SOE ZARNI

ENPM 641

SYSTEMS PRINCIPLES

UML PROJECT

12/12/2004

System-Level Design of Six Sigma Application
On Existing Product/Service

This project uses systems engineering principles for the system-level development and design of Six Sigma Strategy and Methods. UML is applied to the visual modeling of the system functionality and structure.

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1. Introduction

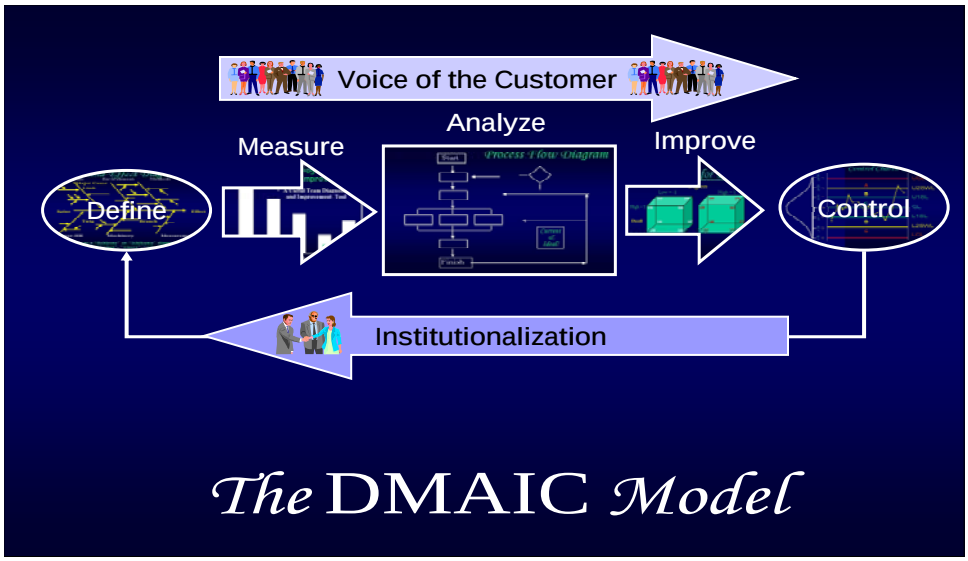
Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, six sigma aims for virtually error free business performance. A company's performance is measured by the sigma level of their business processes. Traditionally companies accepted three or four sigma performance levels as the norm. The six sigma standard of 3.4 problems per million opportunities is a response to the increasing expectations of customers and the increased complexity of modern products and processes.

Six sigma is the application of the scientific method to the design and operation of management systems and business processes which enable employees to deliver the greatest value to customers and owners. The scientific method works as follow;

1. Observe some important aspect of the business.
2. Develop a tentative explanation, or hypothesis, consistent with the observations.
3. Based on the hypothesis, make predictions.
4. Test the predictions by conducting experiments or making further careful observations. Record the observations. Modify hypothesis based on the new facts. If variation exists, use statistical tools to help separate signal from noise.
5. Repeat steps 3 & 4 until there are no discrepancies between the hypothesis and the results from experiments or observations.

Generally, six sigma is about helping the organization make more money by improving customer value and efficiency. The six sigma tools are applied within a simple performance improvement model known as DMAIC described briefly as follows:

D	**Define** the goals of the improvement activity.
M	**Measure** the existing system.
A	**Analyze** the system to identify ways to eliminate the gap between the current performance of the system or process and the desired goal.
I	**Improve** the system.
C	**Control** the new system.



A Six Sigma team consists of Champion, Master Black Belt, Black Belt and Green Belt. The number of team members depends on the size and importance of the project. Organizational chart of six sigma team is as follow:

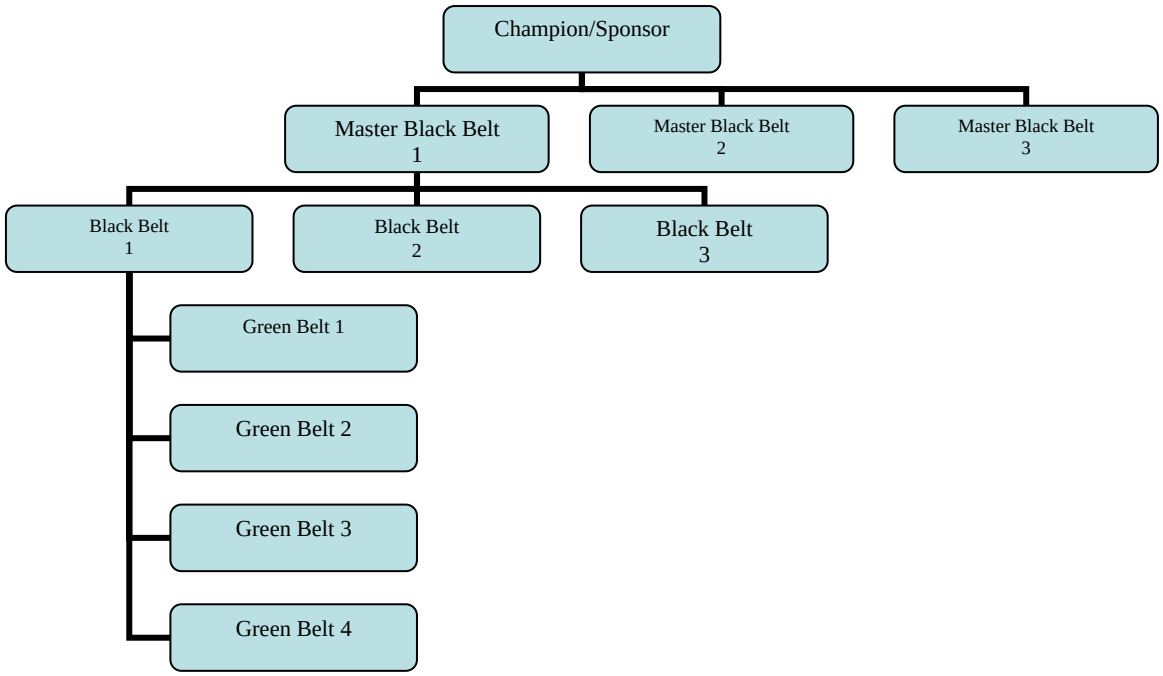


Fig 1. Organizational Chart.

Generally there is 1 to 10 ratio of the team member in each rank.

The Fig.2 shows the system structure of six sigma application on a project.

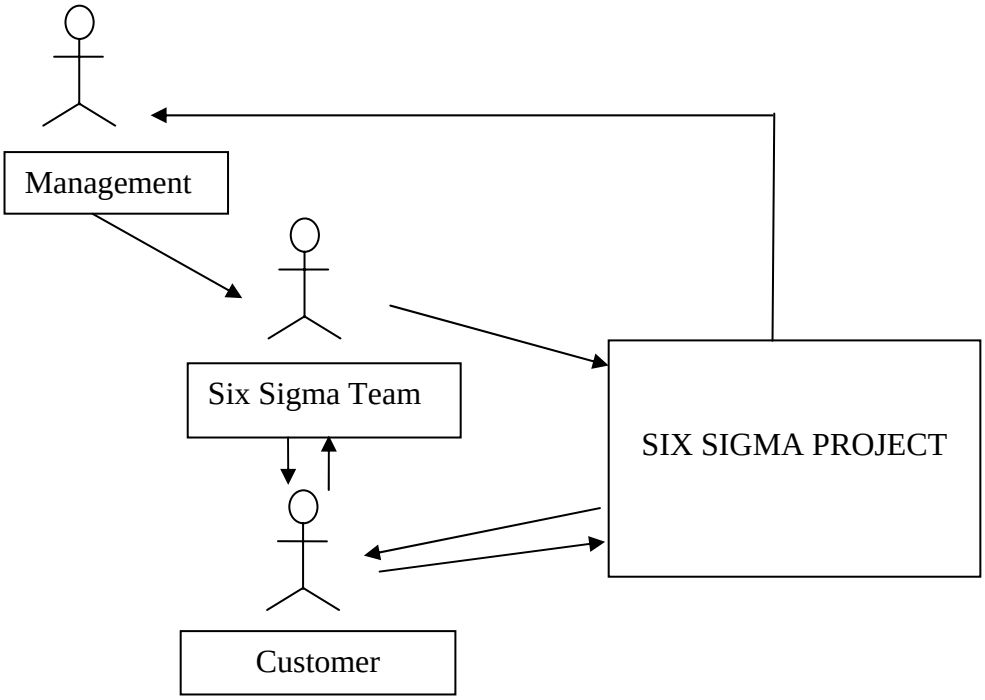


Fig. 2

Management assigns the six sigma team which interacts with the users (customers/operators) to achieve the goals of each stage of six sigma process. The team carries out the project and report/verify the outcomes with management and customers.

2. Problem Statement

The purpose of this project is to demonstrate systems engineering processes concerned with the step-by-step system development of Six Sigma application, from identification of system requirements through to specification of all components. System-level development and design along with UML and, further, explore alternative system design whose objectives vary through the design space bounded by constraints will be studied through.

This case study will evolve as follows:

1. The requirements for the Six Sigma project will be developed by using a use-case development with goals and scenarios elicitation. The key steps involve identification of: (1) the actors and system boundaries, (2) the use cases, (3) information flows between the actors and the use cases, and (3) potential dependencies among the use cases.
2. System hierarchies for this problem and detail communication.
3. State chart diagrams for the system behavior.
4. The system structure of Six sigma.
5. A trade-off analysis for design options versus measures of effectiveness at the logical state of design.

The systems engineering approach is used in order to determine system structure and system behavior from user/system requirements. Once they are determined, the system logical design is obtained.

3. Goals, Scenarios, and User Requirements

Goals and Scenarios for Initial Use Case Modeling

Elicitation of goals and scenarios are very important phase, where system requirements are generated. Once the elicitation of goals and scenarios are done, the following use case modeling is performed. This will help identify systems requirements for the Six Sigma project.

Goal 1. Define: The Six Sigma team must assess customers' need(s) in detail.

Scenario 1.1. Identify the customer.

Scenario 1.2. Define customer's expectation and needs

Scenario 1.3. Clearly specify the deliverables tied to those expectations.

Scenario 1.4. Identify CTQs (Critical to Quality) for those deliverables.

Scenario 1.5. Map the process.

Scenario 1.6. Determine where in the process the CTQ's can be most seriously affected.

Scenario 1.7. Evaluate which CTQ's have the greatest opportunity for improvement.

Scenario 1.8. Define the project to improve the CTQ's you have selected.

Goal 2. Measure: The Six Sigma system must determine what Measurements are Important and What Tools should be Used?

Scenario 2.1. Select Customer Critical to Quality (CTQ) Characteristics.

Scenario 2.2. Define Performance Standards (Numbers & Units).

Scenario 2.3. Establish the Data Collection Plan, Validate the Measurement System, and Collect the Necessary Data.

Goal 3. Analyze: The 6 σ must identify ways to eliminate the gap between the current performance of the system or process and the desired goal.

Scenario 3.1. Team determines the current baseline.

Scenario 3.2. Team uses exploratory and descriptive data analysis to understand the data.

Scenario 3.3. Team uses statistical tools to guide the analysis.

Goal 4. Improve: The six sigma system must able to test sources of Variation to determine which of these actually cause process Variation in the Customer CTQ and the precise changes needed.

Scenario 4.1. Screen / Identify Causes of Variation.

Scenario 4.2. Discover Variable Relationships.

Scenario 4.3. Estimate operating Tolerances & Pilot solutions.

Goal 5. Control: The system must able to statistically confirm that the implemented changes have produced improved performance.

Scenario 5.1. Validate the measurement system of the control variables.

Scenario 5.2. Determine process capability.

Scenario 5.3. Implement process control system and bring the process to a close.

Use Case Modeling

Identify Actors

The six sigma system has the following actors;

Actor	Description
Management	Top level management of the company.
Six Sigma Team	The team assigned by the management to carry out the project using six sigma methods.
Customer/User	People who use the service/product of the company.

System Boundary

System boundary is about what things are inside the system and what are outside the system. It is defined by identifying the actors and the use cases. The system boundary of the six sigma is defined by itself that has an interface through which Management, six sigma team and customer can interact to come up with a better product/service. Management, team and customer are all external systems.

Use cases

The use cases represent system goals or system functions.

The purpose of the initial use case modeling is to provide high-level framework and traceability for the system functionality, expected performance, and system requirements.

The following figure shows the high-level use cases and activity diagram.

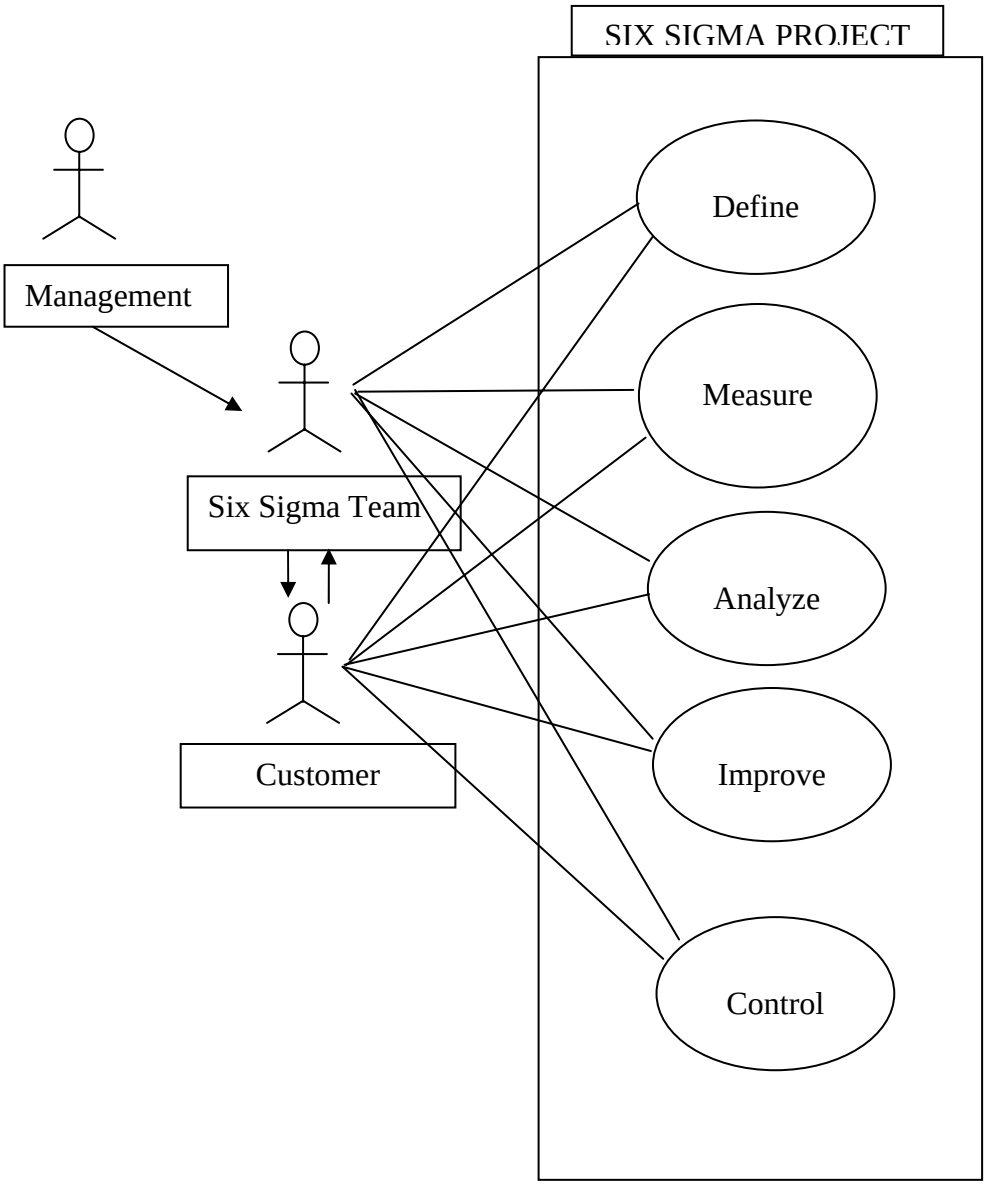


Fig3. initial use case diagram.

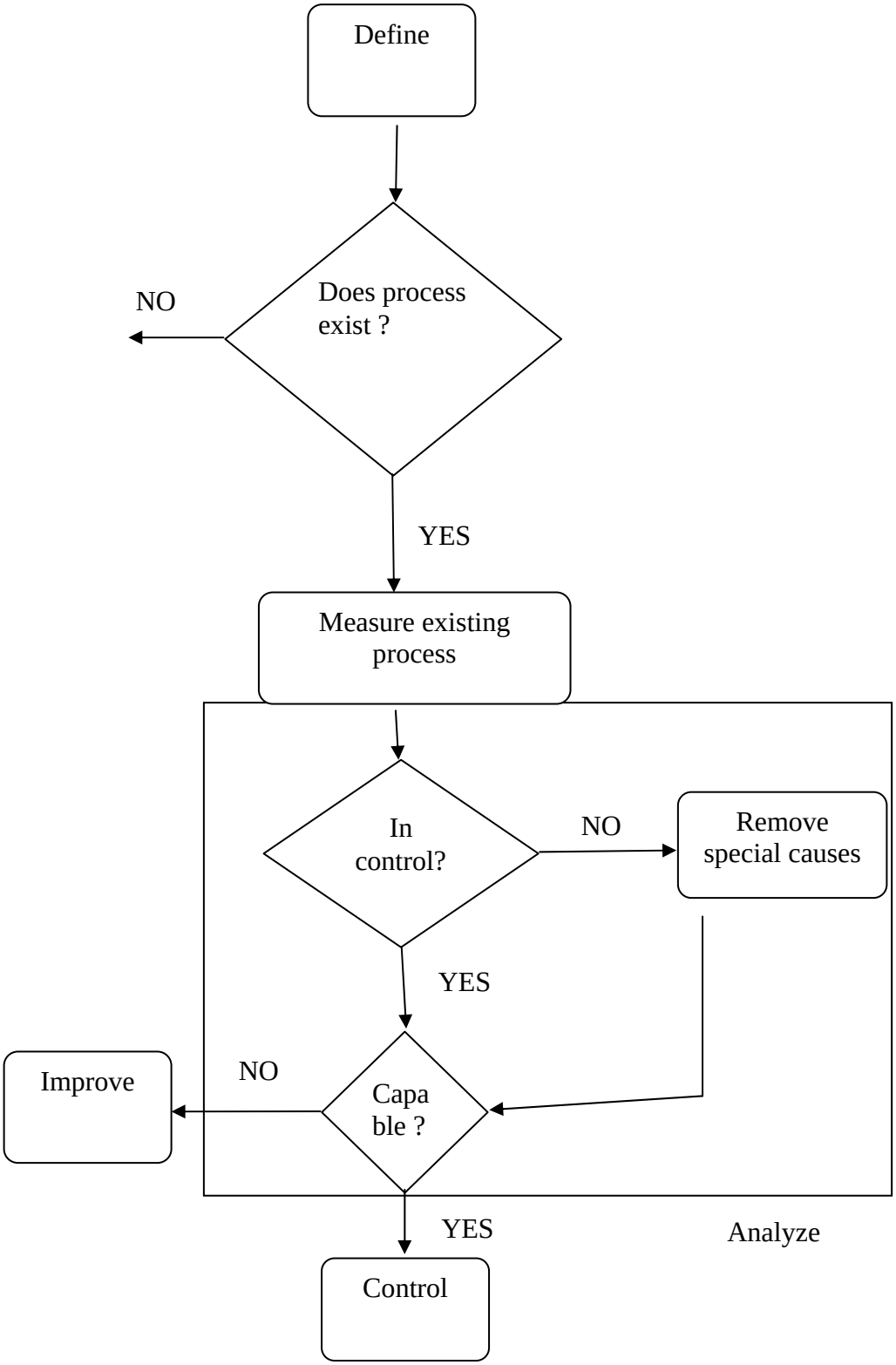
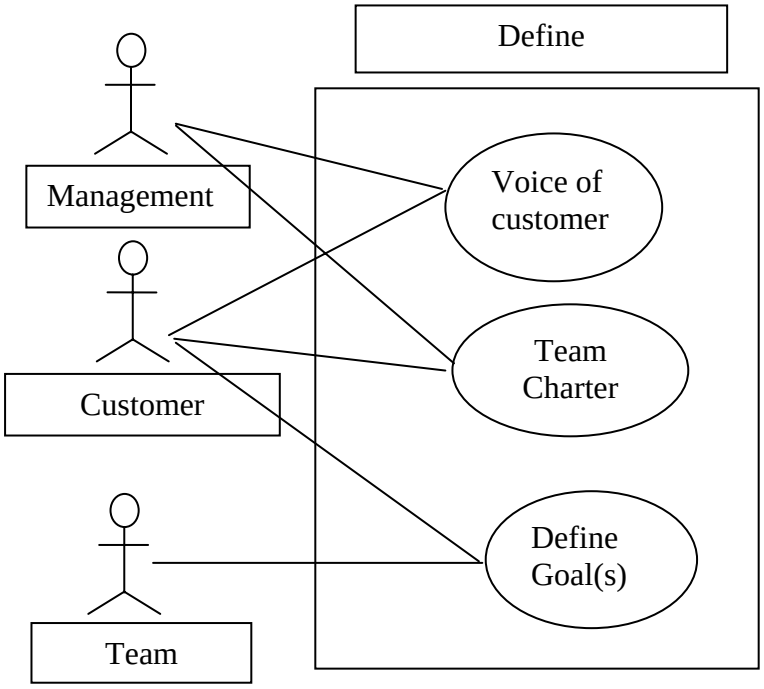

Define
Does process exist ?
NO
YES
Measure existing process
In control?
NO
Remove special causes
YES
Capa ble ?
NO
Improve
YES
Control
Analyze

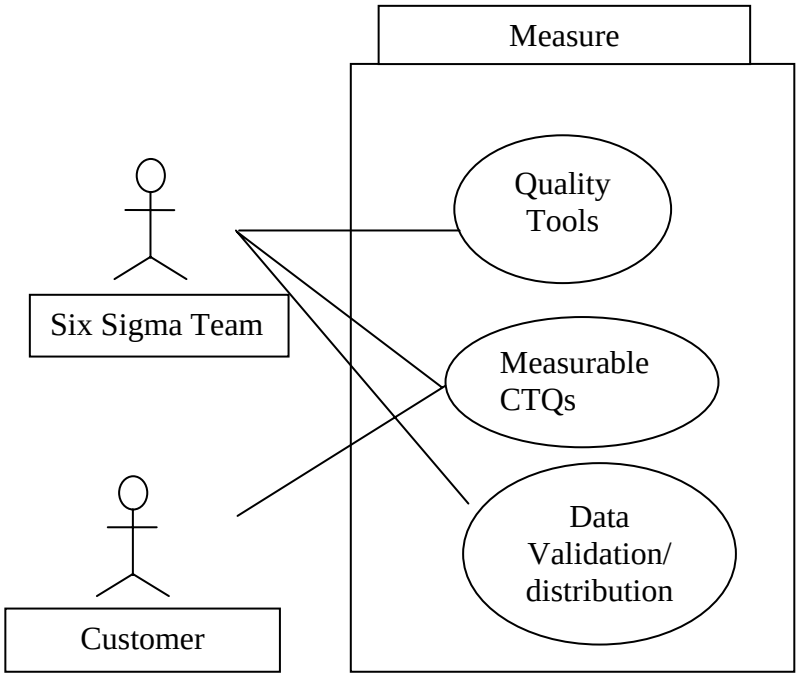
Fig 4. Initial activity diagram.

Expanded Use Cases

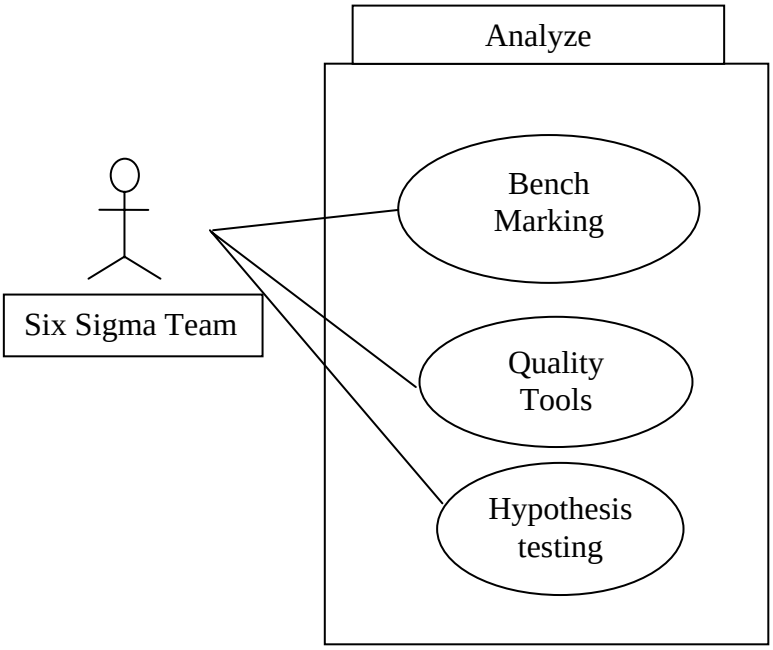
Expanded Use Case 1. Define



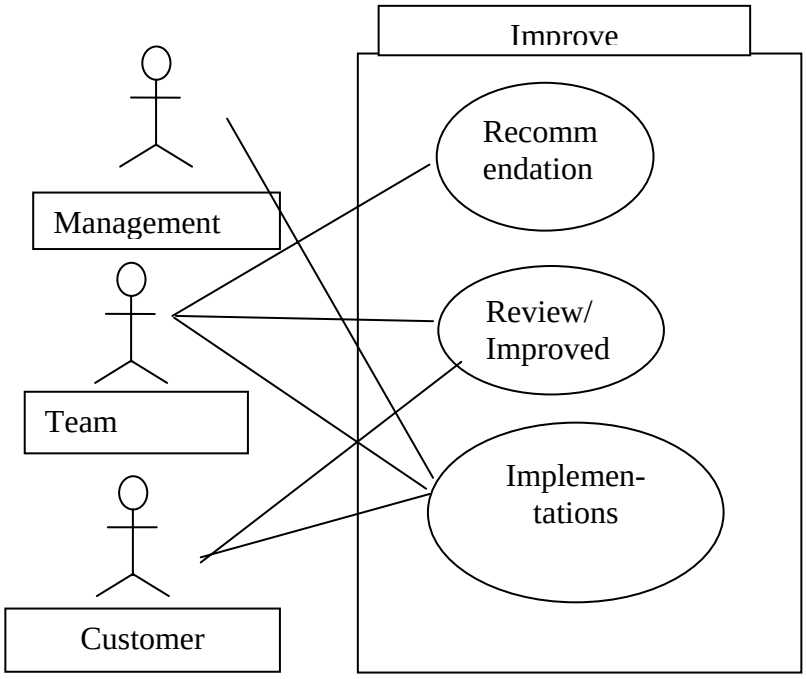
Expanded Use Case 2. Measure



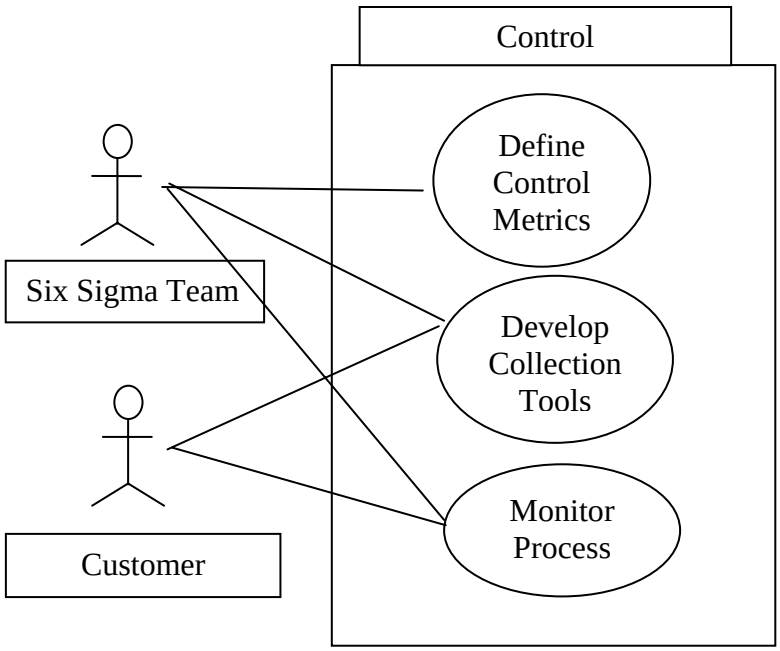
Expanded Use Case 3. Analyze



Expanded Use Case 4. Improve



Expanded Use Case 5. Control



Baseline (Textual) Use Cases with Activity Diagrams

When the flow of events is linear, a textual description of behavior is often sufficient to capture the system behavior. Activities diagram provide a visual documenting sequence of task making up a single activity. They especially are useful for activities governed by conditional logic, and flow of event running concurrently. We described the basic system functionality with textual use cases, and now will employ activity diagrams for a visual representation of the corresponding sequence of task or flow of information.

Exd. Use Case (1): Define.

Description: Choose the team and define the project's goal(s).
Actor: Management, customer and team.
Precondition: Project approved by management and financial department.
Flow of event:
1) Team selection.
2) Review project documentation.
3) Define project's plan and goal clearly.
Post condition: Project is ready to go to next phase.
Alternate flow of event:
1) Used existing team.
Assumption: None.

Exd. Use Case (2): Measure.

Description: Collection of required data.
Actor: Customer and team.
Precondition: Project already has clearly stated goal.
Flow of event:
1) Identify CTQs.
2) Define data collection method and measurement system.
3) Collect data.
4) Validate measurement system.
Post condition: Project has necessary data and ready for analysis.
Alternate flow of event:
1) Used historical data.
Assumption: None.

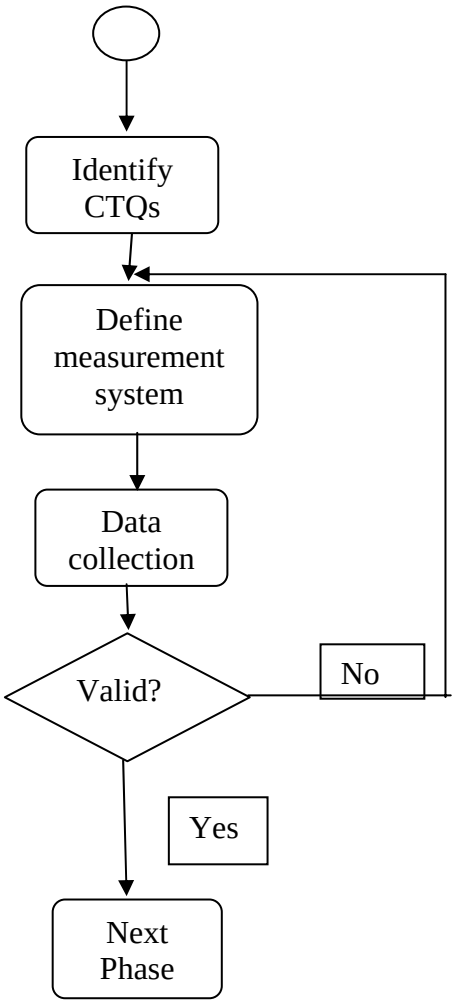


Fig. Activity diagram for Measure phase.

Exd. Use Case (3): Analyze.

Description: Analysis of collected data to address problems and required changes/improvement.
Actor: Team.
Precondition: Project already has validated data.
Flow of event:
1) Prepare baseline.
2) Determine the distributions of the data and analyze them using statistic tools.
3) Benchmarking.
4) Draw alternatives from the data analysis results.
Post condition: Project result is ready for presentation to management and customer.
Assumption: None.

Exd. Use Case (4): Improve.

Description: Determination of the optimal solution to the problem and implementation.
Actor: Management, team and customer.
Precondition: Project already has alternative solutions to the problem.
Flow of event:
1) Present recommendation/solutions to the customer.
2) Formulate test pilots.
3) Analyze pilot results.
4) Determine optimal solution and develop implementation plan.
5) Present final recommendations to the management.
Post condition: Project result is implemented.
Assumption: None.

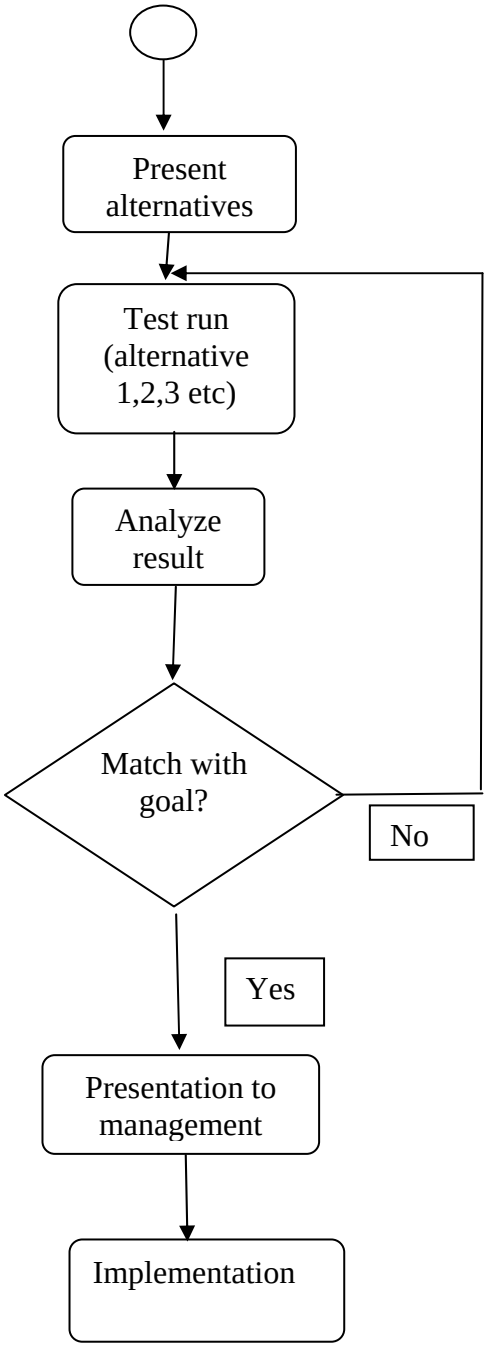


Fig. Activity diagram of Improve phase.

Exd. Use Case (5): Control.

Description: Maintaining of the implemented improved process.
Actor: Team and customer.
Precondition: Project has been completed and the process has been improved.
Flow of event:
1) Define control metrics.
2) Develop metrics collection tool.
3) Monitor process periodically using control metric.
Assumption: None.

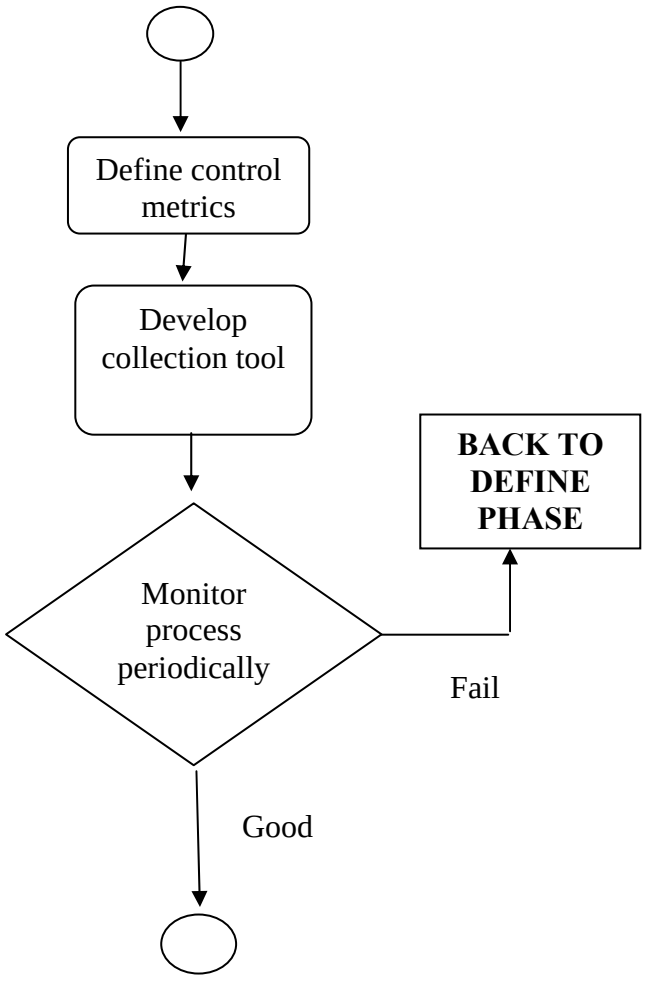


Fig. Activity diagram for Control phase.

Generation of System Requirements

Six sigma system should be able to do the followings;

1	**Identify opportunity for improvement**
2	**Estimate savings**
3	**Draft project charter**
4	**Team selection**
5	**Complete project charter**
6	**Team training**
7	**Define project objectives and plan**
8	**Present objectives and plan to management**
9	**Review and re-define problem, if necessary**
10	**Identify CTQs**
11	**Collect data**
12	**Validate measurement system**
13	**Prepare baseline graphs**
14	**Analyze impacts**
15	**Benchmark other companies**
16	**Consolidate analyses and findings**
17	**Present recommendations**
18	**Review recommendations and formulate pilot**
19	**Prepare for improved process pilot**
20	**Test improved process**
21	**Analyze pilots and results**
22	**Develop implementation plan**
23	**Present final recommendation**
24	**Define control metrics**
25	**Develop metrics collection tool**
26	**Roll-out improved process**
27	**Roll-out control metrics**
28	**Monitor process**

4. Simplified Models of System Behavior

Statechart diagram is used to show the system behavior. First, high level statechart diagram is given to show the overall system behavior, and then detailed statechart diagrams are used to show more specific system behavior.

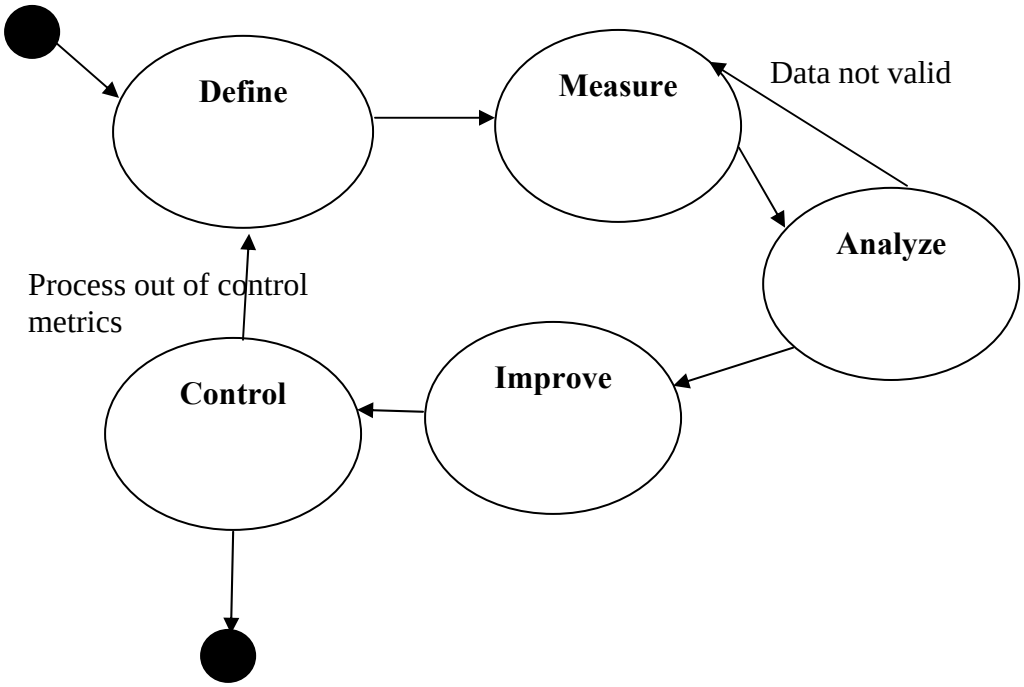


Fig. Initial Statechart for Six Sigma System.

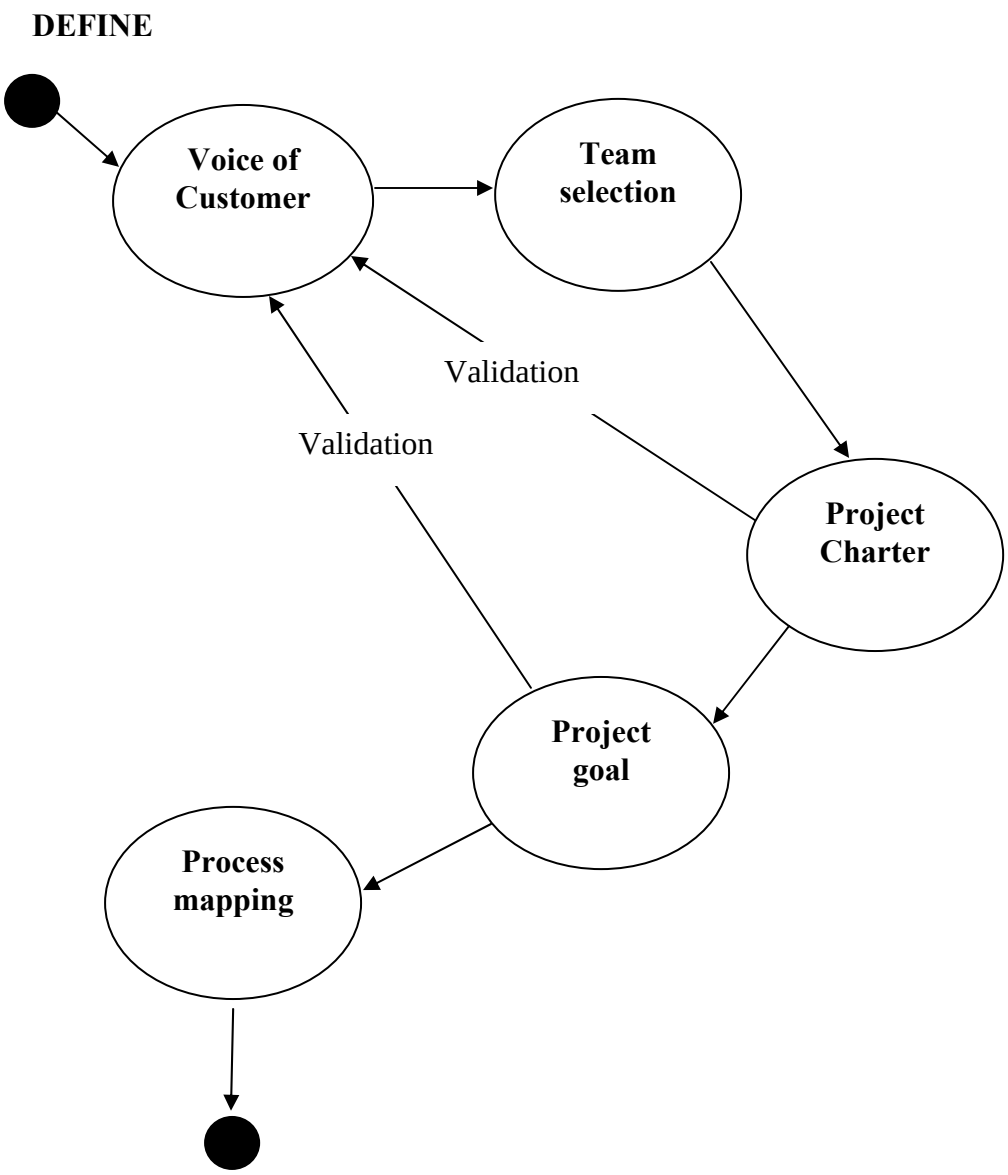


Fig. Statechart diagram of Define phase.

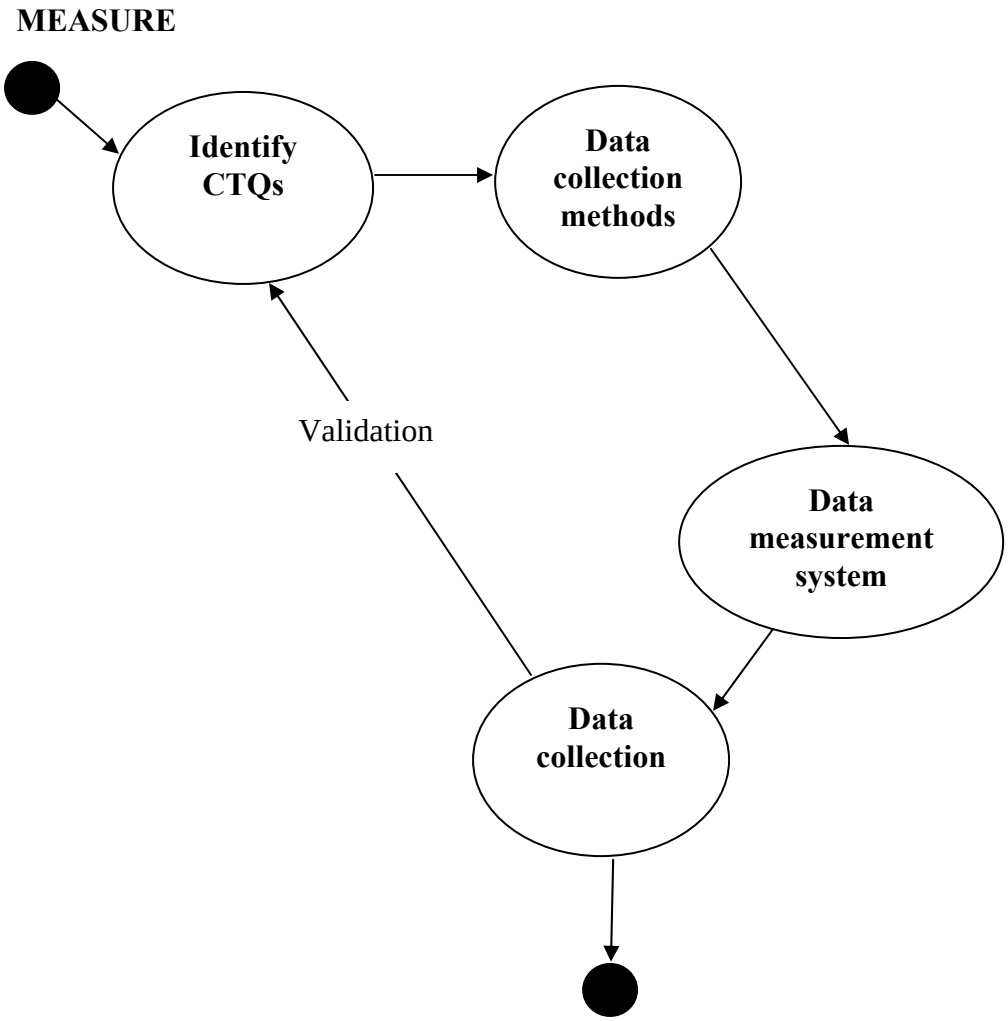


Fig. Statechart diagram for Measure phase.

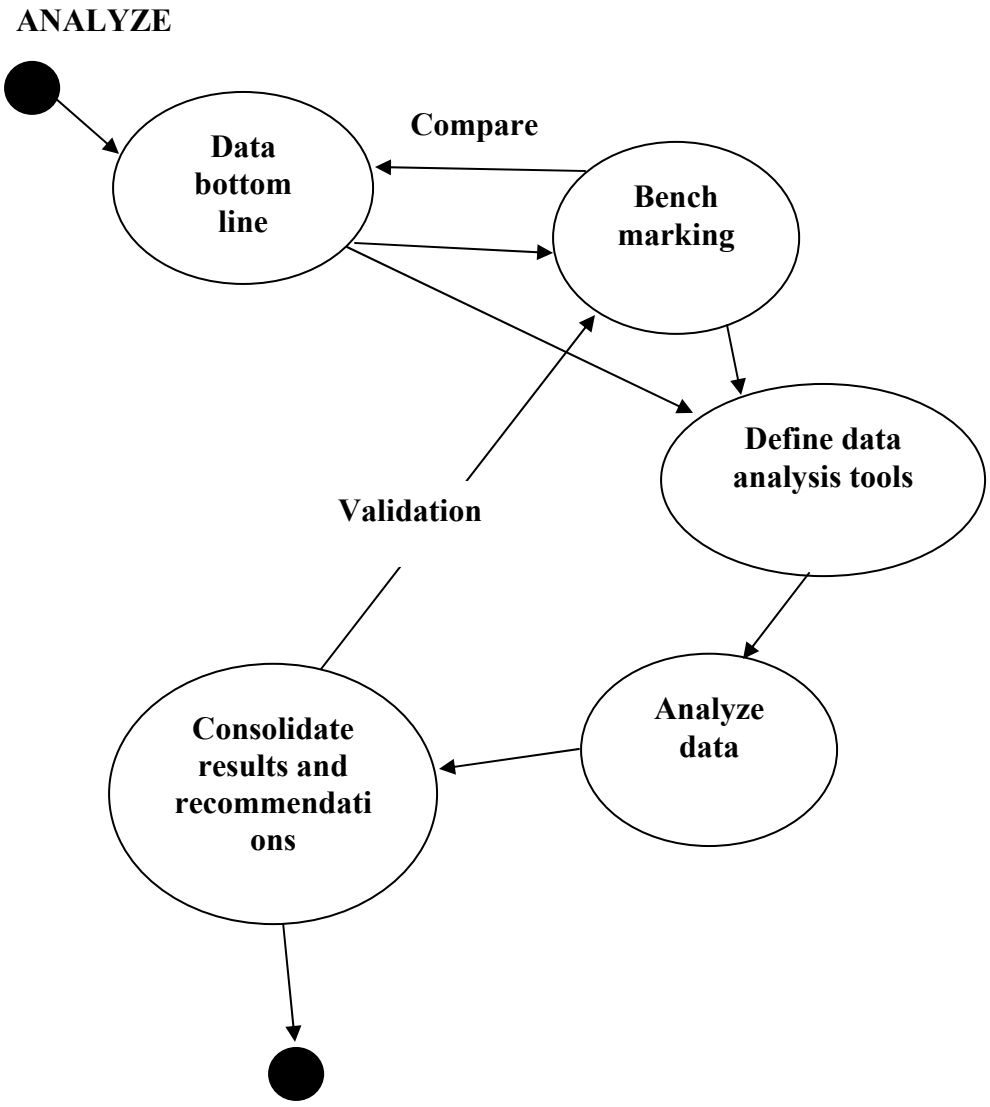


Fig. Statechart diagram for Analyze phase.

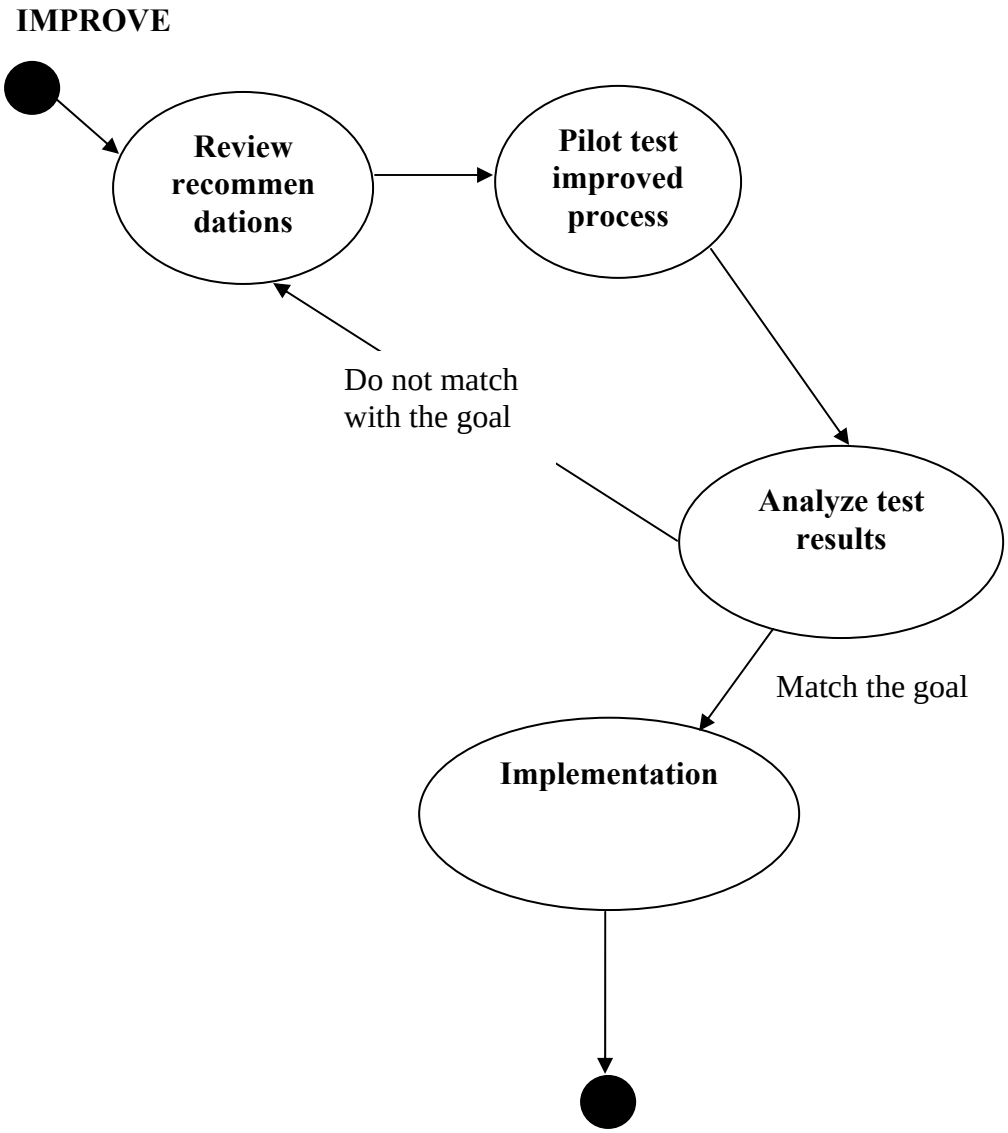


Fig. Statechart diagram for Improve Phase.

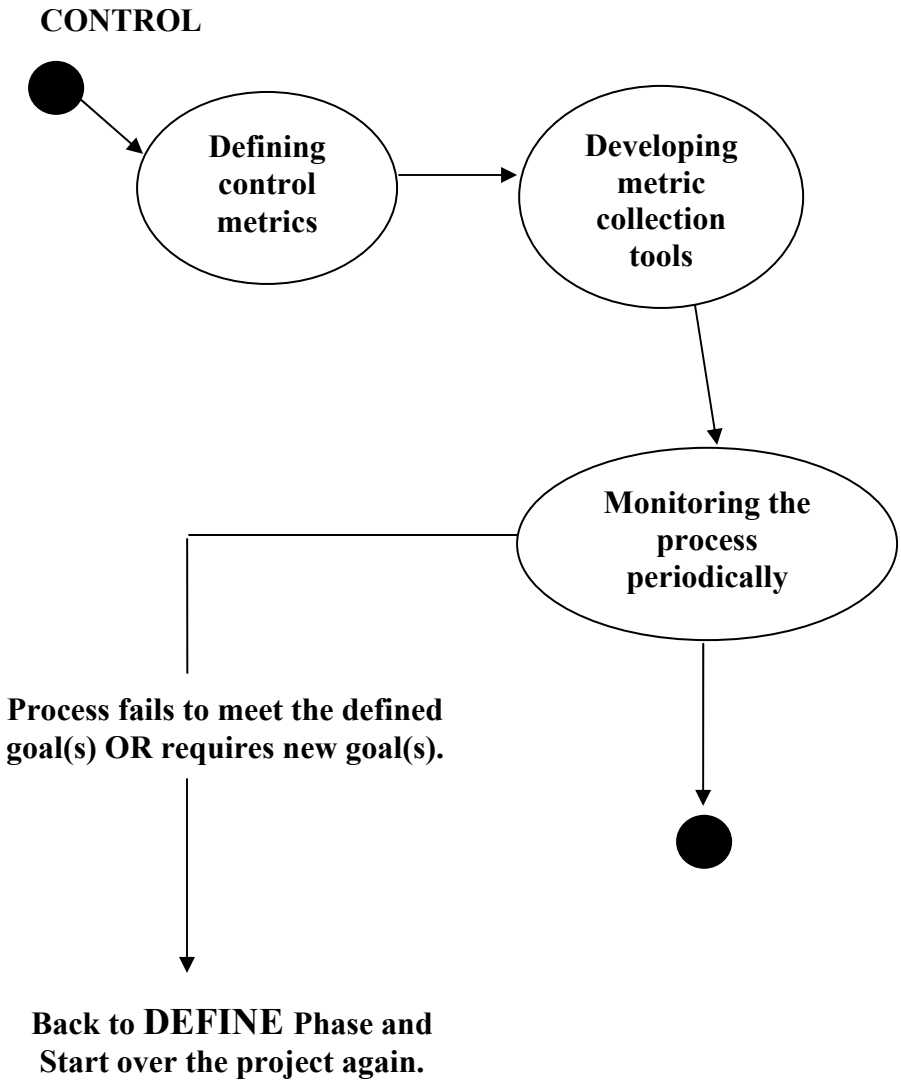


Fig. Statechart diagram for Control phase.

5. Simplified Models of System Structure

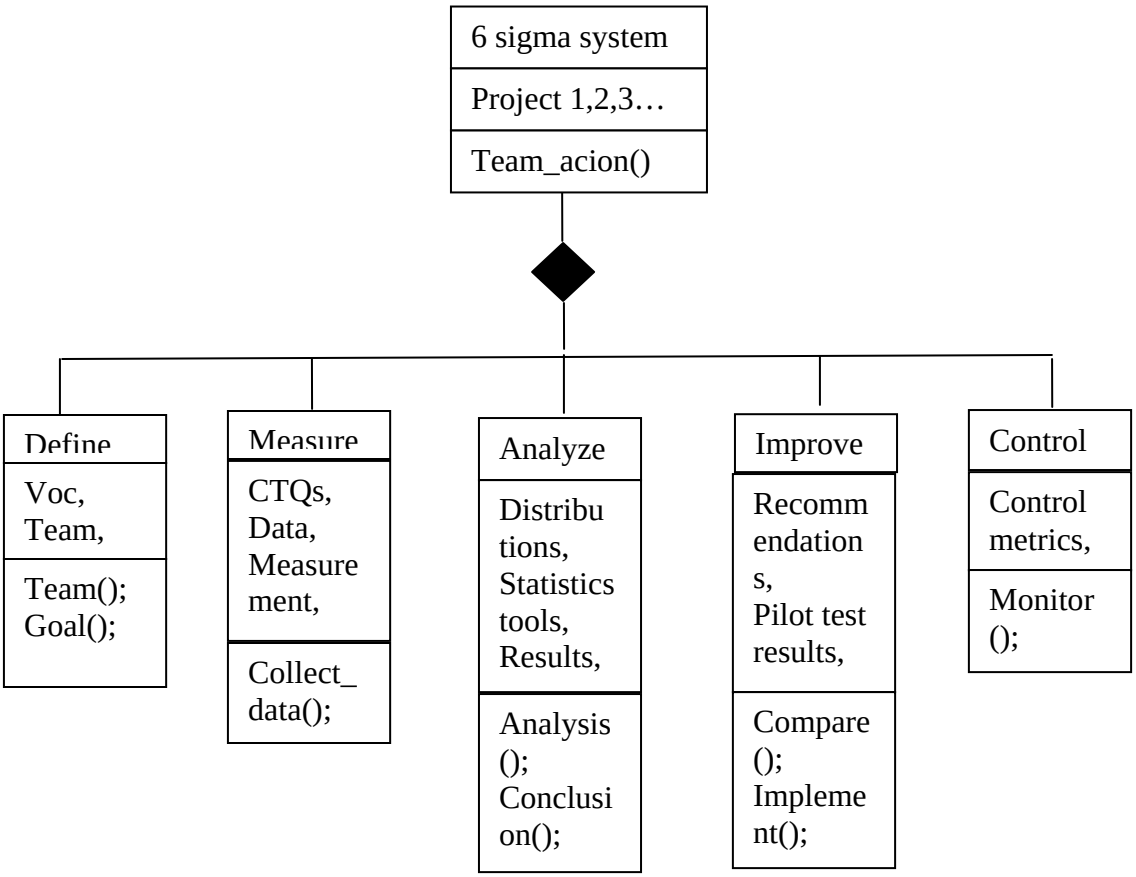


Fig. Class diagram of six sigma system.

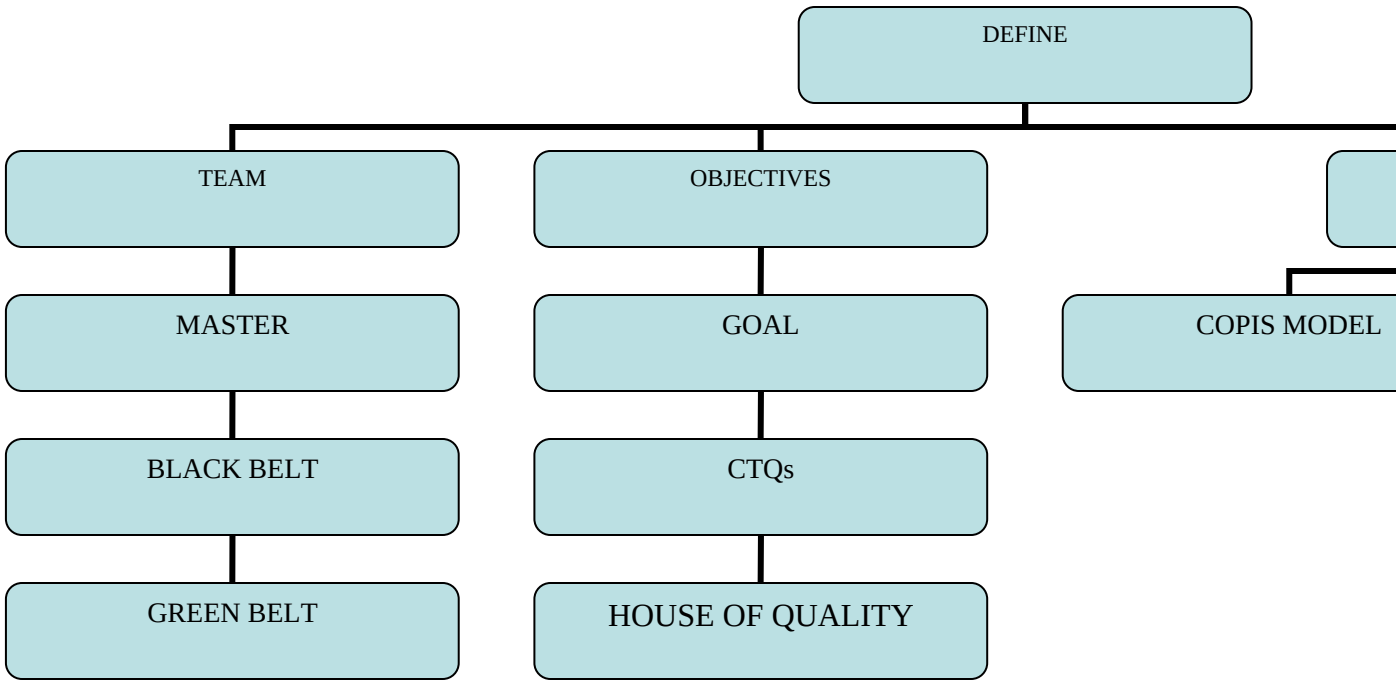


Fig. Class diagram of Define phase.

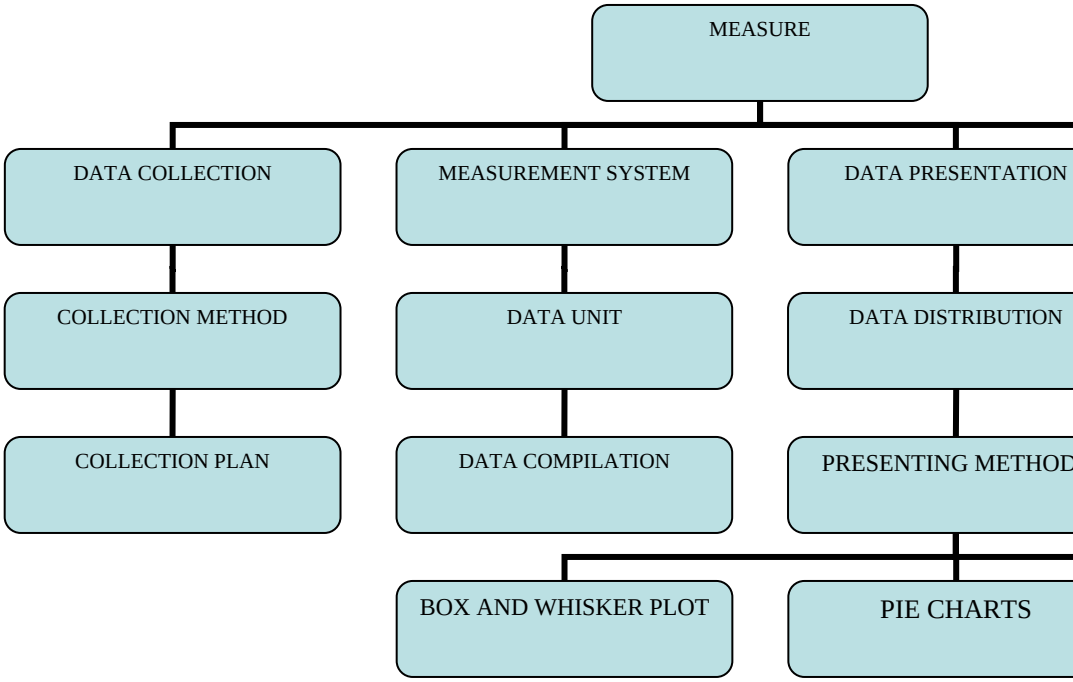


Fig. Class Diagram of Measure phase.

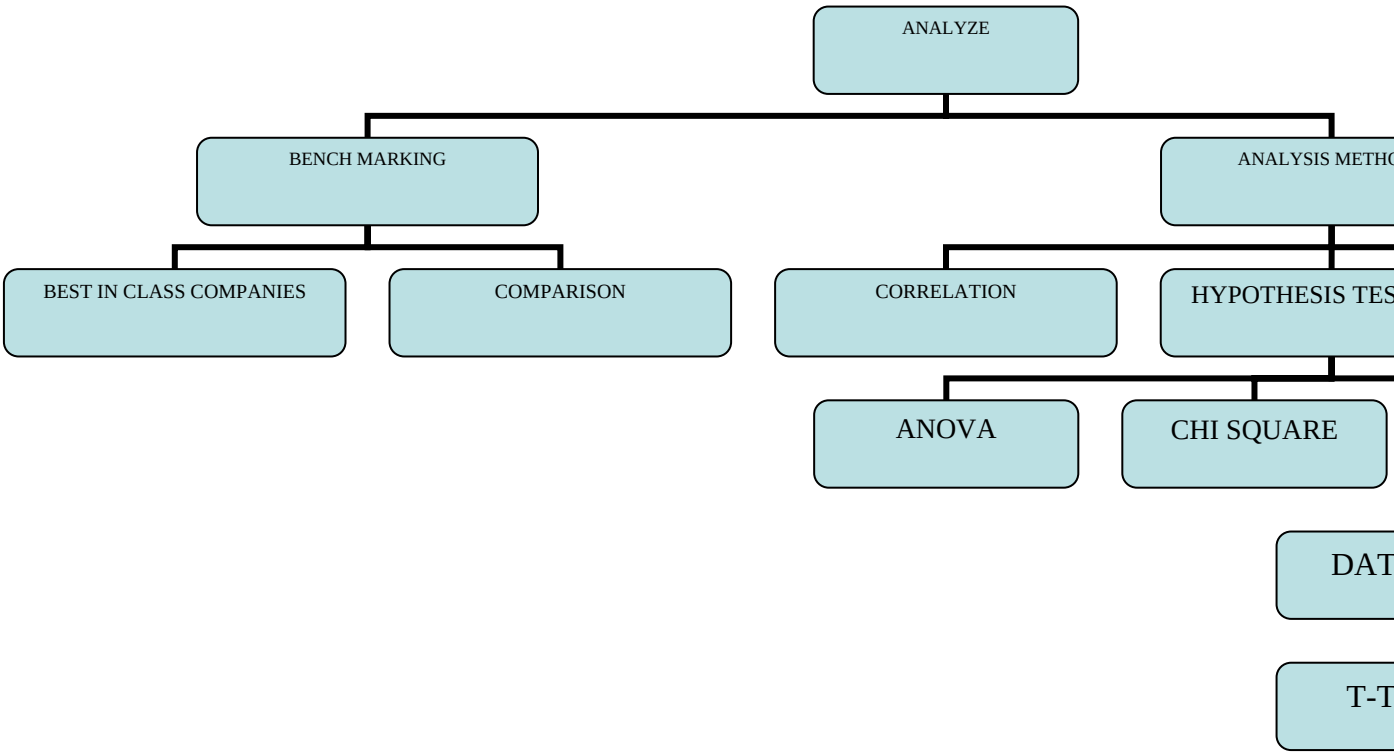


Fig. Class diagram of Analyze phase.

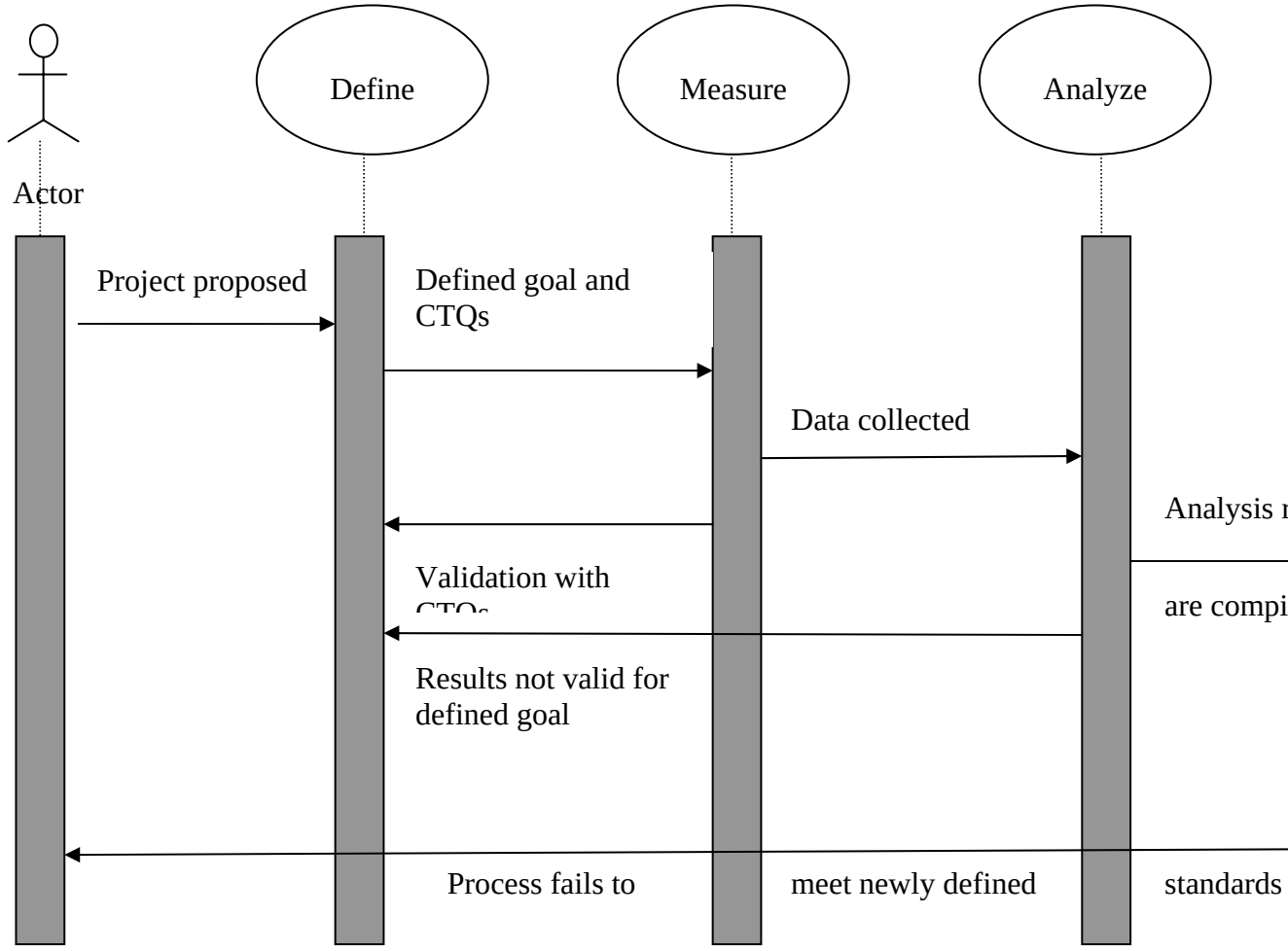


Fig. Sequence diagram of Six sigma system.

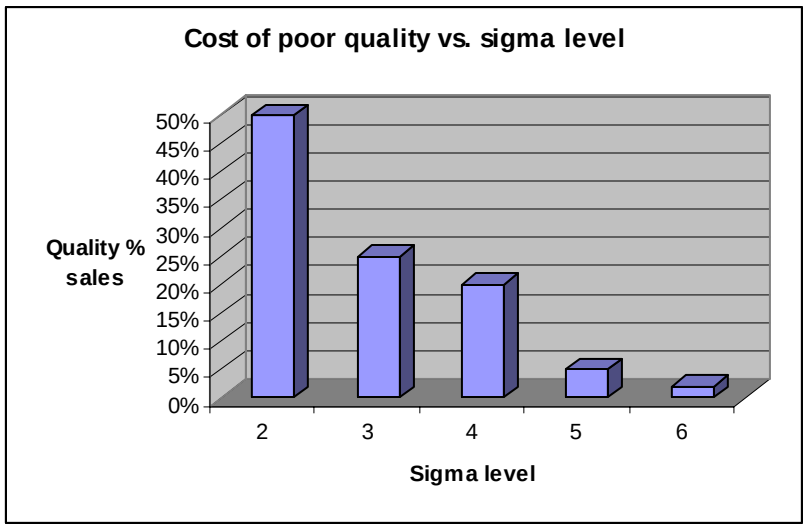
6. Traceability

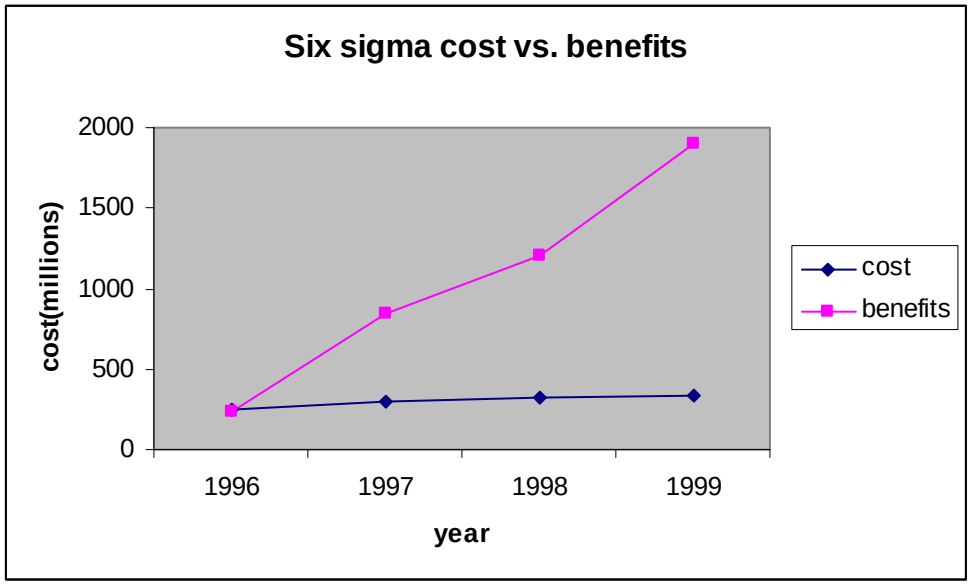
The following traceability matrix shows how use cases trace to groups of requirements and how individual requirements have been taken into account in the system-level design.

REQUIREMENT	RESPONSIBILITY	USE CASE
Identify opportunity for improvement	master	six sigma
Estimate savings	master	six sigma
Draft project charter	master, customer	six sigma
Team selection	black belt	define
Complete project charter	black belt	define
Team training	black belt and green belt	define
Review existing process documentation	team, customer	define
Define project objectives and plan	team	define
Present objectives and plan to management	green belt	define
Define and map the process	team	define
Review and re-define problem, if necessary	team	define
Identify CTQs	green belt, black belt	measure
Collect data	team	measure
Validate measurement system	black belt, customer	measure
Prepare baseline graphs	black belt, green belt	analyze
Analyze impacts	black belt, green belt	analyze
Benchmark other companies	team	analyze
Consolidate analyses and findings	team	analyze
Present recommendations	management, team	improve
Review recommendations and formulate pilot	team, master	improve
Prepare for improved process pilot	team, customer	improve
Test improved process	customer	improve
Analyze pilots and results	blackbelt, green belt	improve
Develop implementation plan	team, customer	improve
Prepare final presentation	team	improve
Present final recommendation	green belt	improve
Define control metrics	master, black belt, green belt	control
Develop metrics collection tool	black belt	control
Roll-out improved process	customer	control
Roll-out control metrics	customer	control
Monitor process	customer, black belt	control

7. **Tradeoff Analysis**

In the age of Internet and web enabling there are lot many areas that one has to look into. In order to stay in business and more importantly to retain the customers it is very important to identify the key areas of focus. These include the performance characteristics and the decision variables to achieve that performance characteristic. This is largely a multi objective optimization problem with competing objectives with respect to the decision variables.





In our systems design we have considered the following performance characteristics and the decision variables.

Performance Characteristics

The main performance characteristics are

1. maximize benefits
2. minimize cost
3. minimize project time
4. minimize people involved

Decision Variables

1. pay rates of the people involved
2. efficiency of the team
3. scope of the project
4. cost of product/service in the project

8. Conclusion

The purpose of this project was to implement systems engineering principles to a six sigma system. As one can see that these principles help us to view each system objectively and understand the level of hierarchies. It has shown how to form the whole system virtually and how to relate it to the real world system. Functional flow block diagram helps you understand the system behavior and how it is mapped it to the structure model. One should have a clear picture about the requirements of the system before actually making the system. Initial requirement, implied requirement and derived requirement should be considered during the assessment process. System engineering principles helps to become a good decision maker.

9. References and Web Resources

- Dr. Mark A. Austin. Lecture Notes for ENSE 621/ENPM 641: Systems Engineering Principles.
- Dr. D. Bigio. Lecture Notes for BMGT 498E: Six Sigma Strategy and Methods.
- Professor Eyad H. Abed. Lecture Notes for ENSE 621/ENPM 641: Systems Engineering Principles.
- Thomas Pyzdek. The Six Sigma Handbook. McGraw-Hill.2003.
- UML Diagrams http://pigseye.kennesaw.edu/~dbraun/csis4650/A&D/UML_tutorial/diagrams.htm
- UML Tutorial in 7-days http://odl-skopje.etf.ukim.edu.mk/uml-help/