma project. The the term Six Sigma itself if you look at if look at the the way it is done. Six Sigma. This Six Sigma this particular thing it actually is registered service mark and a trade mark of Motorola Company. Motorola Company were the first people who coined this phrase Six Sigma. And as you saw in the earlier part of thing Motorola they were the pioneers. Of course, many people followed from there. The reason is that it produced results. It produced good results for them.

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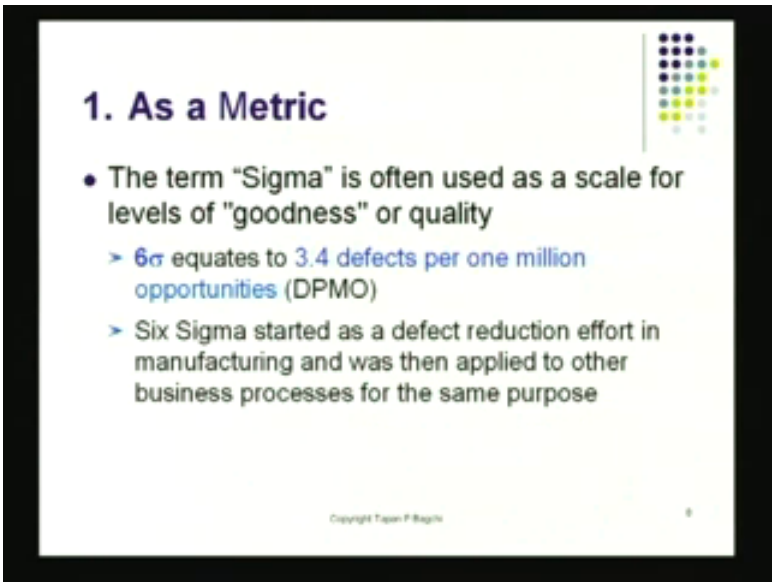

Let us take a closer look at what I meant by these three different things. What is Six Sigma is a metric. It is a way to measure your performance. So, in fact Six Sigma equals 3.4 defects per one million opportunities. That is a metric. In fact it may turn out that your level of defect is not quite at this level then your sigma measure is going to be less than Six Sigma. It is going to be may be five sigma or four sigma or three sigma. It could even be two or one sigma. If your process is very poor and I will show you later what it really means to have a Six Sigma program as supposed to a Six Sigma process as supposed to a three Six Sigma process. I will show that to you. You will see right away. A three sigma process is pretty wide. It has a lot of variability and a Six Sigma process is pretty narrow. It is pretty tight. It is very well within what we call the specification limits. Specification limits which are acceptable to the customer, any product inside is

acceptable to the customer and this is quite different from a process which has got tails that are coming out of the spec limits and it is got lot of losses there.

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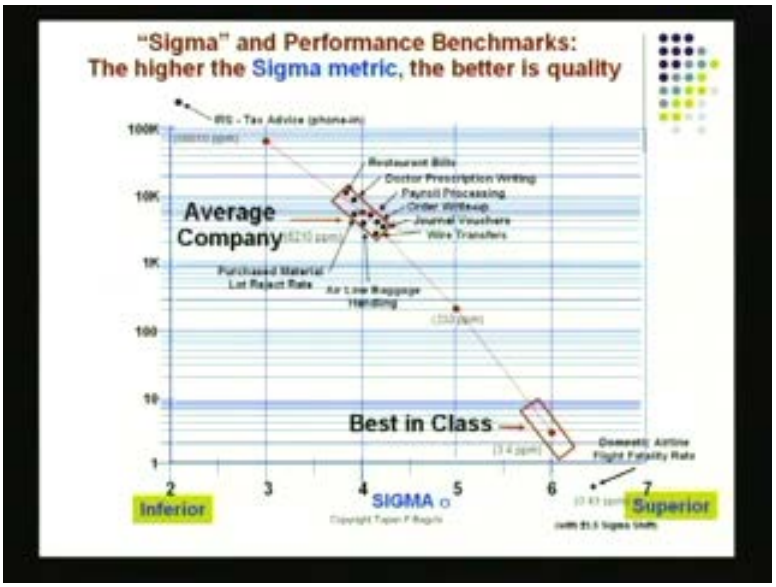

Let us a look at the second way of looking at this thing. I have a display here of various types of systems. I have various types of systems which exist around us today. We got of course, the best in class and these are near the Six Sigma level and the best best in class these are near the Six Sigma level For example, airplanes landing. You hardly have any fidelity. That is not a routine thing. You may have a few per million landings or takeoffs but, there are some incidents. I in between you have got a process which is like at four sigma level. Sigma is the metric which is like superior when you are near six or seven sigma level that is a tag given to the process. And it is simply inferior if if you are down to the level when you have got only two sigma. The processes qualify when a process is only two sigma or perhaps three sigma. Now in between which is near four sigma. You got things like airline baggage handling. That is got a few mistakes going on everyday. And then you got restaurant bills, errors on restaurants bills errors with doctor's prescription, errors in payroll processing and writing up orders and joint vouchers and wire transfers and so on. If you look at these things these are at the four sigma level. The error level there are a few parts per thousand. That is that is the common experience today and these are certainly then not near this Six Sigma level. They are at four sigma level. If come down for example, if you look at if you look at the system were in the in the IRS office, there are people who answer some questions. If you given them a call, it

is almost like a call center, expect that these people are supposed to be advisors. They are some people knowledgeable about the different tax laws and so on and so forth. If you ask them a question, there are pretty big chances there may be about a one chance in twenty or one chance in thirty or one chance in a hundred that their their their answer is going to be wrong and that is going to be at the two sigma level. So, in fact over here I have got if you go from the left to right I have got very inferior system that have a lot of defects in them we got intermediate system like airline baggage handling that is got a few mistakes per thousand. For example, then I have I have got of course, the parts per million type of system which are out here on the on the right hand side like such as airline aircraft landing or or baby has been taking care up in the hospital and so on. There are very few fidelities there. Those are at parts per million level. And I fact the strive is to take a process which around here take a process which is to the left and slowly through statistical methods and experiments and by applying the DMAIC process to try to push them toward this side. This is what we will be doing. This is what we are reviewing right now in this lecture. We are going to be seeing how we can take a process which is not so good and gradually moving towards moving towards Six Sigma. We will go through we will walk through the process.

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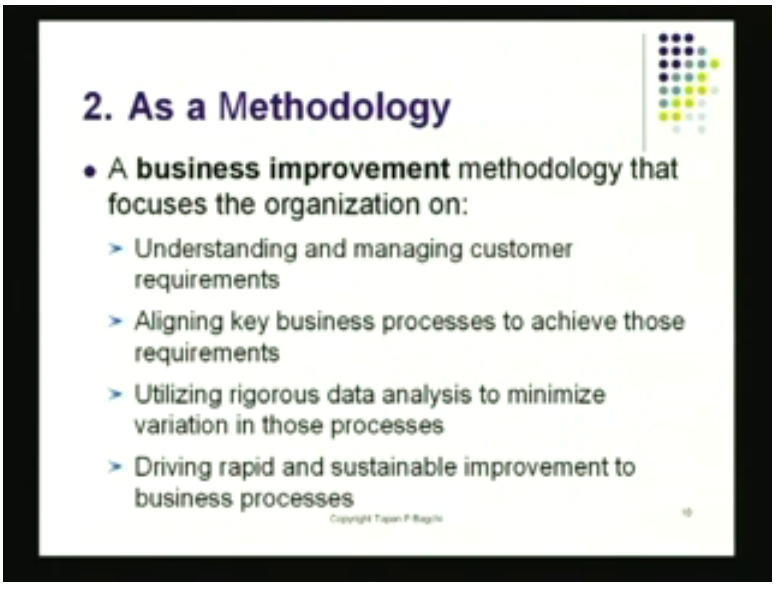

Six Sigma is a methodology. It is a business process improvement methodology it is a process improvement methodology and what it really does is, it really requires managing customer requirements. It starts of course, with understanding customer requirements.

That is very, very important. Then, aligning the key business processes; the ones that deliver those products and services to the customer. What we would like to be able to do we would like to able to control and align those processes so that we get the delivery the way we expected to go out to the customer for example. We would also like to make sure that the method utilizes rigorous data analysis procedures. And in fact in particular it it uses design of experiments that is like that is used in the DMAIC process it is used at the I the improvement stage we use design of experiments. And of course, we would like to be able to deliver rapid and sustainable improvement. This is something that we would like to be able to deliver. All these characteristics all these characteristics they exists with the Six Sigma processes, with the DMAIC process. The method methodology it is a business improvement process. That is what this is.

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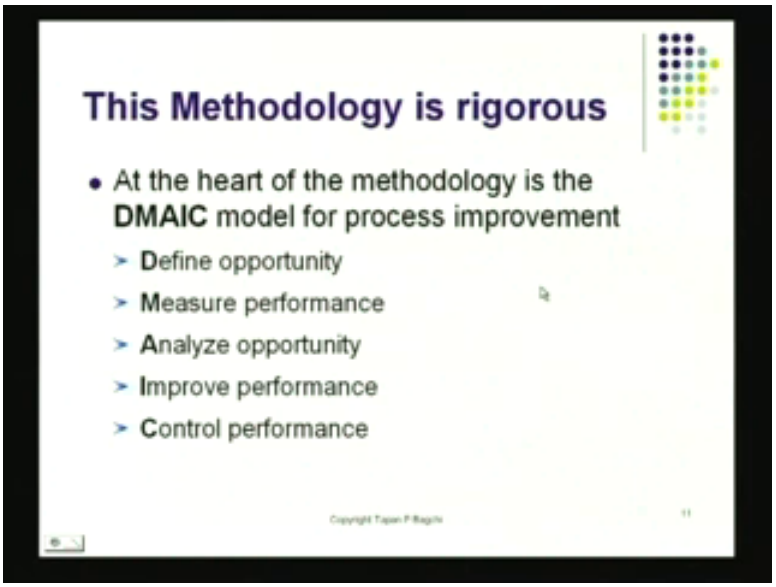

This method is rigorous and I said there are these five steps; define the opportunity, measure performance as it exists today, analyze the opportunity, improve the performance by using whatever means it takes, it would involve in many cases conducting D O E design of experiments. And then of course, once establish the optimum level for these different factors. We got to make sure the process variables stay at that level. That is called control and this could utilize s p c for example.

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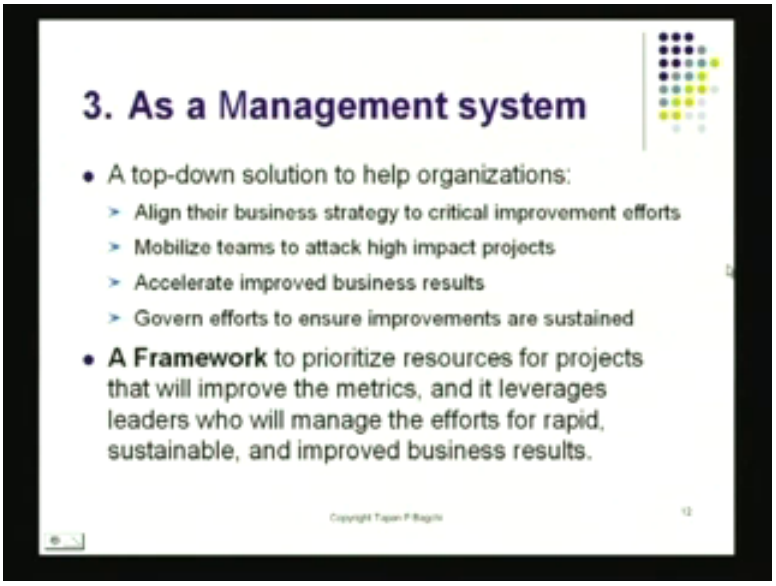

Six Sigma is also management system. Now, what exactly is management system? It says top down solution. it is a top down solution It is driven by top management and it begin with aligning the business strategy to critical improvement efforts. That is like something that has to be done. So, moving towards Six Sigma really is a is a strategic move. That is something you got to remember. It has a long term impact on the company's projects and processes and everything else. It mobilizes teams. There are teams who are given certain chatter. Then they will define a scope of it, then they will get into the world breakdown structure, then they will work on the details of the planning and this is run project by project by project.

All Six Sigma undertakings are really projectized and they are delivered with with a certain R O I. Each of them is justified with a certain R O I and in the end when you have done; when you have completed the project you take a look at the output and then you try to sort of see have I delivered that? Have I actually ended up delivering that? That is a post audit you got to do when you end up with the Six Sigma project. And of course, the management system will govern the the total effort and it will make sure that the improvements that you achieve, that you suggest that yes, they can be delivered those are sustained in future. It turns out that this that this management system provides a framework. This framework will help people prioritize resources for projects that will be improving the matrix the different performance measures. It also leverages leaders. These are the people who have special expertise. I am going to be talking about them in a

couple of minutes. Those are going to be master black belt people. First of all, the champions that the master black belt, then the standard black belts, then the green belts. These are the people who are going to be basically taking care of the actual Six Sigma project. Those would be there.

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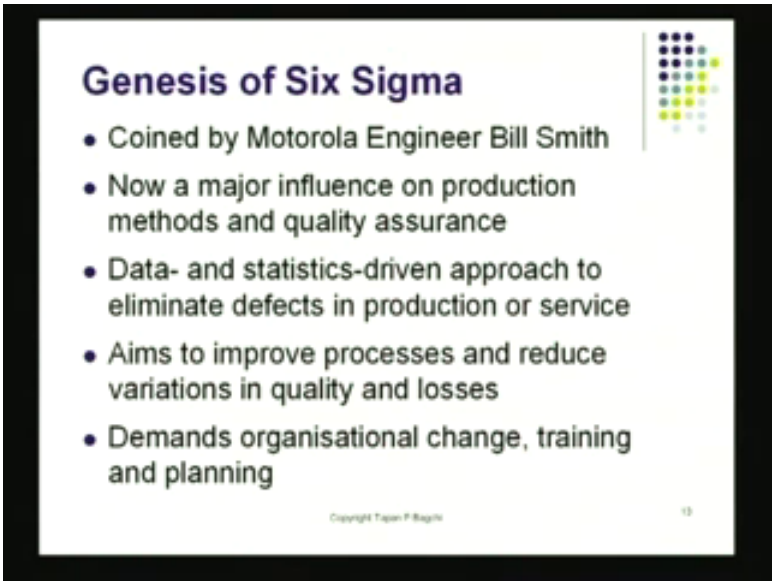

How did it all begin? Let me try to recall this for you. We did that some weeks back. The phrase was coined by Motorola and the gentlemen who did this he had a pretty simple name Bill Smith, William Smith. He is the one who was an engineer at Motorola and he designed this approach and so on and so forth. And of course, they chose this very catchy name, catchy tag of Six Sigma which is the level of perfection that talks about parts per million only in terms of defects. Now of course, Six Sigma is a major influence on production methods and quality assurance worldwide. Most of the leading companies they go by this Six Sigma way. They they actually are going this way. Many are still getting off the ground and they are doing their training and so forth but, the ones that are leading the pack they actually have Six Sigma in place. The method itself is data-driven and the science that helps you handle data in statistics. So many methods utilized, many technique utilized they are they they are they are taken from statistics and the idea is to try to improve process and reduce variation in quality. Say we got wide variation we would like to tighten it, we would like to tighten it that is moving towards Six Sigma. You start with the process that is pretty bad, that is got lot of defects being produced in the fringes you try to compress it and this should be doing by compressing the sigma that

is there. The sigma of the process and I will be showing that. As I show you the pictures you will be able to see how this is done. But, Six Sigma also demands organizational change and lot of training and a good bit of planning. All these are required by Six Sigma.

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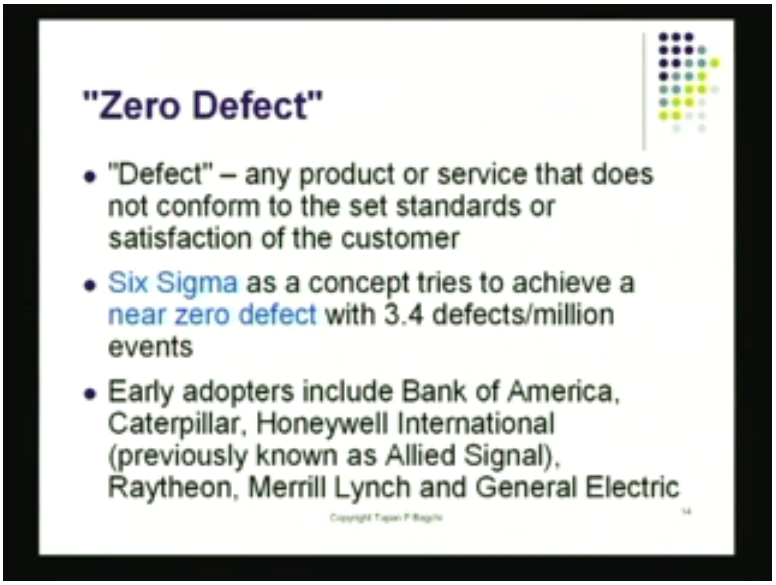

Now, what about this zero defect phrase that we heard some time back? Now, zero defect actually is a target. It is it is something that is like, that has been that was you know, the quality gurus they ended up setting this high enough goal and they called it zero defect and they actually said quality is free. If you produce everything defect free then quality is free. If the product and the output is defect free then quality actually is free because you do not have those loses those various loses that go with imperfect production and defects and so on and so forth. Six Sigma actually does not really lead to zero defects but, it does lead to near zero defects because you are talking about defects level defect levels which are now parts per million people, who bought this idea early on the Bank of America, Caterpillar, Honeywell and Raytheon and Merrill Lynch and so on and so forth. Many of them they adopted this approach and they ended up improving the process. And I do not have to tell you about General Electric Jack Welch, one of the biggest champions of Six Sigma. In fact he went around telling people unless you are a black belt your position in the company is frozen and perhaps you will be asked to go out. That is also is actually quite possible. And this was actually true for Jack Welch. He himself got trained and made sure almost everyone in the company understood what what he meant by Six

Sigma. What the company may what the company general electric meant meant by Six Sigma.

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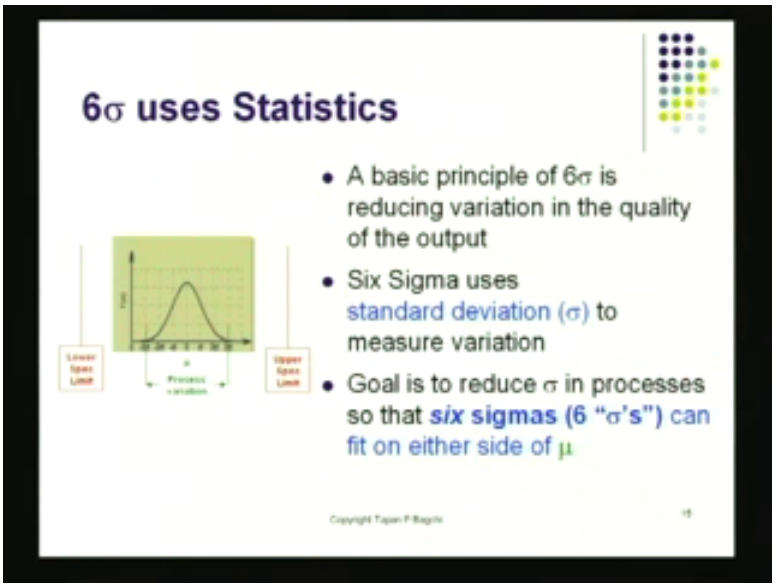

How do Six Sigma use statistics? Let me try out with a very simple example here. If you look at this curve there, many of you will recognize this is a normal distribution curve and this normal distribution curve has two parameters; one is of course, the mu which is the process average, then the other parameter that is this curve has is the sigma. Sigma is your standard deviation. So, I have my process and hopefully the target is close to where the process average is which is like mu is sitting right on where the target should be. Sigma process is a Six Sigma process is so tight that from the midpoint if you try to take a look at where the upper specification limit is or were the lower specification limit is it is sigma distance away. It is quite a bit away from here. Now, you know the general distribution of almost all of the items which have this distribution of mu being the mean and sigma square being the variance of it, most of the production is going to be confined in this area.

Almost all of it will be confined in this area. And if I put a mark there, if I put a barrier, if I put a limit there which is Six Sigma away from here you can understand that whatever trick was beyond this that is the tail of this little curve here and the tail of this little curve here those tails are going to have almost a few parts per million when they when they come out beyond the specification limit. That is actually how we are visualizing. We

have the statistical view of this process now. So the process itself has a variation the process itself has a variation which is plus minus three sigma but, the spec limits are far out here and far out here they are farther away from the ends of the process. The ends of the process are three sigma up and three sigma down. If I put away the spec limits if the customer if my process has been made so tight, it has been made so precise that products come out pretty close to what target is. They vary only by plus minus three sigma. Sigma being the standard deviation of the process that you got in action, if the spec limits now are Six Sigma away from the midpoint; this way and Six Sigma away from the midpoint this way, you hardly have anything that could be called a defective item coming out of this process, coming of the process which is here in the middle. So basically the principle of Six Sigma is reducing variation. This is what we have been like to able to do and we are using sigma as the measure and what we would like to be able to do is center the process and keep it keep it so tight make it so precise that the midpoint is Six Sigma away from either end of the spec limits. That is what we should be able to do.

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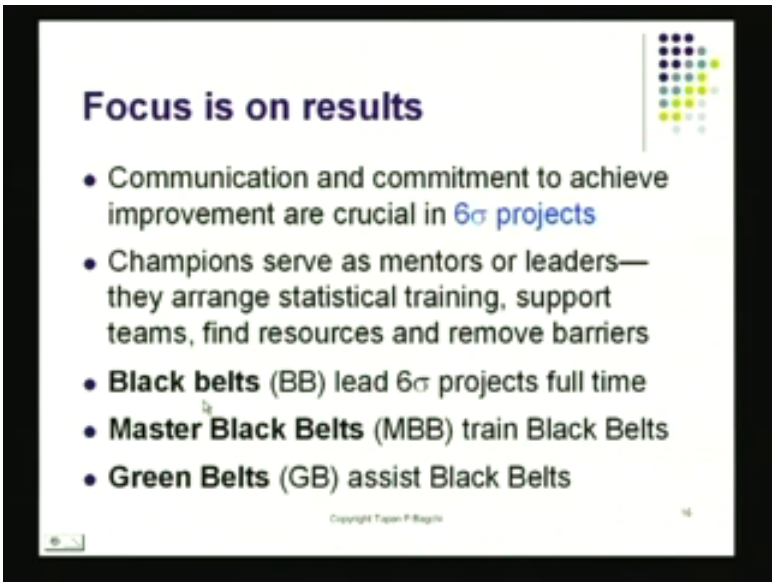

Our result; that is where our focus should be our focus should be on the results and in fact every Six Sigma project must focus on results, nothing else. It must focus on results what is going on to be the output, what was the output before, what is the output now and after I adjust the process, after I improve it. What is going to be the output I have got to keep an eye on the output itself. That is like something I should be able to do. I must have very good communication people should understand within the company and

certainly within the team they should understand when I am talking sigma and so on so forth. When I am talking design of experiments optimization, they should understand what is going on. When I am talking C T Q people should understand what is going on. Also there should be the commitment to achieve perfection. That also is something that must come must come along side the the thing. Now, who are the people who are culturally oriented toward this? And these are the black belt people. The black belts, these are specially trained people. They know a lot of statistics and these statistical techniques and so on so forth. They are the ones who lead Six Sigma projects full time. That is their job then of course, you got master black belts. Master Black belts are really, they are the supports. They train black belts black belts in turn. Then of course, other people are there in the team they are called the green belts. They also know plenty of statistics. They are the ones who carry out lot of detail work. That is there, that are guided by the black belts people. So, you have got the master black belt, then you got the black belts, then you got the green belts. This is the full team and of course, overriding all of these people there is a champion. There is a champion for the project itself. Then of course, is the process owner, some who is interested in the output; output coming out of the process. That is also, someone who is going to be part of the thing. They all put their focus on results.

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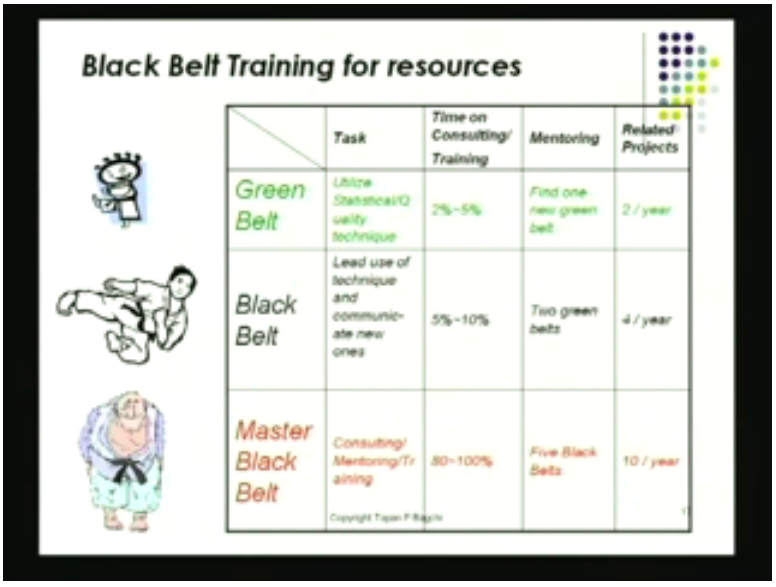

Let us quickly take a look at what are the characteristics of some of these people that we just mentioned. The master black belts, they are like the top-notch people. They do most

of their time they do consulting and monitoring and they do training and they spend almost of their time in doing just that. And they should be able to mentor five six black belts any time and they guide or they stay involved with about ten Six Sigma projects per year. Then you got black belt people and they are the ones who really at high competent technically. They are they are actually master black belts of course, have been black belts before. The black belt themselves they lead use of the techniques and they communicate the new ones, communicate the new techniques to the team. They spend five to ten percent of their time consulting or training and most of the time they are leading the details of the project itself. And they might be mentoring the couple of green green belts and they do about four Six Sigma projects per year. Then you got green belts and they are the ones who utilize statistical methods. They have also been trained in statistics and so on so forth. They also understand C T Q's and so on. They also do consulting because there are other people who are none of these three and they are in the company and they are the ones that the green belt people work with. They try to make sure that the the the language is understood and so on and so forth. That is like something that is got to be done by these green belt people. And they will probably try to get some new green belts and they will probably find one new green belt in a year. That is like something they would like to be able to do and they complete generally two Six Sigma projects per year. That is like the thing so you have got I will say (( )) there, then you got the (( )) there then you got the the huge ones the whales there. They are the ones if you actually see their competence probably, the master black belts they are the real gurus they are real the real gurus in the company.

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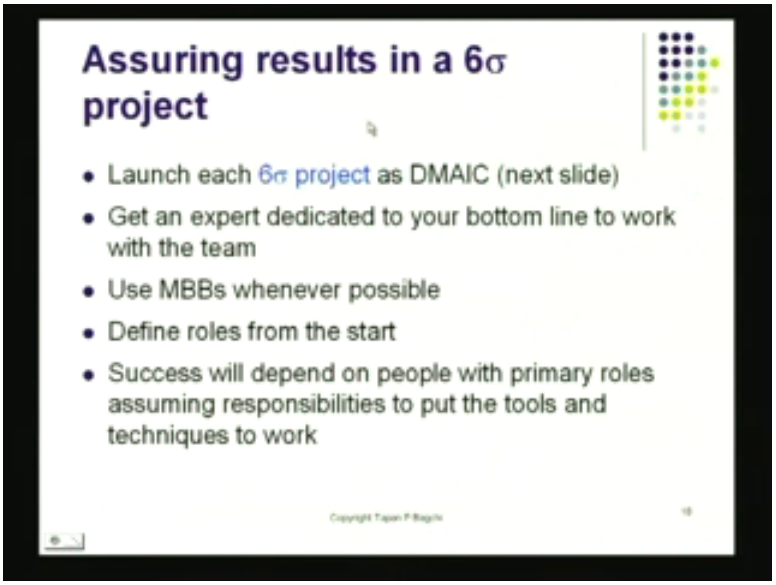

Assuring results: what are the things you require to be able to assure results in Six Sigma? First of all you must launch the Six Sigma project as a DMAIC project and this is something I am going to explain in a minute. You should have a expert who is dedicated help you and he is the one who should have focus on your bottom bottom line. That means the gains of the project. He must have very clear focus on that. He should be striving to deliver those financial things. He must you know do all the matrix and measurements and everything else. But, this is the expert who really can see the link between quality the process and the R O I, the potential R O I of the project itself. These are generally people who are generally people who are master black belt holders. You must define the roles of the team member's right in the beginning. This is something that is also required to succeed with Six Sigma project and success will depend very much on the roles and responsibilities and also making sure that the tools and techniques have output to use. And this is something that I have got been done. So may people that are well trained but, you must also bring along the tools and techniques. And you must combine the two to be able to exploit this new approach.

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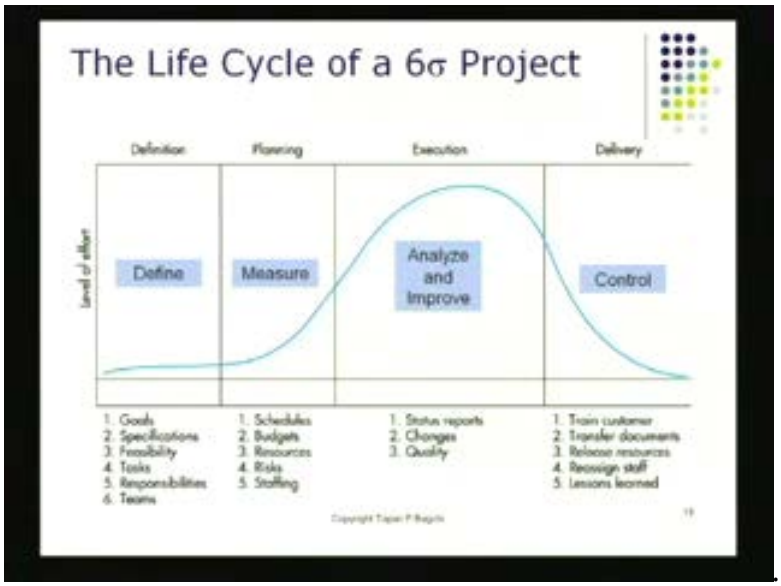

Let’s take a look at.

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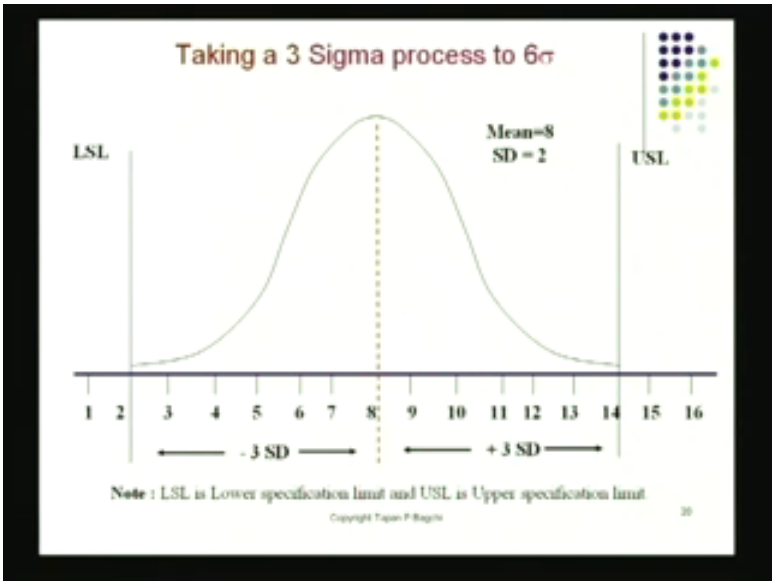

A Six Sigma project let us take a look at a Six Sigma project. How does it go? A Six Sigma project, every Six Sigma initiative is got to be launched as a project. And let us a look at this project. This project you know, it has got a define phase, then you got a measure phase, then you got a analyze phase, and then you got a control phase. And they are they are just like a regular planning project. I define the project and measure the quality characteristics as they are. When I plan the analysis and improvement steps my

design of experiments would be going on there. Once that is complete I get the optimal settings of the process those are controlled there. Down below I list the various things that get into defining the project; the goals, the specs, the feasibility, the tasks, the responsibilities in the teams. All this has to be done right here as you kicking off the project.

Then of course, in the planning phase you would be doing some measurements. So you get the directions. You would be working on the schedules for various things. The budgets, resources required, any risk involved and staffing. All those things you have to sort out here so that execution goes on nicely. And the execution would then involve generating status reports are the are the improvements the way projected them to be or or do you need some corrections there. Obviously, measurement of quality that is there and so on and so forth. These would be done at the analysis phase and the improvements phase design of experiments D O E would be done at this stage. Once this done of course, you got to bring in the client or the customer. You got to train him you got to write some documents, you got to make sure that you set up the new process control shall I say protocol. There also be draft in draft in be there. That also would have to be there. You will perhaps reassign the project team to some other project there and you will document the lessons learnt from this effort. That is if you touch also, something that you would like to be able to do.

Now, what happens when you take a 6 sigma, three sigma project and take it to a Six Sigma project? I am beginning with a, I am beginning with a three sigma project and just see what happens when I shrink this project, shrink this process. Did you see what happened? Let me do it again. I start with a process that is a that is a three sigma process. The distance between the target here, the midpoint and the spec limit is three sigma this way and three sigma that way because this curve is pretty flat. It is got a high standard deviation mean is at eight but, the standard deviation is two.

Look what happens when I shrink this to a four sigma process. When now by shrinking I made these sigma metrics gone up but, standard deviation came down from 2 to 1.3 and now got most of the process confined between minus 4 sigma and plus four sigma as far as the midpoint is concerned. I have got it reduced there. This is a 5 sigma process. You can actually see it is got tightened further and this is a Six Sigma process. It has got

tightened even more. So, again going back by the pictures this will go always like a movie. Now, I have got a Six Sigma process there.

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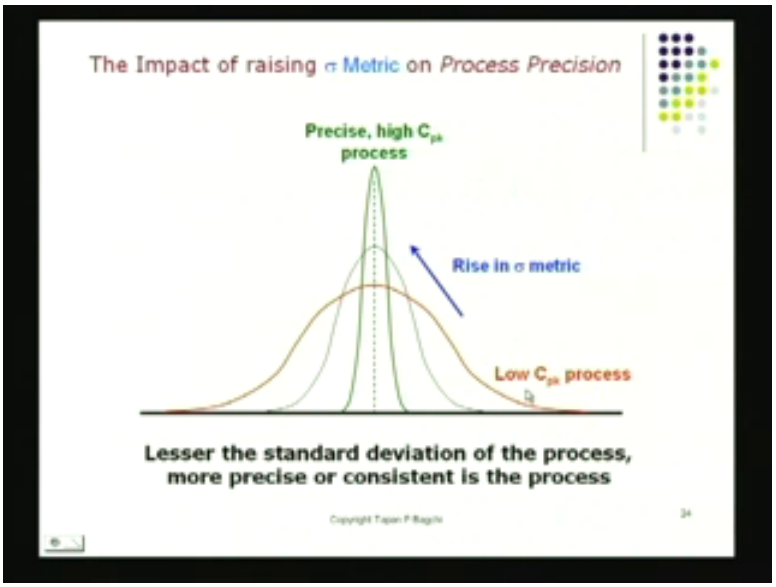

What are the what are the results? What are the benefits of Six Sigma? Well, for one thing you are going to be improving C p k. Remember C p k? C p k is the process capability measure for a process. How capable you are of satisfying your customer from your routine production. That that probability is actually low when it comes to 100 % satisfaction of the customer when you got a process which is like perhaps a three sigma process. When you move toward higher and higher sigma metric number, sigma metric; I am not talking about sigma actual standard deviation is reducing but, the sigma metric is going up. This is something that you got to know you got to remember.

When I do a Six Sigma project, I am reducing standard deviation. But, I am increasing what we call the sigma metric of the process. So, it goes up from three sigma metric to four sigma metric to five sigma metric to Six Sigma metric. This is what is happening and in the process, the process is getting tighter and tighter and tighter and tighter. So the green one here, is a pretty tight process that has got a high sigma metric value and the red one of course, is a poor process. It has got a low sigma metric value.

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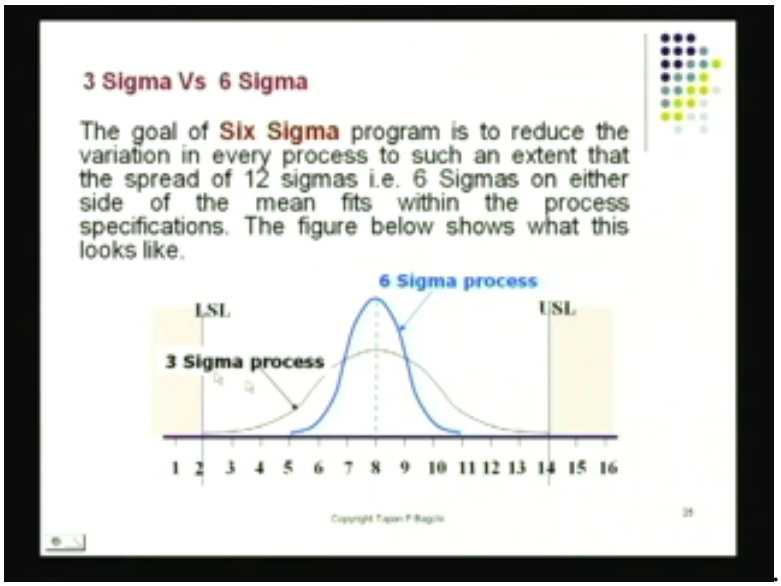

So, three sigma process actually will have part of the tail actually beyond what we call the spec limits and the sigma process will have almost nothing beyond what we call the three sigma limit. In fact there will be nothing in fact it could be only be a few parts per million defects that will go beyond beyond what we call this specification limits. That is like one of the advantages you go in from a three sigma process to a Six Sigma process.

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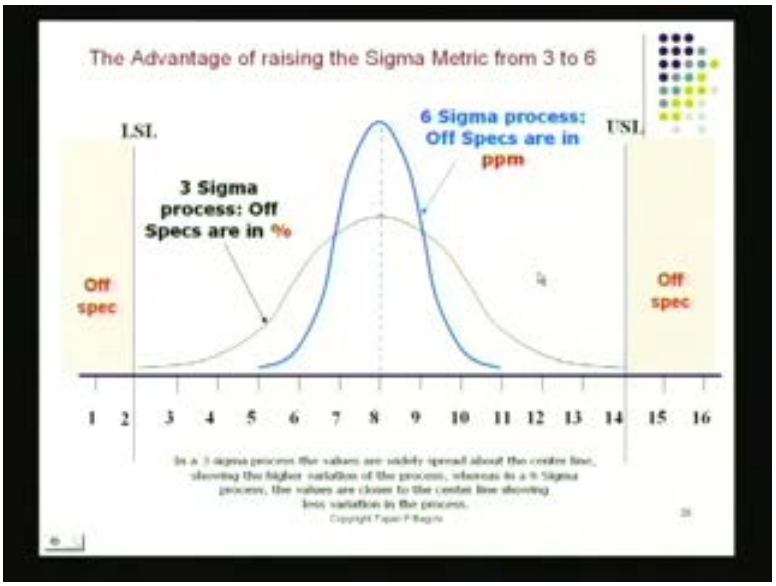

This is like another way to show the same thing. I have off spec material beyond this and beyond this, these are my spec limits the upper spec limit and the lower spec limit.

A 3 sigma process just fits in. It just fits in inside that limits set by the upper and lower spec limits. So, the black curve just fits in this black curve is going to give you defects in percents. Compare that to the blue curve. The blue curve is a Six Sigma process. It will actually have a tiny amount. This blue tail going beyond it but, that will be at a level of parts per million. So, in fact a three sigma process will have off specs at percent level and a Six Sigma process would deliver material that will be, that will really be off spec at parts per million level. That is a pretty good level of quality. that is pretty good level of quality.

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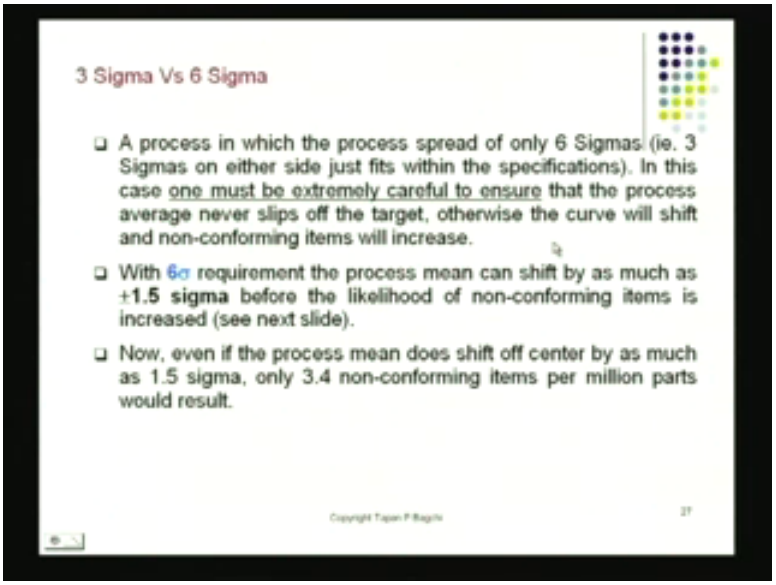

So again, I have I have given you some other details of what is the impact of going to Six Sigma. Now notice something; I had told you quite some time back that the best best place to be in terms of delivering products to a customer is, to try to identify what the target performance is that he is looking for. What is my target shirt size for example, and I would like to sort of see make sure that I get I get my size forty two. If that is my size, that is the shirt I would like to get. I would not like to get a 39, 40, 41 or 43, 44, 45. I would be the happiest man when I get a size 42 shirt. What happens here is because your process is already so tight you can allow that average to be floating around a little bit and let me show you that in a picture.

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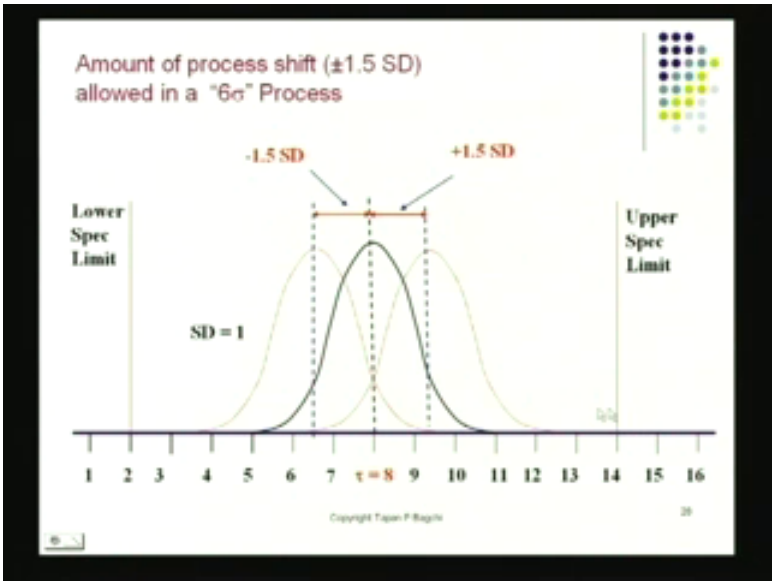

I have this black process here is a Six Sigma process and the spec limits are far out here and they are far out here. You notice here the off specs are over here and the off specs are over here. So even if this black curve shifts a little bit, it goes up and down by what we call one and a half standard deviation level. If it does that, I will still have almost nothing going beyond the spec limits on this side or the spec limits on that side and that is why if a process is truly Six Sigma, if it is operating at the level of plus minus. If it is at Six Sigma level you can allow the average to vary as far as that process is concerned by plus one point five sigma and minus one point five sigma. You will still maintain that high level of customer satisfaction because even if I move that black curve to the left or to the right I am not really producing any significant amount of defects because my control limit, my my specification limits they are pretty far away. I really have no danger to get into that area there. That is like something that again I gain when I come down to Six Sigma.

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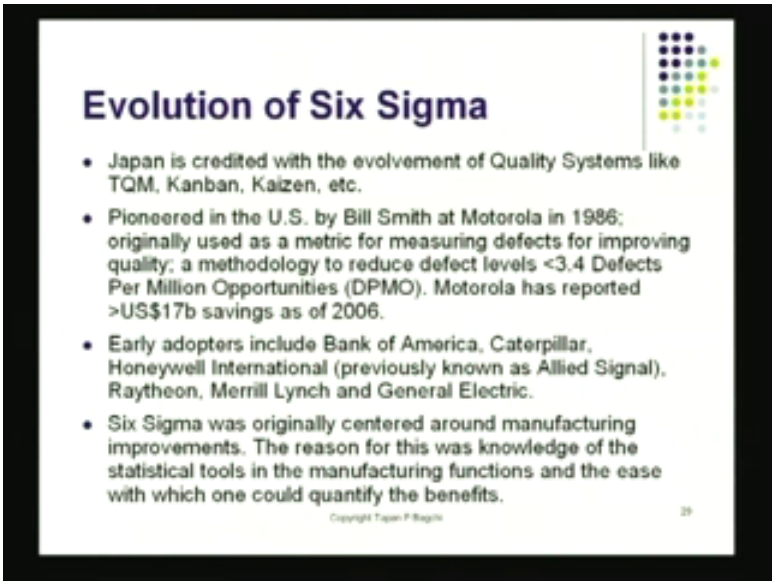

Evolution of Six Sigma: How did it actually evolve? Well, if you look at Japan, Japan contributed many things in the movement of quality, in trying to improve quality. They gave us parts of T Q M, a lot of T Q M tools came from Japan, they gave us Kanban, and they gave us kaizen and many other things q f d and so and so forth. Those and even the latest Kano model it has also come from Japan. So, the Japanese have been contributing a lot of things. By contrast, this Six Sigma movement and the Six Sigma method has come from the US and it was pioneered in the US by Bill Smith of Motorola in 1986. And from that point onward because it was a superior level of quality many companies they tried to move towards Six Sigma. And of course, the attempt there was to apply statistical methods, to try to understand this cause and effect relationship. Once that is understood, it is not going to be very difficult for you to tighten the process. Once you know what are the factors that cause a high sigma, a high level of standard deviation? And then adjust those things to try to make sure that that standard deviation. The process reduces and you end up with the Six Sigma level of performance.

Early adopters of Six Sigma they were Bank of America, Caterpillar, Honeywell and number of other people and GE became a pretty big champion of Six Sigma.

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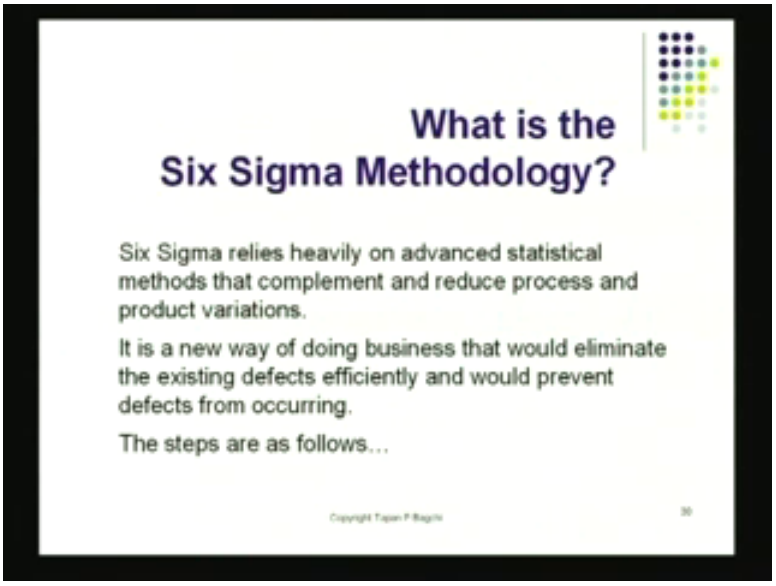

If you keep looking at the method itself what are the methods and the first and foremost is of course, the DMAIC methodology. So I am going to again write that down for you DMAIC.

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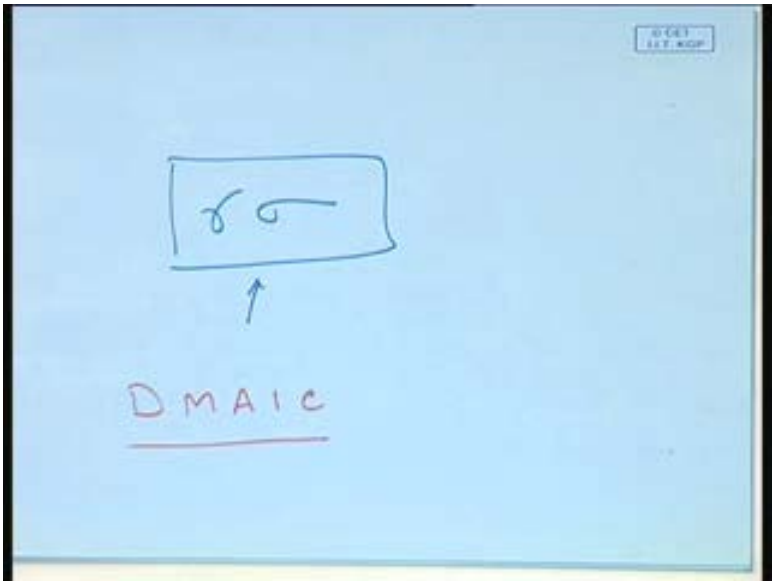

D M A I C dmaic. DMAIC stands for define, measure, analyze, improve and control. You got to go through these five. You got to go through these five steps to be able to able to achieve this Six Sigma level of performance.

So, it really relies very heavily on statistical methods and some are pretty advanced methods you got to get some training in this area. It is a new way for doing business. It is a new way to deal with your customers and so on so forth. And in in almost all cases it eliminates a lot of defects which might be there.

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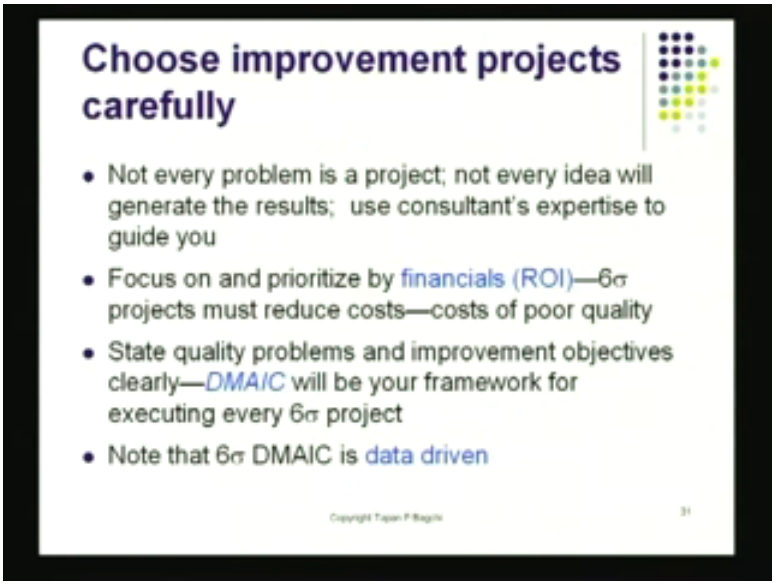

The steps of this are of course, again I am going to be walking walking you through the steps, choose the improvement projects, study carefully that is something you got be able to do. These are not just a low hanging fruits but, also problems. In fact persistent problems are chronic problems. These are the ones you got to be able to target, you got to also make sure that you produce an R O I, a potential R O I, a possible R O I that might be if I tackle this issue. If you tackle something that does not produce any R O I it is going to be tough to get management support for it because you would need a lot of resources to be able to walk through the, to be able to execute this Six Sigma project. That is why it is very important that you identify the financial incentives for doing this.

Then of course, you should be applying the DMAIC procedure and I am going to be again walking you through the steps of DMAIC. So, it will be a reminder for you and of course, the whole process going to be data driven you would be a making.

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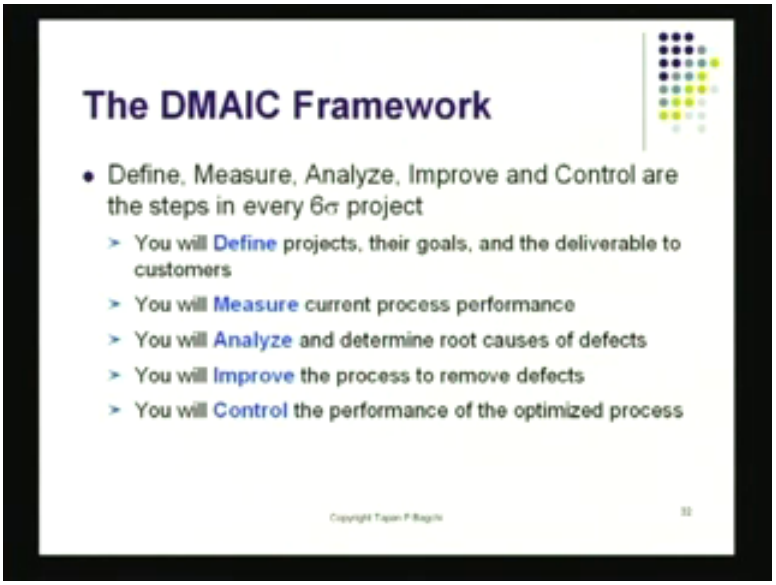

A lot of measurements lot of approaches and so lot of lot of data collection analysis and so on. Those could also follow through if you as you walk through the DMAIC process. So the very first thing is you define the project, the goals of those projects and the derivables to the customer. This is something you are going to define. There may be an issue there. There may be a quality issue, some c t q's may not be being being looked after. That is something you got to be able to do. You must measure the current process. This is the second step of DMAIC. You must measure the current process performance this could really be measuring the number of defects you are producing or c p k any of those things and find out precisely which C T Q is leading to those things there.

Then, is the analysis. You try to do some route cause analysis you try to solve or find out and this would be involving some some techniques, some mapping and process mapping and so on. I am going to illustrate that with a case that we have for you today. Then of course, the next step is improve. Now, that I have done the analysis, I have identified the factors that might be causing this high level of defect to be able to reduce them. I have got to apply some special methods such as design of experts. That is something personally by the way I am a very, I am very, very fond of design of experts. That is something I have succeeded with many, many time in my life time, my professional career. I have probably conducted thirty five, forty different design experiments and these have had applications in widely different areas in biotechnology, in genetic algorithms, in mechanical production, in chemical processes, in metallurgical processes.

All kinds of processes I have i've tried to apply D O E. Even in some qualitative areas when you basically look at qualitative results come out. Even there I have found D O E method to be a pretty decent framework to you to apply to utilize.

Then of course, the last step is in DMAIC is going to be. Once I have located the optimum settings for these different process control factor, I have got to keep them there. I have got to control to be there and there of course, only then my process is going to be stabilized at that point there. I must have sustainable improvement. I must have improvement that'll continue after I walk away from the process and I set them at the right levels there. I set them at the optimum levels there and I walk away from it my process control system should be able to keep it there, should be able to keep that process there. This is something I should be able to do.

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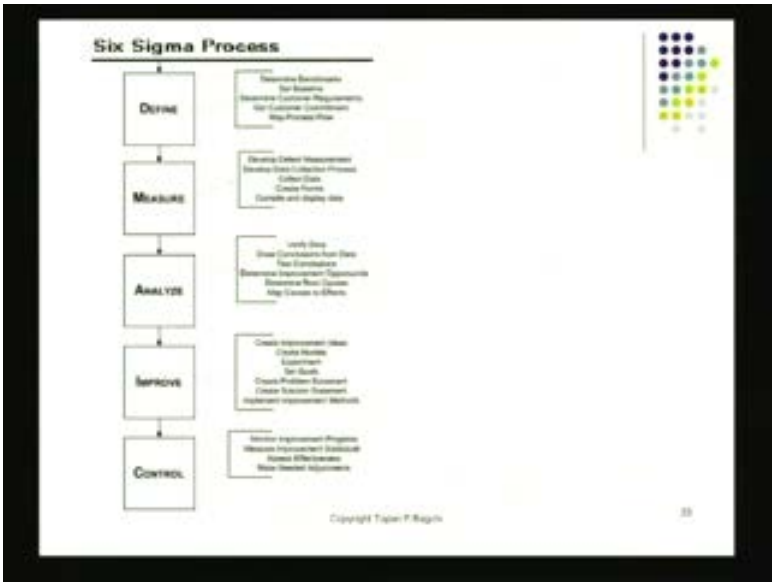

Now I have given you a bunch of slides there. These actually also amplify the define, measure, analyze, improve and control steps. For example, there is the issue of bench marks, base lines, customer requirements, customer commitments and mapping of the process flow then of course, defect defect measurement, data collection process, collection of data creating of certain forms on which you collect the data and then compilation and display of the data itself. Then you got verification of the data itself, then drawing some conclusions from it and setting up some tests, determining improvement opportunities. These are all going to be there, determining the root causes,

identifying those factors that might be there, then again mapping the causes to effect. That is like something I need now. Then I move move into the improvement phase where I create the improvement ideas. I create models these could be processed, input response type of model Y equal to f X type of model there. I set some goals. I have created the problem statement, then I create the solutions statement. Then this this the this is the step that goes through D O E design of design of experiments.

Once I got the improvement there, once I got the improvements achieved, I demonstrate that that it is there. Once I have the optimum levels of these different factors identified at the improvement step, I am moving to control. But, I try to keep, I monitor the improve process and I try to make sure that I maintain the process control variables at the levels where at which they are optimal. So, that I maintain sustainability. That is something that is done by this Six Sigma process itself.

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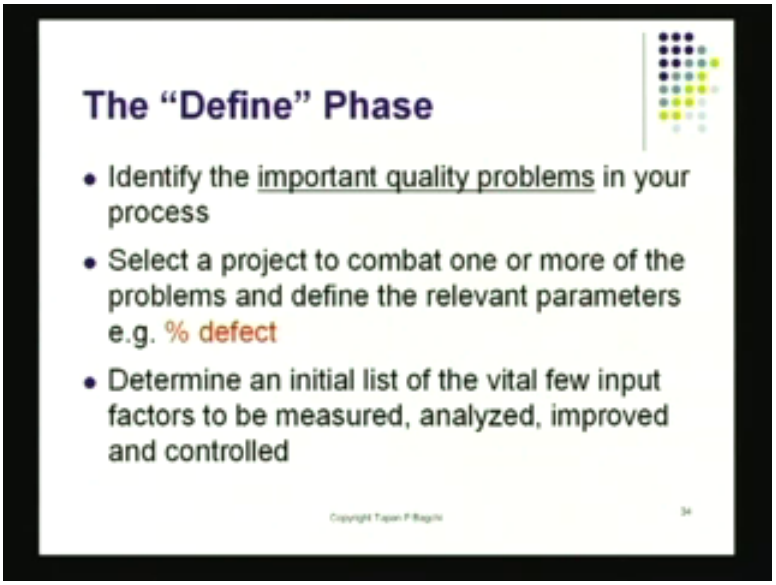

Give me a few more details on the define process itself. It is going to be very important for you to identify important quality problems. Do not just look at very low sort of low return projects. They are not going to have much, much you know kind of a following in the company. Even if you come up with a with a great improvement for a tiny problem that was there no one was concerned about it, it is not going to you might put a lot of effort and resources to try to improve that please find a problem that is an important

problem for the company. And there may be two, three or four of them and it could do a little parade to to try to understand what really is there.

Select a project to come back one or two of these big problems there and define the relevant parameters and these would be normally defined using those c t q's as percent defects as they prevail today. And you will be looking at some input factors and this is something where you could produce an an initial list.

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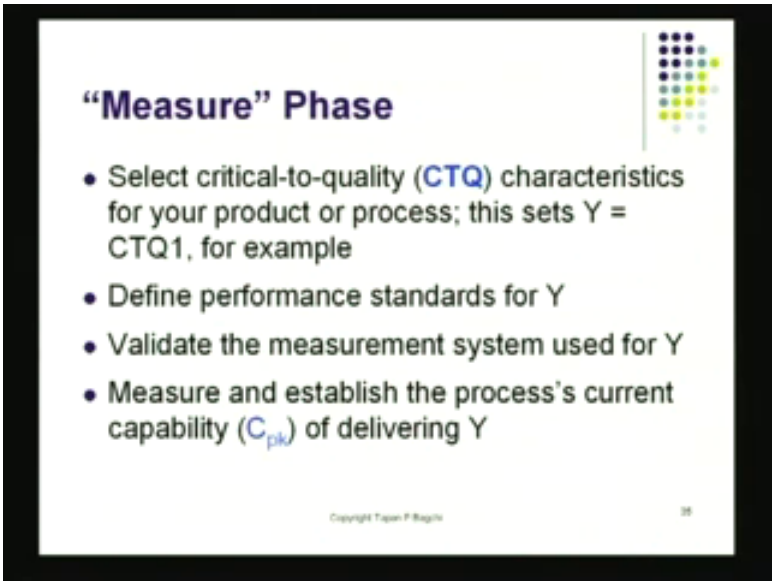

Then of course, you would be going to measuring these c t q's. That is something you would like to be able to do. This is like you are measuring the process as it exists today. You also should measure measure c p k process capability, how capable is the process as it is today. Is it near one? Is it below one? Is c p k below one, then of course, you need some lot of improvement. Is it like one point 3 or 1.4 then of course, it would need some improvement. If it is near one point 6 it might need a bit of nudging to move it two as c p k equal to two is available for you got Six Sigma quality.

So that is like something if you got a, if you got a reading of c p k on your process you pretty well you can probably say at what say, at what sigma metric level my process is operating. So, this is to be done at the measure phase.

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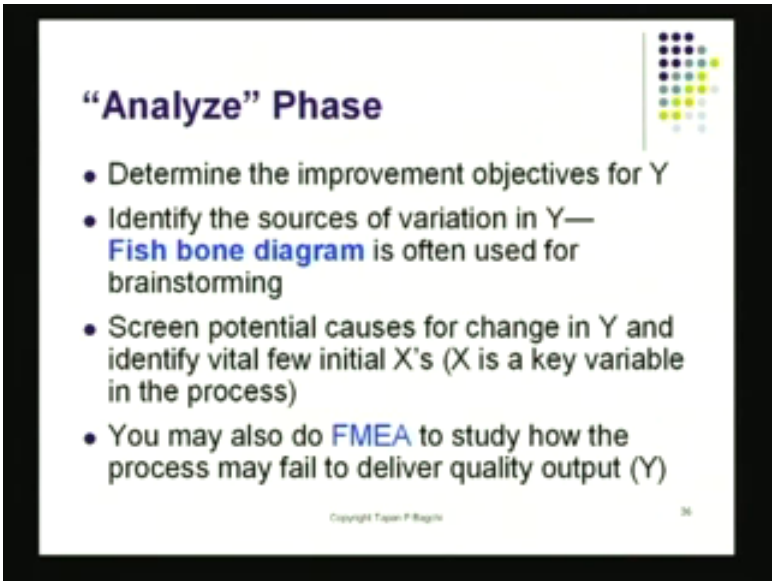

Then, you got the analysis phase wherein probably you will be using the fish bone diagram. I find the fish bone diagram extremely handy.

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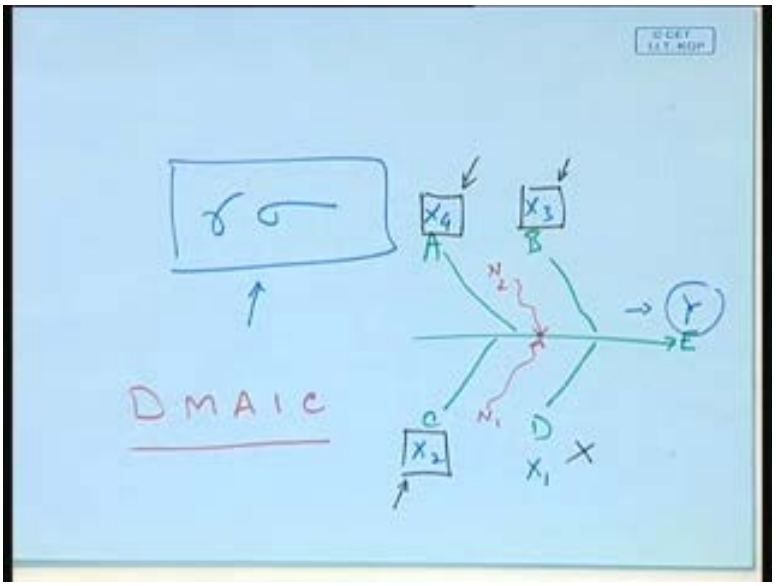

If I try, if I can remind you of what that fish bone diagram is; the effect is at the end and then I have got various causes. These causes are a b c d and perhaps even noise factors where as there will be some noise factors also. That would be disturbing the process. I may have some noise factors also. n one and n two. This diagram this diagram is the fish bone diagram. It is a brainstorming too you. In fact bring together people who are going

to be interested, they are knowledgeable about the process. There might have a contribution in terms of identifying or listing one or two of these factors that should then be further investigated. That is something that is done in the analysis phase. So, this is the place where you might do either you do brainstorming or somehow you construct this list of these factors that are going to be utilized then later on on the thing.

You could also do at the analysis phase, you could also do this engineering analysis study called f m e a, failure mode and failure mode and effect analysis and this is also, something that is very very handy if you do FMEA, you are going to be winning. It is going to identify all those factors that could have something going wrong with them.

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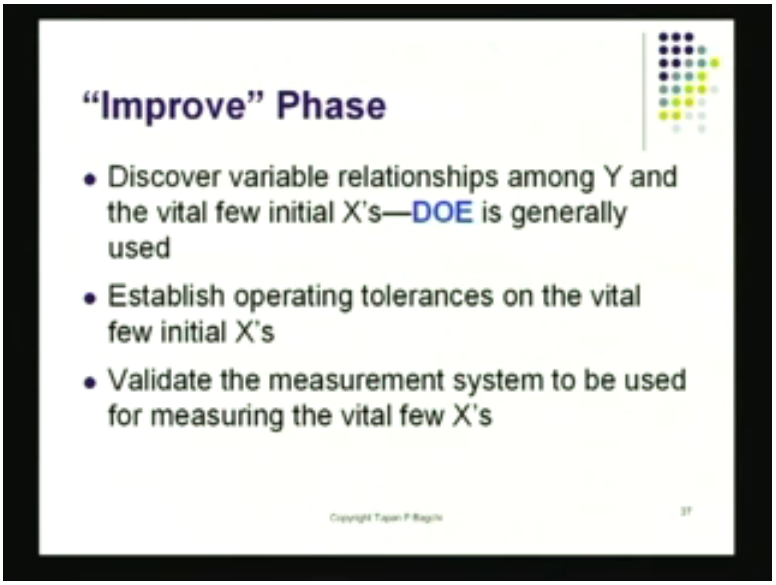

Then of course, you got the D O E phase, which is the improved phase. There you try to you try to discover the relationship between Y. y is the response and X is basically the various control factor. So, X here in this case is going to be X one is here X 2 is here X 3 is here X four is here and Y is sitting right here. So, Y I would put down here, Y is here I have got X one as one of the factors X 2 here X 3 here X four here. These are going to be the control factors, the experimental factors. My goal is going to be to study the effect of X, the various x's on Y. I am going to be studying that empirically and this is to be done using what we call the design of experiments the D O E frame work as I show on the slide there.

This slide shows you where D O E comes in. D O E is generally used to try to find the potential causes and see whether whether or not been have an effect on on Y. So, it will be involving many different x's in your D O E step to try to sort of see which of these things are important and which of the ones that need to be controlled, need to be adjusted in order for us to achieve an improvement there.

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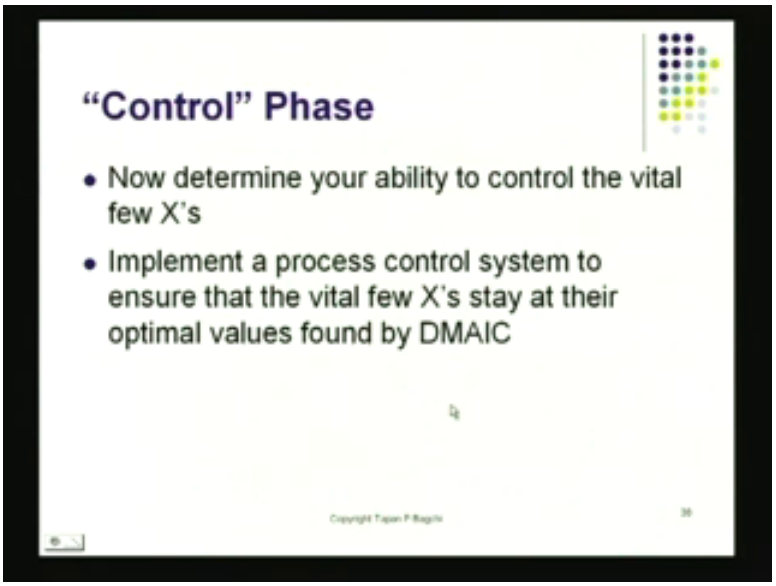

Once I ahve achieved the optimum settings for these control factors, I will be setting them at the at the optimum level. So, the X one X 2 X 3 X four there I have that I have identified so far, perhaps identified only three of these factors that that have become important. So, I have identified X 2 X 3 and X four. Perhaps these are the ones that are the important ones that have the largest impact on this and this employment does not have much of an impact. I need a process control setting for this. I need a process control setting for this and I need a process control setting for this. This would be done when I come to the step called control. See that slide there. It says controlled phase and it says now determine your ability to control these vital x's. Now that I've identified them, I should have the means to control them. This will be done when I when I have actually focused, I have come down to this level of process control.

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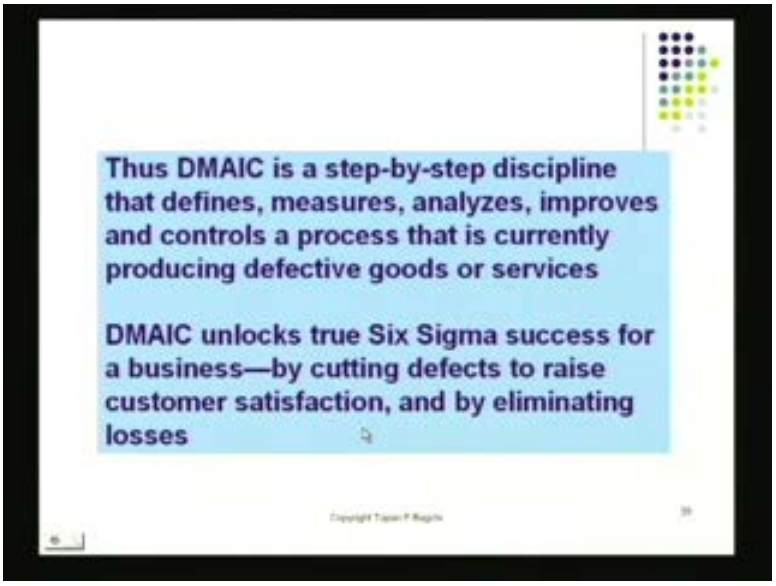

So DMAIC is now a step by step process. It is a discipline that defines, measures, analyzes, improves and controls a process that currently produces defective, currently producing defective goods. DMAIC unlocks the true sigma success for a business and it does that by cutting defects, raising customer satisfaction and by by cutting down losses. This is something that has to be done. Unless this is done of course, you are not going to be moving up the ladder of quality assurance. I am going to continue in a few minutes and just wait for the next session to begin.

Thank you.