

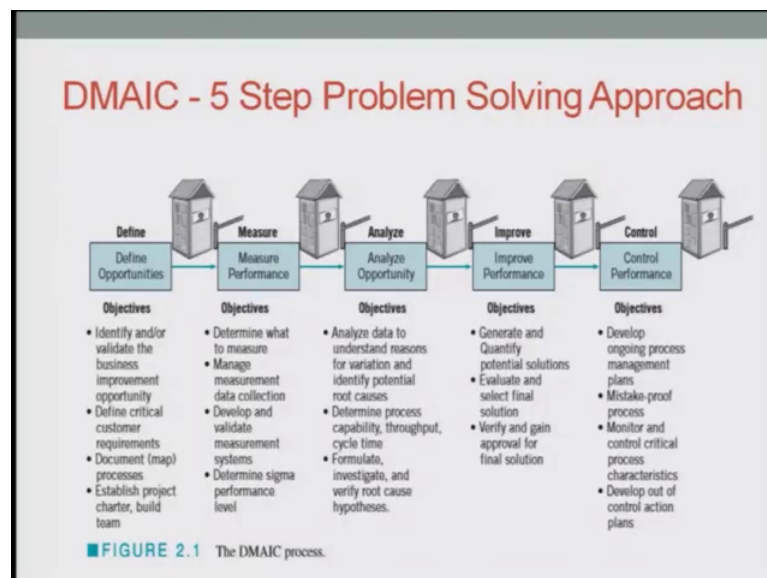
**Total Quality Management - I**  
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**Lecture - 08**  
**DMAIC for Problem Solving**

A very good afternoon my dear friends, welcome back to this Total Quality Management course, and I am Raghunandan Sengupta from IIT Kanpur, and this is the 8 lecture. So, in the 7th lecture, we were discussing in details the overall framework, how quality could be brought on to the system. So, were basically known as the 5 steps of solving approach for quality. So, I was just discussing the first pillar, which is basically defined, but considering the time duration for the last lecture was already lower.

So, hence I had to cut short the deliverance for which I apologies. So, I will start of a fresh with full enthusiasm. This is the discussion of the 5 steps for problem solving approach for quality.

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So, to just rehearse the main bullet points based on which we will discuss the D M A I C step. DMAIC steps are defined measure analyze, improve and control. So, the objectives for define opportunities are, and identify, and or validate the business improvement opportunity. So, as I said in the last few seconds of the last class. So, depending on how

you have been able to pass on the overall benefit, which you are going to get to the customers.

So, whatever benefit which you get, you try to define, and whether those quality improvements are necessary. You try to basically buy new machineries, give good training to your workman, for either manufacturing goods or training. Try to implement good raw materials. Try to basically have a good lighting system, try to have a cleanliness in your work force, in your layout. Whatever it is, have a good relationship with the vendor, have a very good relationship with the retailer, or the distributor, who is going to basically distribute your products and so on and so forth.

So, you define continuing with the discussions on undefined. You define critical customer requirements, what that do, the customers want you document or map; the whole overall process, and that how the general production of the service process starting from your end, till the customer end. It is mapped rather than going details of the technical one. You basically try to understand what are the flow process, based on which the products are utilize at your end, made in to finish goods. And basically through the distributors to the generals supply to the customer you establish the overall concept.

Based on which, you are going to implement that work, considered as the project, and have a very code team, who really believes in the philosophy, but having said that, if you remember I did mention that quality should basically be a top down approach; that means, the philosophy of the people who are running the show, who are running in the company, whether the manufacturing one, or the services one should basically have inside them. The believe that quality is, and should be an incurral part of the overall process, and they should be in a position that they enthusiasm should percolate from the top level to the bottom level.

So, are the people feel that quality is important, they should be enthusiastic about that, and should be in a position to improve the overall process of manufacturing or the services having defined, you basically measure the performance. So, the objectives of measure and performance are determine, what is to be measured, is it basically you want to measure the parts per million defective, which is coming out, are you interested to measure the overall tolerance level, which you give for your products, or are you

interested to measure the level of time you are willing to give for yourself to deliver the services to the customer.

So, consider that many of the delivery products of food they say that you will get your products within half an hour. So, that may be a moto based on which you are trying to render services to your customers. So, then you understand and try to study how the management, and the measurement of the data collection should be done. So, need to basically collect data, based on which you can say that, how the measurements been done, and whether the measurements which you are trying to, would have an implication when you do a detailed analysis, and basically lead to quality improvements you will develop.

And validate the measurements systems based on which you are trying to study, and you will determine the sigma performance level, whether to a level of plus minus 1 sigma or plus minus 2 sigma, or plus minus three sigma, based on which you will try to implement what is actually practically possible, based on the overall motivation level which you have, then you will try to basically analyze. So, objectives under analyze would be analyze the data to understand, reasons for variations, and identify the problems, where they occurring. So, the problem may be that the coolant, which you are trying to use, may be bad the overall workman ship is bad, or the training of the workman is not good, or whether the humidity in the shop floor is high.

Which has negative implication for the raw materials, which may be vary, the sensitive to humidity or say for example, the temperature may be high, or they may lot of dust particles in the shop floor, or say for example, it may happen the raw materials which are supplied are not of good quality. So, consider you are getting copper. So, the copper may be not of high quality. So, there may be impurities, which may have a negative effect on your overall production process, and the raw materials you are going to utilize to manufacturing the finished goods, you find out the root causes, where the problem is occurring.

Then you determine the process capability throughput and the cycle time. So, what is the cycle time, what is the production rate per hour per week per month, and what effect does it have. If you try to basically implement quality to a higher level; obviously, initially, it would have a detrimental effect, and try to reduce the throughput, but;

obviously, that should be compensated with better quality. So, you will have to basically make study of all those things you formulate the investigation process, and verify the root causes of the hypothesis based on which you are going to implement quality. Then we come to the second last stage of, in the five step problem solving approach which is improved.

So, objectives under improve would be generate and quantify the potential solution. So, what are the solutions would be at. Do you think that the worker should be given training. Do you think better colon should be used. Do you think the raw materials should be purchase from a second vendor, or do you think the vendors can be basically trained in order to supply the same goods, or do you think, basically you are able to purchase good quality raw materials at higher cost. All this things you have to consider in details, or do you think say for example, the overall supply can needs to be improved, based on that you take a decision, you evaluate

And select the final solution which is best for your case, considering quality, considering cost, considering workmanship, considering the overall infrastructure, which you verify and gain approval for the final solution from all the persons who are there as the implementation stage, starting from the raw material purchase, still the delivery of good, because the workman, the accountant, the vendor, the marketing person, the workman who is basically studying the quality, everyone you should be in the same frequency, that their main motivation is to improve quality, but; obviously, they would have a different implication for each of them.

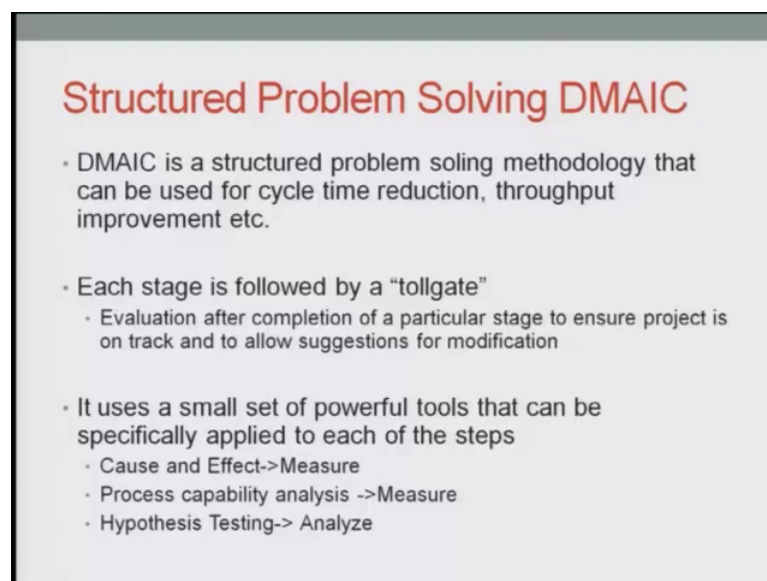
So, how it can be done everybody's thought process should be considered very rationally very scientifically; such that the overall process improves, and then you come to the after the final solution, and the approval of the final solution have been done, then you basically come to the last step, which is the control step, and the objectives under the control steps are developed, the ongoing process management plans. So, it is basically implementable cycle after cycle.

So, mistake and proof process are in the schedule, in the sense they should be there such that people, if some mistakes occur, how would they can be rectify, then you monitor the and control the critical processes, which are happening, and basically take a very minute study that what are the critical processes, how they affect the overall production, how

they affect the overall services, how quality can be effected, and he is basically. You make a detailed study of that, then the last stage would be develop out of control action plans, in case, say for example, the action, the overall process going out of control. So; obviously, there would be some reasons.

So, you have to analyze that what may be the actual reason, based on which this is happening, and you should be able to analyze and go back that, how remedial steps can be taken in order to bring the overall process back into action.

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**Structured Problem Solving DMAIC**

- DMAIC is a structured problem solving methodology that can be used for cycle time reduction, throughput improvement etc.
- Each stage is followed by a “tollgate”
  - Evaluation after completion of a particular stage to ensure project is on track and to allow suggestions for modification
- It uses a small set of powerful tools that can be specifically applied to each of the steps
  - Cause and Effect->Measure
  - Process capability analysis ->Measure
  - Hypothesis Testing-> Analyze

So, that structured problem solving and on the DMAIC steps as I discussed if I go into more details, it would be DMAIC is a structured problem solving methodology that can be used for cycle time reduction throughput improvements and so on and so forth. So, each stage is followed by a tollgate; that means, you basically implement that analyze at the level of decision whether things are going as of plan.

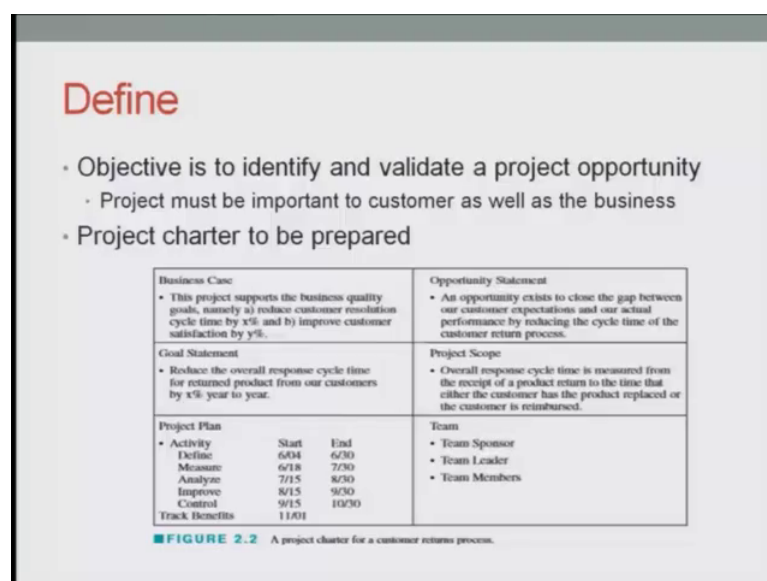
Whether implements are occurred, and if not try to basically give some feedback, based on which you are able to rectify the problems, which you think are important and need to be looked into. So, evaluation after completion of a particular stage is basically to ensure the project is on a track and allow suggestion for modifications, and if modifications are needed, you basically implement that accordingly. This five steps problem basically uses a small set of powerful tools that can be specifically apply to each of the steps. So, the

steps are; this is a cause and effect and; obviously, if this is a cause and effect, you measure what are the cause, what are the effects.

And try to basically quantify them and bring into the notice of the people who are involved in the process; such that they can give you the right decisions, right information, right knowledge, right set of suggestions based on which you can improve and measure the cause and effect and basically try to take correct way actions for the cause and what are the effects, on the effect then comes the process capability analysis and you measure that. So, that is the thing which I have been discussing about. Use the standard statistical process control tools, the normal distributions and the other distributions.

And what are the charts; expert charts, art charts, pie charts and so, on and so, forth. Then; obviously, we have some hypothesis testing to be done. So, the hypothesis testing are done in such a way that they will give you some information that the test which you have implemented are basically as for the norm, and whether the hypothesis based on which you had actually started to work on improving the overall level of work concept in the shop floor or in the service sector. Wherever you want to implement the concept of quality, whether that really makes sense in the defined stage considering for the five steps of quality improvement approach.

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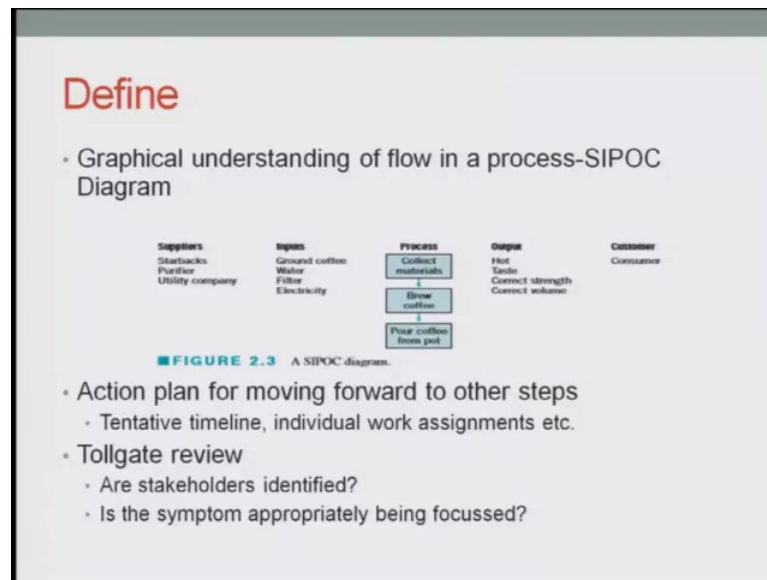
So, the objective is to identify and validate a project opportunity. Project means you are trying to understand the overall implementation from the project point of view. So, project must be important to customer as well as to the business so; obviously, when I am trying to implement a project on a detail scale. Project means I am trying to implement or improve the quality. You should have a positive consequence for the customers and; obviously, you should have positive consequence for the business also. So, it does not mean that I am giving, going to give the best quality to the customers, but at my end, if the cost are very high, it does not basically make any sense. So, I have to basically be rational.

So, the project charters have to be prepared, which would be basically be the business case, and under that you will basically have the, and this project supports the business quality goals which are basically to be implemented, then you have the goal statement, then you have the project plan, and on the opportunity statement would be an opportunity to exist. To close the gap between the customer expectation and our actual performance what we are able to deliver. The project scope would basically have the overall response time, which is measured from the recipient of the product returned, to the time that either the customer has the product replaced or the customer is re embraced.

If there is problem and; obviously, there would be team which would consist of the team sponsor or team leader or team members, who are in a position to implement the overall concept. So, even though I may be skimming the overall writing, which is there in the slide, but I was strongly urge; the participants, the students basically, to have a look at the book, and trust me, the book Montgomery has a lot of information. So, what I am trying to give you is basically, a feel that quality is important and how it can be done; so both quantitatively as well as qualitatively.

So, I have tried to the maximum possible extent as possible to blend a balance between quantity and concept, and as well as the qualitative concept. Quantitative means in a way that what are the tools, which you are going to utilize, and qualitative means how you are trying to basically analyze the problem in a much bigger scale, and try to basically build the concept of quality in each one of the step; such that they give you some information, how quality can be improved.

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So, when you come to the graphical understanding of the flow process in the SIPOC diagram. So, they would be, what are those tough tools or the concepts.

Which are important and what are the notes in the diagram are suppliers, the inputs, the process, the outputs and the customer. So; obviously, supply means the vendors who are supplying goods to you, and then those inputs would be the raw materials, would be the coolants would be; say for example, type of services which I am getting from the vendor. If I am trying to basically offload the production to the vendors, or the sub contractors. So, obviously, there would be a process based on which the raw materials are collected. They are processed and they are manufactured. Then I have basically the output and the output goes into the customers.

So, if I consider the overall the supplies input process, output and customers from the point of view of; say for example, Star Bucks or a provider of services which is basically coffee. So, it would basically have the utility company, who provides the electricity, the water, the goods which are to be add on in order to basically make my overall service, or product, which I want to basically give to the customer. So, the inputs would be the ground coffee, which I am getting the water, the filter, the electricity, then the actual process would be. I collect the materials from the vendors, brew the coffee, pour coffee from the pot, and basically give it to the customer.



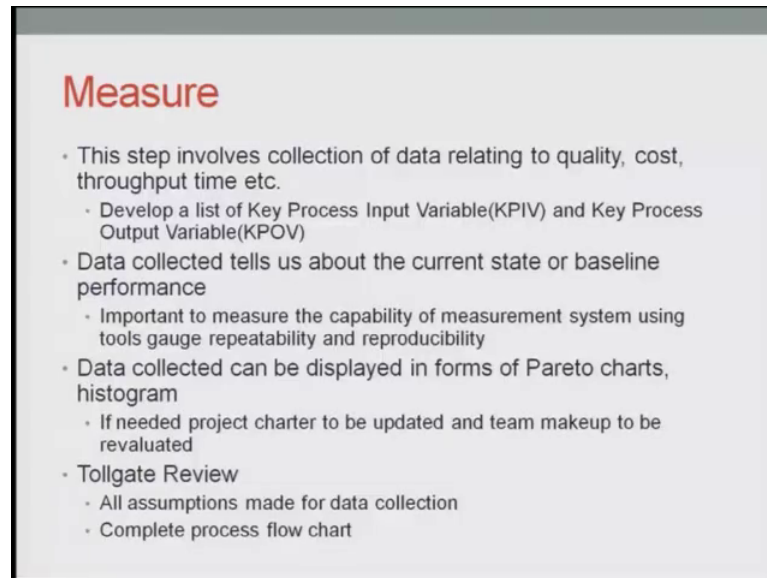
So, actually output should be hot, tasty of the correct quality, depending on the taste of the customers, and the customers are basically the consumers, who come and buy the product or the service. So, again this diagram as I am mentioning has been taken from Montgomery. So, continuing the discussion, the action plan from moving forward to other steps would be. Basically they should be tentative timeline individual. Work assignment should be very specifically, mentioned the reviews, which are happen on the tollgate are. We will try to basically answer, or the stakeholders identify what are the basic points based on which the stakeholder would analyze the problem.

What are their problems, which are there; they can face what is the level of quality conscious. They are to them which are the stakeholders of the customers to them. What is actual concept of quality? What do they think the quality? Is it something to do with the product? Is it something do with the price. Is it something to do with the services? So, we have to basically, as the provider of the goods, provider of the raw material from the services. We have to basically analyze from the point of view of the customers, not from your point of view. So, we will also try to review is this symptom appropriately being focused.

So, if customers are complaining that the products are not being supplied at on time. So, we will try to analyze at whether is it basically specific to a customer, or is basically a general inherent, negative point in the overall supply chain management. So, in that case, in the first case, if it is very specific to few customers with respect to the second point, which is a very general symptom in the overall supply chain process, as you supply the goods. So; obviously, you have to analyze the problem which is poor delivery, late delivery of the goods or the services to customer from two points of view. If it is specific, then you basically concentrate on that particular note of the supply chain, and try to analyze the problem accordingly.

If it is very generic; obviously, you have to basically do a much more thorough understanding of the overall supply chain, and what is the problem, the customers are facing.

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**Measure**

- This step involves collection of data relating to quality, cost, throughput time etc.
  - Develop a list of Key Process Input Variable(KPIV) and Key Process Output Variable(KPOV)
- Data collected tells us about the current state or baseline performance
  - Important to measure the capability of measurement system using tools gauge repeatability and reproducibility
- Data collected can be displayed in forms of Pareto charts, histogram
  - If needed project charter to be updated and team makeup to be reevaluated
- Tollgate Review
  - All assumptions made for data collection
  - Complete process flow chart

So, when you want to basically come to the concept of the measurement of the actual concept, which we discussed in the five steps process. So, this step would basically involve a collection of the data, relating to the quality. So, what we mean by quality? Is it something to do with texture? Is it something to do with taste? Is it something to do with weight? Is it something to do with color? So, that has to be understood in a very specific manner. So, they would be cost, they would be throughput time. So, all this things have to be analyzed. So, develop a list of key process input variables, and key process output variables.

So, what are the key processes based on which you can analyze the product or the services, the inputs with respect to the key process outputs. So, you basically should have a thorough understanding what are the inputs, and what are the output based on which you are trying to understand and study the whole process in details. Data collected tells us about the current state of baseline, or the business which you are trying to do, and how the process works. So, it is important to measure the capability of measurement system, using tool, gauge or repeatability or reproducibility should be there. So, if I am trying to measure the overall length, measure the overall height, measure the weights.

So, I should be in a position; such that I keep measuring it without any much of variance; obviously, there would be white noise, which is in variance coming out from outside, which is not our under our control, but we should be in a position to measure the quality

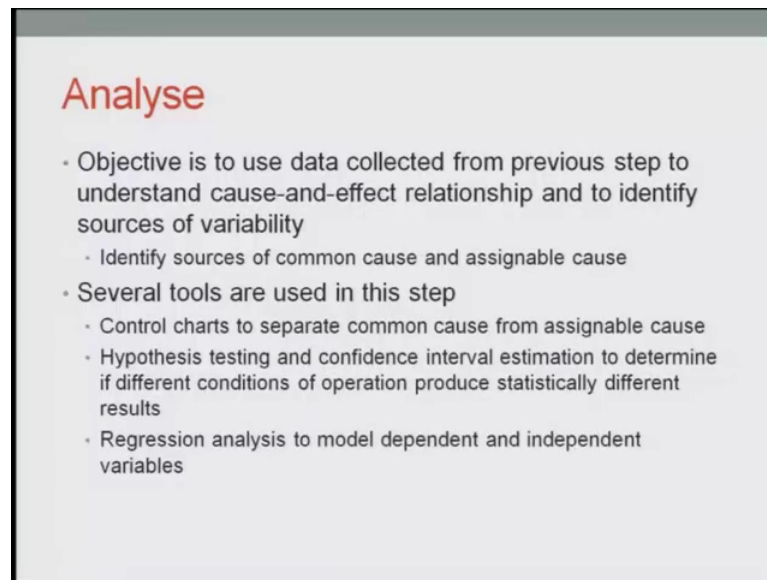
characteristics, based on which you are trying to implement your overall process. Data collected can be displayed in form of Pareto charts. So, what are Pareto charts? I will come to that later on and histogram. So, if you remember I did mention when we are considering the concept of P D F P M F and the C D F. I did discuss the P D F and P M F with respect to the C D F value.

So, how the histograms can be plotted, and which looks like a normal distribution. If you remember I did mention that. So, that would only be applicable in the case, if we have a huge amount of samples, and try to basically plot the histogram; so as per the concept of central limit theorem. Obviously, I am using this concept of central limit theorem for the first time. we will see that later also, and as per the concept of central limit theorem, many of the distributions which we will try to implement can be converted into a very simple case of normal distribution. So, if needed project charter to be updated and team makeup to be reevaluated. so; that means, in case the histogram, the Pareto diagrams are giving us some other informations.

We may need to basically have a relook at the team which, who are there team members, who are there, and try to either give them training or basically reshuffle the team in order to actually see to the point that the basis idea of quality improvement, which is. there is the overall process is an integral part of the overall system. So, the tollgate review happens; such that all assumptions made for the data collections are basically analyzed and understood, and we complete the process, the flow chart such that the flow chart gives us along with the diagram, which is a good understanding, how the overall process is being implemented from the vendor side to our side and from our side to basically the distributors.

And finally, from the distributors to the customers in the analysis face, which I did discussed earlier in the five steps of improvement.

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**Analyse**

- Objective is to use data collected from previous step to understand cause-and-effect relationship and to identify sources of variability
  - Identify sources of common cause and assignable cause
- Several tools are used in this step
  - Control charts to separate common cause from assignable cause
  - Hypothesis testing and confidence interval estimation to determine if different conditions of operation produce statistically different results
  - Regression analysis to model dependent and independent variables

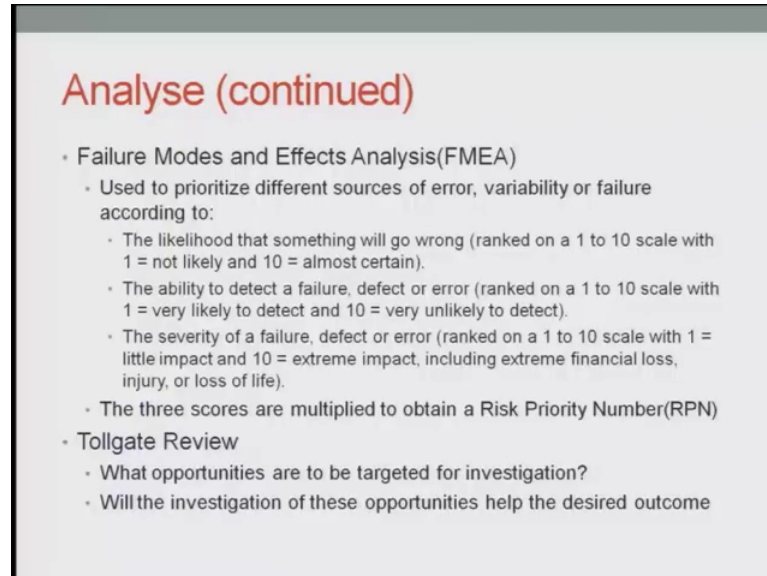
So, objective is to use data collected from previous steps, to understand cause and affect relationship, and to identify sources of variability which may be there. So, main aim is to identify sources of common cause and assignable causes. Several tools are used to in this step, which are control charts to separate common cause from assignable cause. hypothesis testing are done based on the fact that what should be actually to the overall study.

So, if I am, I hypothesis that some process capability are shifting, or say for example, the temperature is shifting, or say for example, the length of the tie rod is shifting, or say for example, the overall brittleness of a product is shifting. So, all this concept should basically be hypotheses; such that I basically collect the data use that in the implementation stage; such that using very simple statistical rule. I am able to either prove or disprove my hypothesis, based on which some corrective action, if needed can be taken. So, continuing that hypothesis testing and confidence interval estimation to determine, if different conditions of operation procedure statistically give different results. so; obviously, we will try to collect the data.

And try to prove or disprove this fact, and then regression analysis can also be utilized to model dependent and independent variables; such that they can be implementable in the actual process. Obviously, we would not be going to such details for the regression

analysis. What we will definitely go into the concept of hypothesis testing, and how the different types of statistical process control tools are utilized.

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**Analyse (continued)**

- Failure Modes and Effects Analysis(FMEA)
  - Used to prioritize different sources of error, variability or failure according to:
    - The likelihood that something will go wrong (ranked on a 1 to 10 scale with 1 = not likely and 10 = almost certain).
    - The ability to detect a failure, defect or error (ranked on a 1 to 10 scale with 1 = very likely to detect and 10 = very unlikely to detect).
    - The severity of a failure, defect or error (ranked on a 1 to 10 scale with 1 = little impact and 10 = extreme impact, including extreme financial loss, injury, or loss of life).
  - The three scores are multiplied to obtain a Risk Priority Number(RPN)
- Tollgate Review
  - What opportunities are to be targeted for investigation?
  - Will the investigation of these opportunities help the desired outcome

So, continuing the analysis concept. So, analysis we have the failure mode and effective analysis process is there, which is basically use to prioritize different sources of errors variability or failure, according to say for example, the likelihood that something will go wrong, would basically be ranked from a scale from 1 to 10 with 1 mean.

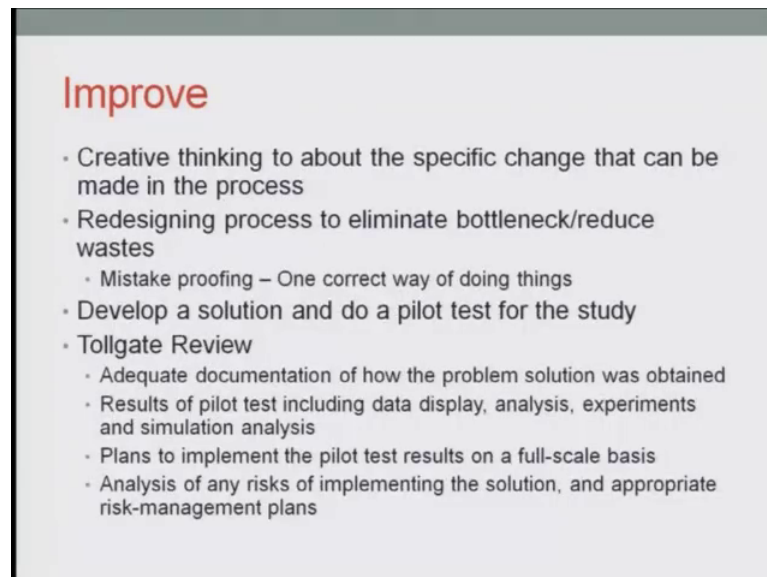
Say for example, not likely and 10 means; say for example, almost certain, or say for example, the ability to detect defect, or defect is there, or a failure is there, or a error is there, and we basically again rank them from a scale a 1 to 10. 1 being very likely 10 being very unlikely or say for example, we try to bring into the analysis the failure modes would be the severity of a failure defector, or a failure or an error. again from a rank from 1 to 10. So, when 1 basically is the scale for little impact and 10 being the scale for extreme impact. So, if this 1 to 10 scale, which I am mentioning basically gives you a level of importance to that level or to that metric, which you are going to study.

And how it can basically characterize from the very good to the very bad, or very problematic; one for the one, which are not at all that problematic. the three scores are multiplied to obtain a risk priority number. So, this levels which I have the likelihood the ability, the severity, basically they are scaled on in such a way that you basically are able to understand, on this is scale, what is the level of importance you are going to place on

this level of defect, which level of severity of defect, or say for example, the ability to detect failures, or how good and bad this overall thing is, there on a one to one basis the tollgate review.

Basically understands what opportunities are there to be targeted for investigations, based on the detail studies. and while the investigation of this opportunities helped us to get, they have to get or basically have the overall desired outcome, based on which we are trying to analyze the overall process for the production on the services which are going to render.

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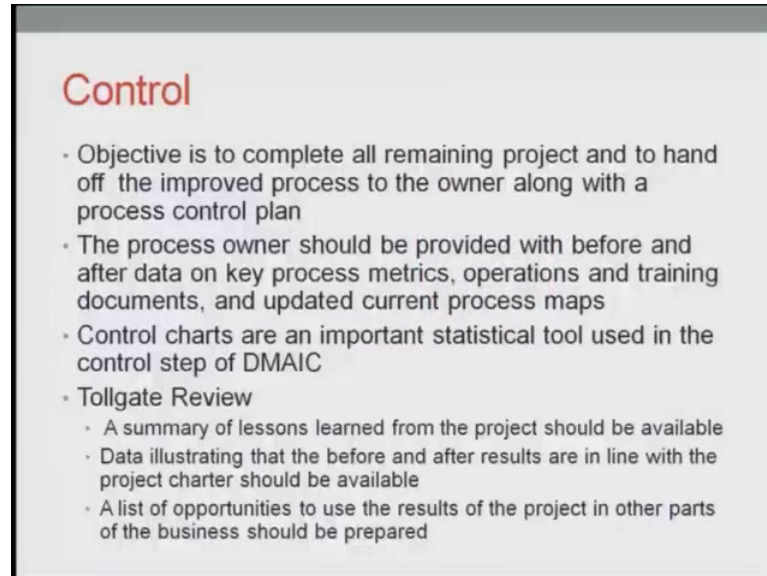


So, in the improve one or improves concept of analysis for the points of discussion, for quality improvements would be creative thinking, to basically understand this specific change that can be made in the process, should be analyzed and then we basically redesign the process to eliminate bottlenecks.

And reduce the waste we should definitely be overall important factor, when we are going to consider that. So, then the third one would be basically to develop a solution and do a pilot study for the project, and how this can be implemented, and the tollgate review. again we basically analyze adequate documentation is done, results of pilot test including data display analysis experimental and simulation analysis are done, and plan to implement test pilot, test on a full scale basis should be implementable in the tollgate review stage and finally, the analysis of any risk of implementing the solution, and

appropriate risk management plan should definitely be implementable in the control stage.

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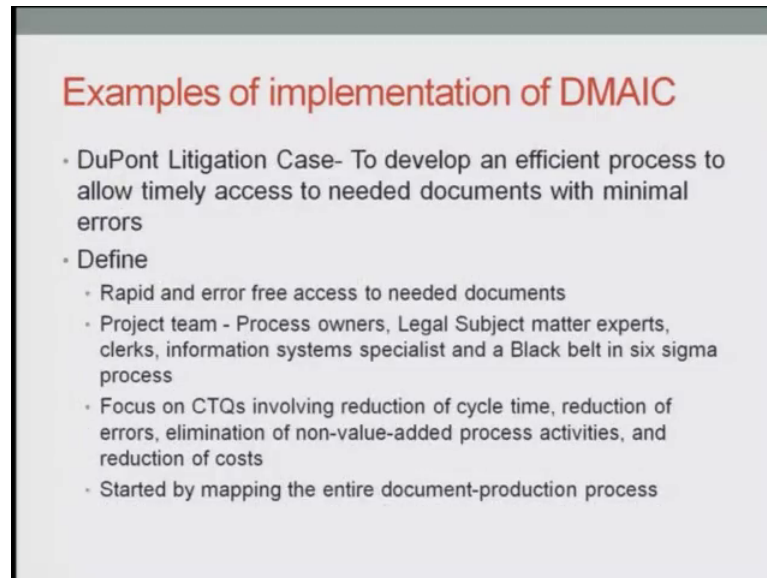
**Control**

- Objective is to complete all remaining project and to hand off the improved process to the owner along with a process control plan
- The process owner should be provided with before and after data on key process metrics, operations and training documents, and updated current process maps
- Control charts are an important statistical tool used in the control step of DMAIC
- Tollgate Review
  - A summary of lessons learned from the project should be available
  - Data illustrating that the before and after results are in line with the project charter should be available
  - A list of opportunities to use the results of the project in other parts of the business should be prepared

We have objective, is to complete all remaining projects, and to hand off the improved process to the owner along with the process control plan, then we have the process owner should be provided with before and after data on key processes. Control charts are important such that statistical tool are utilized in the control step of DMAIC and the tollgate review, which is basically review would be a summary of the lessons learned from the project, should be available data illustrating that before and after results are in line with the project charter should be available; such that the data which we have, can be basically implementable in the use of statistical process control capability method, which are going to implement a list of opportunities to use the results of the project.

Project in other parts of the business should be prepared; such that they can be utilize later on also.

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**Examples of implementation of DMAIC**

- DuPont Litigation Case- To develop an efficient process to allow timely access to needed documents with minimal errors
- Define
  - Rapid and error free access to needed documents
  - Project team - Process owners, Legal Subject matter experts, clerks, information systems specialist and a Black belt in six sigma process
  - Focus on CTQs involving reduction of cycle time, reduction of errors, elimination of non-value-added process activities, and reduction of costs
  - Started by mapping the entire document-production process

So, examples of implementation of DMAIC stage would be the DuPont litigation case, where it was to develop an efficient process to allow timely access to needed documents with minimal error. So, basically it was to define rapid and error free access to needed documents. Project team basically had the process owners legal subject matter experts, information system specialists, and the focus was basically to reduction of the cycle time reduction of the errors elimination on non value added process activities, and reduction of costs.

So, and the last one basically started by mapping the entire document, and production process; so even though this slides which I have been discussing in the last 5 or 6 minutes. I am basically going a little bit fast, but the main emphasis is that, if you read the actual pages from Montgomery, you will understand the overall concept of philosophy based on which you are trying to implement the course, is basically based on the fact that qualities in, is again I am repeating, is an integral part, and it should be implementable in such a way that, they are very logical steps based on which we can take corrective actions to understand whether quality improvements is necessary, and if it is necessary, how it can be done step by step; such that it has basically a scientific implication and also the persons.



So, the set of team who are there to implement the quality are also in line with the overall process implementation of how you are basically trying to improve quality for both the production stage, as well as for the service stage.

With this, I will end this lecture and continue our discussion about Total Quality Management later on also.

Thank you very much and have a nice day.