INTRODUCTION

TO

TOTAL QUALITY

MANAGEMENT (TQM)

WHAT ARE WE GOING TO DISCUSS?

- **Total Quality Management (TQM)**
  - Changing Views of Quality
  - Principles of TQM
  - Basic Components of TQM
  - Elements of TQM

Total Quality Management

- TQM is stimulated by
  - ✓ Need to compete in the global market where
    - Higher Quality,
    - Lower Cost, and
    - Rapid Development are essential to market leadership.
- Today TQM is considered a fundamental requirement for any organization to compete, let alone lead, in its market.

Total Quality Management

- It is a way of planning, organizing, and understanding each activity of the process and removing all the unnecessary steps routinely followed in the organization.
- It is a philosophy that makes quality values the driving force behind leadership, design, planning, and improvement in activities.

Total Quality Management

TABLE 1.11

Periodical Changes in Quality System

Period	System
• Middle Ages (1200–1799)	• Guilds-skilled craftsman were responsible to control their own products.
• Mid-18th century • Industrial Revolution	• Establishment of factories. Increase in productivity. Mass production. Assembly lines. Several workers were responsible for producing a product. Production by skilled workers and quality audit by inspectors.
• Early 19th century	• Craftsmanship model of production.
• Late 19th century • 1880s	• Fredrick Taylor and "Scientific Management." Quality management through inspection.
• Beginning of 20th century • 1920s	• Walter Shewhart introduced Statistical Process Control. Introduction of full-time quality inspection and quality control department. Quality management.
• 1930s	• Introduction of sampling method.
• 1950s	• Introduction of Statistical Quality Process in Japan.
• Late 1960s	• Introduction of QA.
• 1970s	• Total Quality Control. • Quality Management.
• 1980s	• TQM.
• Beginning of 21st century	• Integrated Quality Management (IQM).

Changing views of Quality

- According to Kerzner, *"During the past twenty years, there has been a revolution toward improved quality. The improvements have occurred not only in product quality, but also in quality leadership and quality project management."*

- The push for higher levels of quality appears to be customer driven. Customers are now demanding
  - ✓ Higher performance requirements
  - ✓ Faster product developments
  - ✓ Higher technology levels
  - ✓ Materials and processes pushed to the limit
  - ✓ Lower contractor profit managing
  - ✓ Fewer Defects/Rejects
- The culture of good teamwork and cooperation at all levels in an organization is essential to the success of TQM.

TABLE 1.12

Changing Views of Quality

Past	Present
• Quality is the responsibility of blue-collar workers and direct labor employees working on the floor.	• Quality is everyone's responsibility, including that of white-collar workers, the indirect labor force, and the overhead staff.
• Quality defects should be hidden from customers (and possibly management).	• Defects should be highlighted and brought to the surface for corrective action.
• Quality problems lead to blame, faulty justification, and excuses.	• Quality problems lead to cooperative solutions.
• Corrections to quality problems should be accomplished with minimum documentation.	• Documentation is essential for "lessons learned" so that mistakes are not repeated.
• Increased quality will increase project costs.	• Improved quality saves money and increases business.
• Quality is internally focused.	• Quality is customer focused.
• Quality will not occur without close supervision of people.	• People want to produce quality products.
• Quality occurs during project execution.	• Quality occurs at project initiation and must be planned for within the project.

Source: Kerzner, H. (2001). *Project Management*. Reprinted with permission of John Wiley & Sons.

TABLE 1.13

Cultural Changes Required to Meet TQM

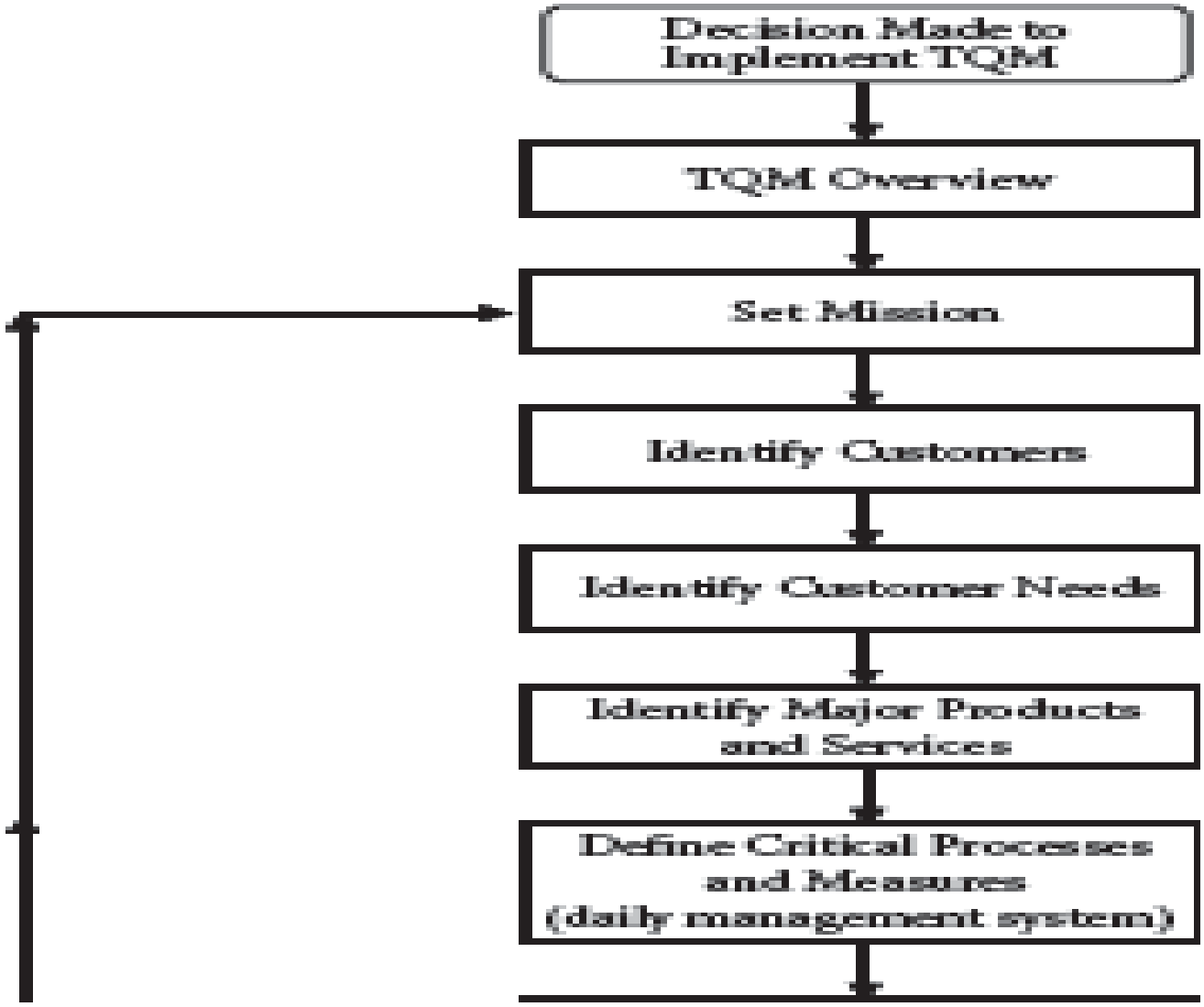
From	To
• Inspection orientation	• Defect prevention
• Meet the specification	• Continuous improvement
• Get the product out	• Customer satisfaction
• Individual input	• Cooperative efforts
• Sequential engineering	• Team approach
• Quality control department	• Organizational involvement
• Departmental responsibility	• Management commitment
• Short-term objective	• Long-term vision
• People as cost burden	• Human resources as an asset
• Purchase of products or services on price-alone basis	• Purchase on total cost minimization basis
• Minimum cost suppliers	• Mutual beneficial supplier relationship

Changing views of Quality

- According to ASQ, "*Total Quality Management (TQM) is a management approach centered on quality, based on organization-wide participation, and aimed at long term success through customer satisfaction.*

- *TQM focuses on customers, both internal (within the organization, the next party in the work process) and external (end users, stakeholders, regulatory agencies).”*

Basic Components of TQM



Basic Components of TQM

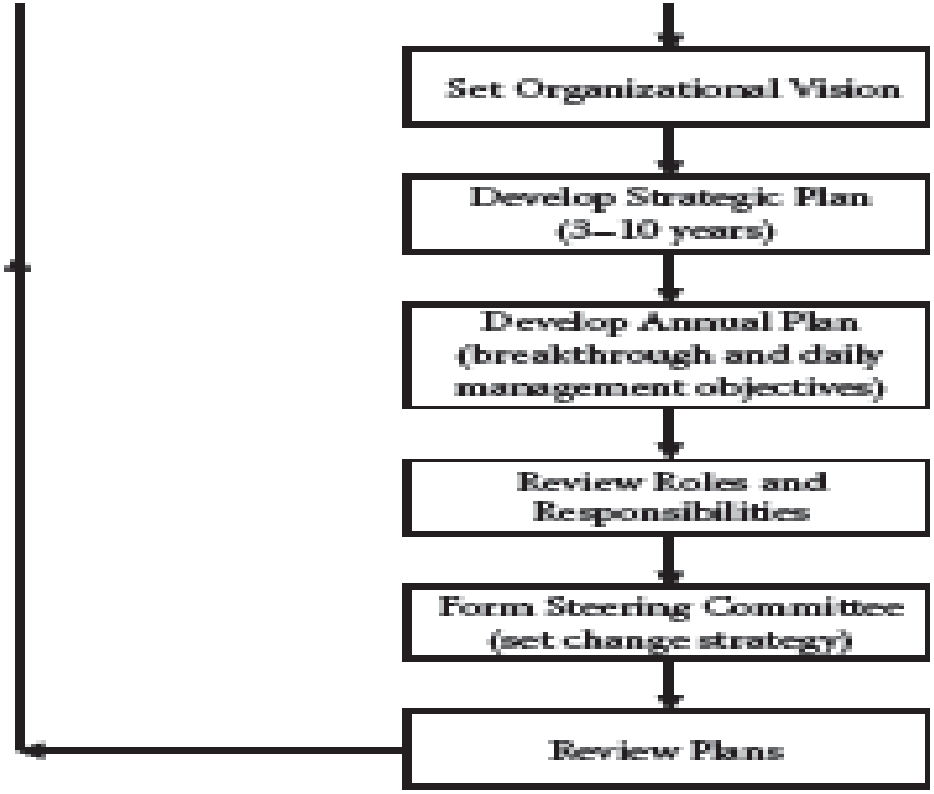


FIGURE 1.25
Basic components of TQM. (From A. Shtub, J.F. Bard, and S. Globerson, *Project Management*, 1994. Reprinted with permission from Pearson Education, Inc.)

Phases of TQM

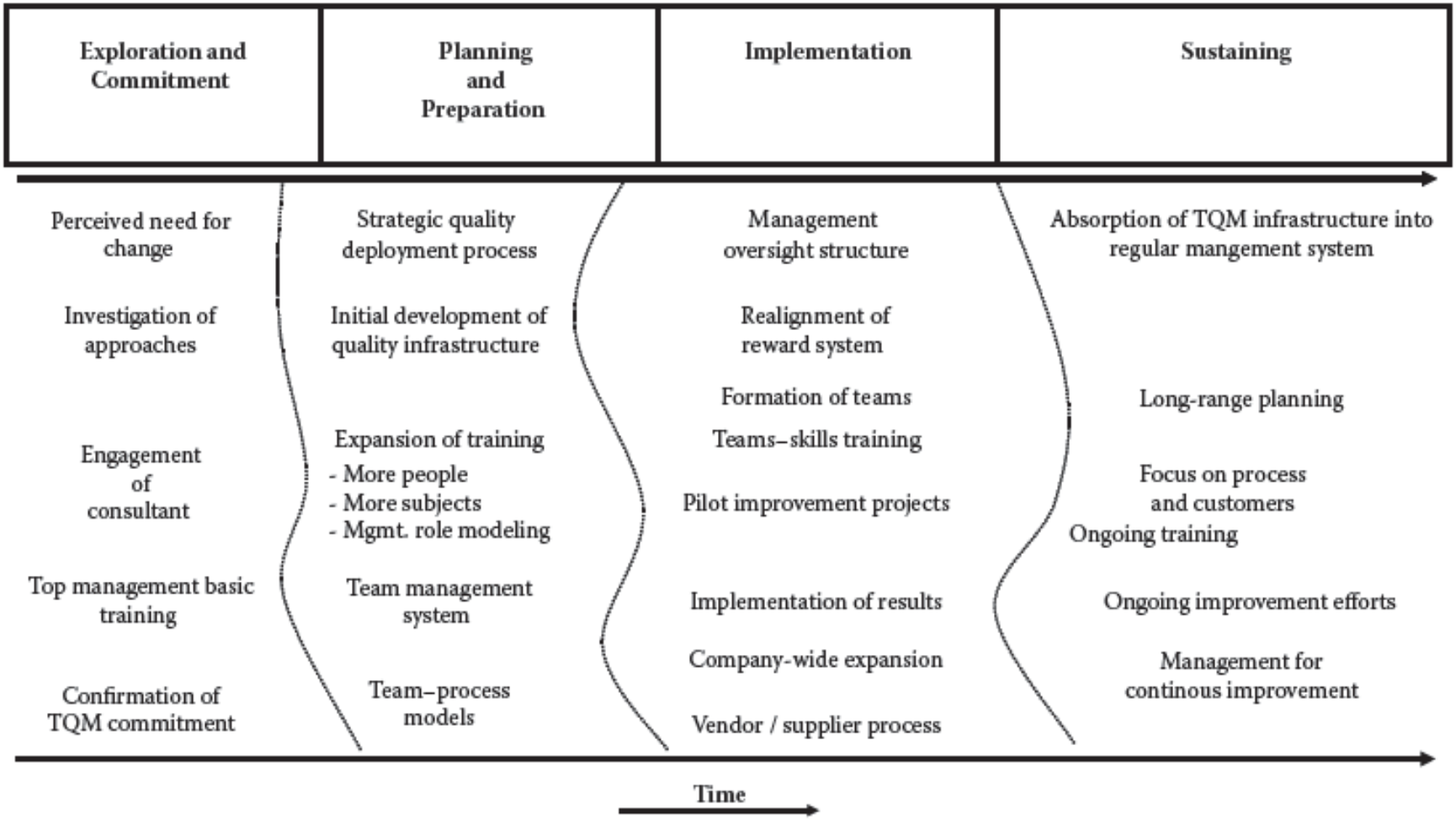


FIGURE 1.26
Phases of the TQM journey. (From CII Source document 74. Reprinted with permission of CII, University of Texas.)

QM Principles

An ISO document has listed eight quality management principles on which the quality management system standards of the revised ISO 9000:2000 series are based. These are as follows:

Principle 1—Customer focus

Principle 2—Leadership

Principle 3—Involvement of people

Principle 4—Process approach

Principle 5—System approach to management

Principle 6—Continual improvement

Principle 7—Factual approach to design making

Principle 8—Mutual beneficial supplier relationship

Elements of TQM

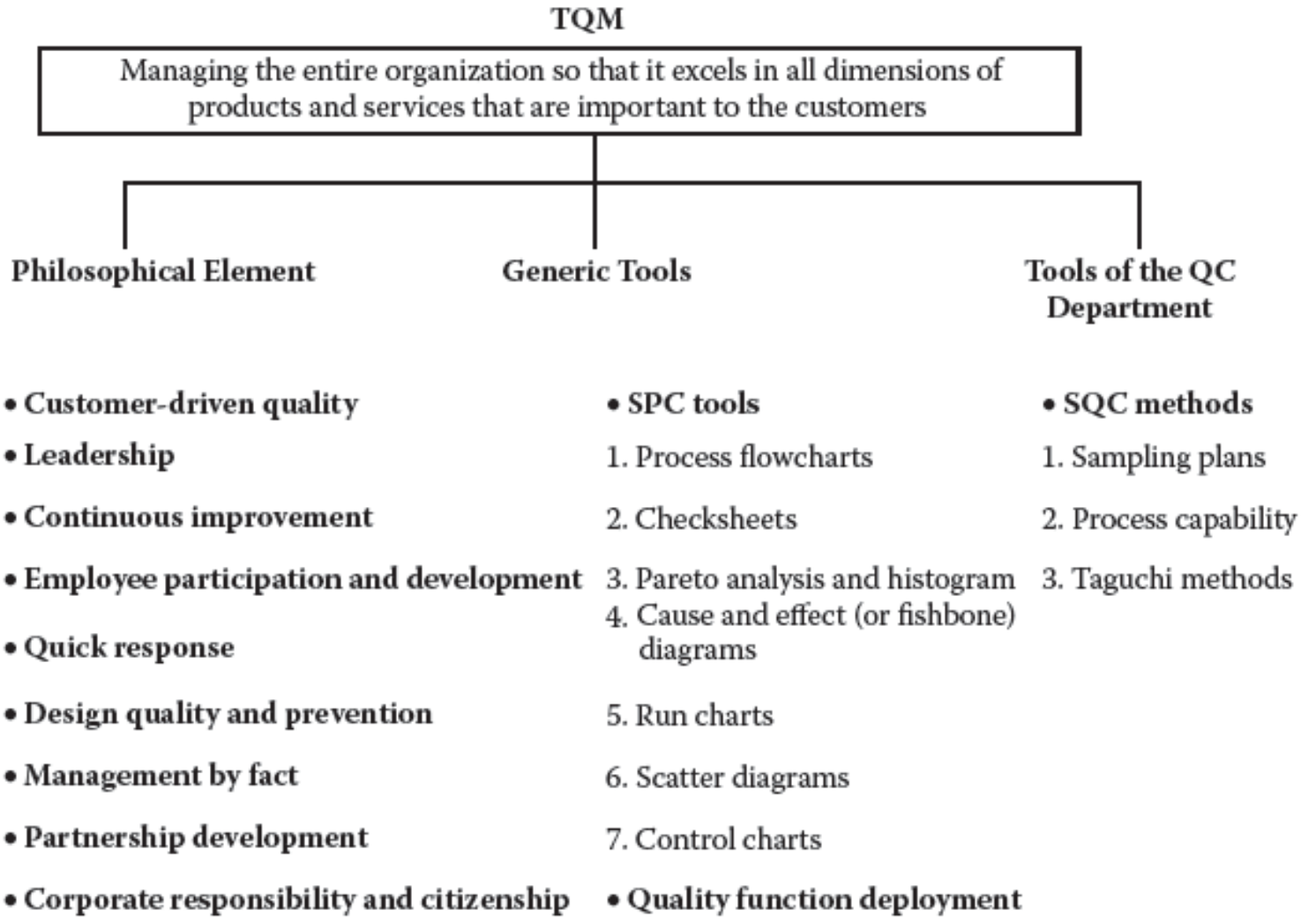


FIGURE 1.27
Elements of TQM. (From R. Chase, N. Aquilano, and F. Jacobs, *Operations Management*, 2001. Reprinted with permission of The McGraw Hill Companies.)

Advantages of TQM

- Achieving customer satisfaction
- Continuous improvement
- Developing teamwork
- Establishing vision for the employees
- Setting standards and goals for the employees
- Building motivation within the organization
- Developing corporate culture

THANK YOU

INTRODUCTION

TO

SIX SIGMA

WHAT ARE WE GOING TO DISCUSS?

- **Six Sigma**
  - Introduction of Six Sigma
  - Six Sigma Methodology
    - ✓Leadership Principles
    - ✓Six Sigma Team
  - Analytic Tool Sets
    - ✓The DMAIC Process
  - Six Sigma in Construction Projects
    - ✓The DMADV Process

Introduction – Six Sigma

- It is a process quality technique that focuses on reducing variation in the process and preventing deficiencies in the product.
- In a process that has achieved Six Sigma capability, the variation is small compared to the specification limits.
- Sigma is a Greek letter, σ, standing for standard deviation.
- Standard deviation is a statistical way to describe how much variation exists in a set of data, a group of items, or a process.
- Six Sigma means that, for a process to be capable at the Six Sigma level, the specification limits should be at least 6σ from the average point.

Introduction – Six Sigma

- With Motorola's Six Sigma program, no more than 3.4 defects per million fall outside the specification limits with a process shift of not more than 1.5σ from the average or mean.

- Six Sigma started as a defect reduction effort in manufacturing and was then applied to other business processes for the same purpose.

- Six Sigma is a measurement of "goodness" using a universal measurement scale.

- Universal means sigma can measure anything from coffee mug defects to missed chances to close a sales deal.

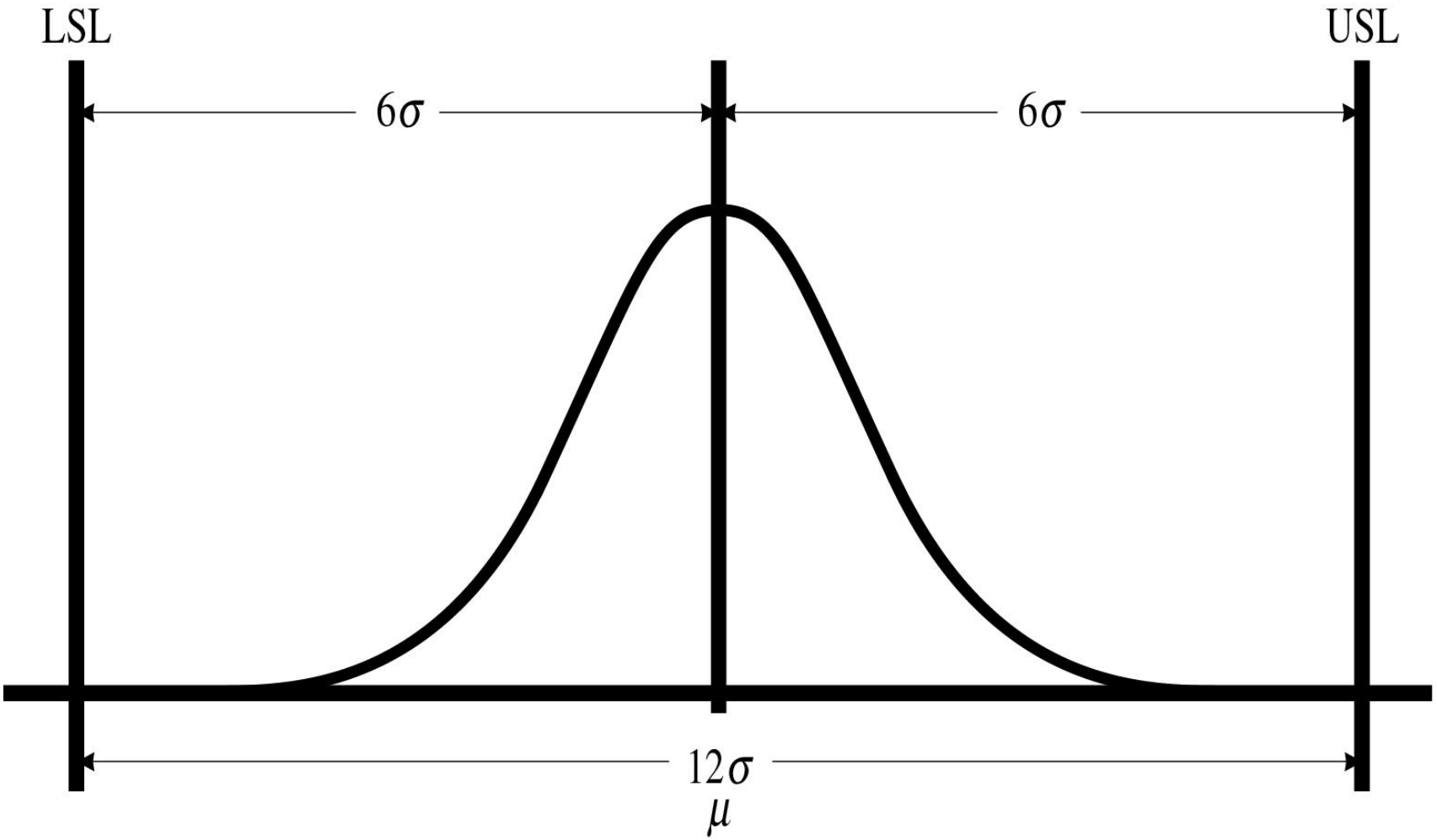
What is Six Sigma?

- A statistical *measure* of the performance of a process or a product
- A *goal* that reaches near perfection for performance improvement
- A *system of management* to achieve lasting business leadership and world-class performance
- A *collection of managerial and statistical concepts and techniques* that focus on reducing variation in processes and preventing deficiencies in product.

Introduction – Six Sigma

- Sigma is measured in defects per million opportunities (DPMO).
- Example: A level of sigma can indicate how many defective coffee mugs were produced when one million were manufactured.
- To reach a level of Three Sigma, you can only have 66,811 defects, given a million opportunities.
- A level of Five Sigma only allows 233 defects.
- Minimizing variation is a key focus of Six Sigma. Variation leads to defects, and defects lead to unhappy customers.
- To keep customers satisfied, loyal, and coming back, you have to eliminate the sources of variation.

Introduction – Six Sigma



Levels of Sigma Performance

SIGMA LEVEL	DEFECTS PER MILLION OPPORTUNITIES
6	3.4
5	233.0
4	6,210.0
3	66,807.0
2	308,537.0
1	690,000.0

Six Sigma Advantages

- Six Sigma is an overall business improvement methodology that focuses an organization on

  - ✓ Understanding and managing customer requirements
  - ✓ Aligning key business process to achieve these requirements
  - ✓ Utilizing rigorous data analysis to minimize variation in these processes
  - ✓ Driving rapid and sustainable improvement in the business process by reducing defects, cycle time, impact to the environment, and other undesirable variations
  - ✓ Timely execution

- Six Sigma is a high-performance management system for executing business strategy. It uses the concept of facts and data to drive better solutions.

Six Sigma Advantages

- Six Sigma is a top-down solution to help organizations

  - ✓ Align their business strategy to critical improvement efforts
  - ✓ Mobilize teams to attack high-impact projects
  - ✓ Accelerate improved business results
  - ✓ Govern efforts to ensure that improvements are sustained

Six Sigma Methodology

- Six Sigma methodology focuses on

  - ✓ Leadership principles
  - ✓ Integrated approach to improvement
  - ✓ Engaged teams
  - ✓ Analytic tool
  - ✓ Hard-coded improvements

Six Sigma Roadmap

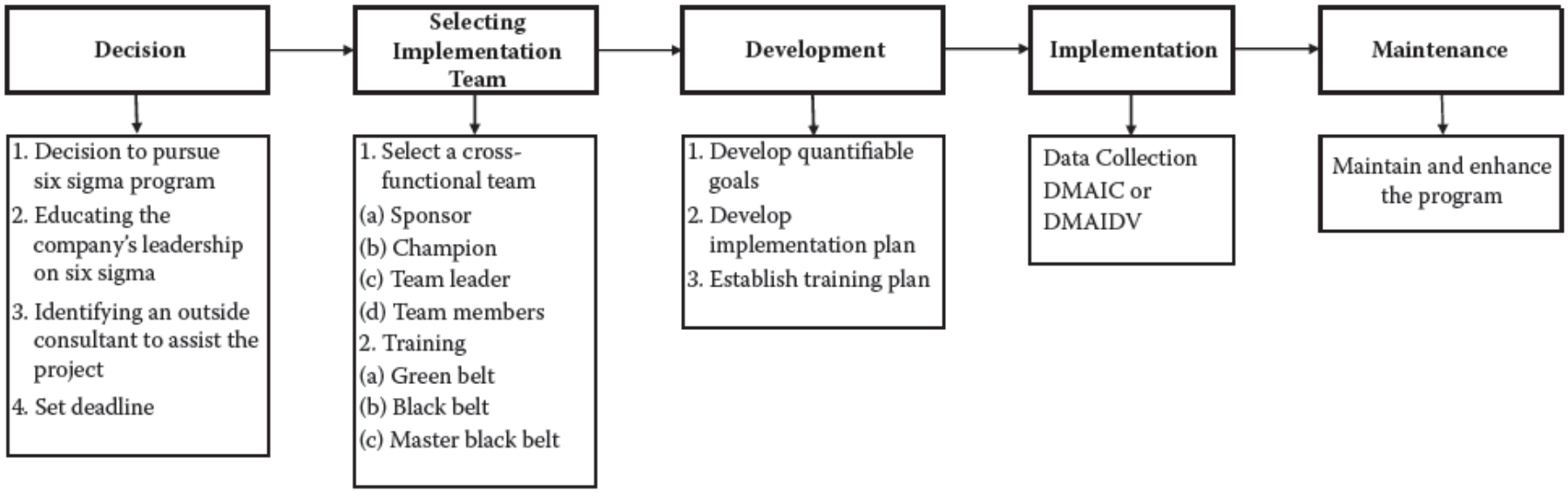
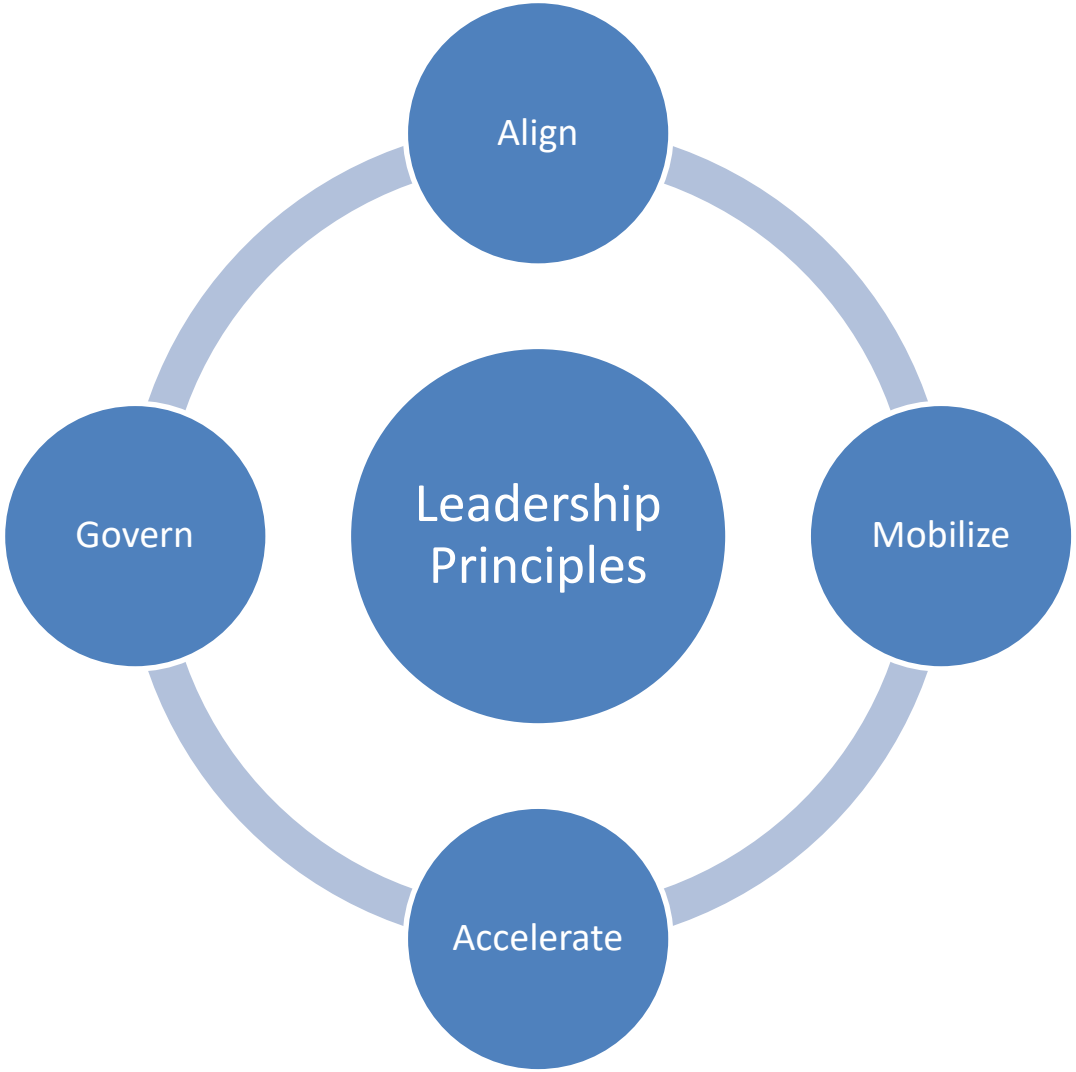


FIGURE 1.30
Six Sigma roadmap.

Leadership Principles



Leadership Principles

1. Align

- Leadership should ensure that all improvement projects are in line with the organization's strategic goals.
- Alignment begins with the leadership team developing a scorecard.
- Just as a scoreboard at a sporting event tells you who is winning, the scorecard tells the leadership how well the company is meeting its goals.

Leadership Principles

2. Mobilize

- Leadership should enable teams to take action by providing clear direction, feasible scope, a definition of success, and rigorous reviews.

- Mobilizing sets clear boundaries, lets people go to work, and trains them as required.

- The key to mobilizing is focus; lack of focused action was one of the downfalls of previous business improvement efforts.

- True focus means the project is correctly aligned with the organization’s scorecard.

Leadership Principles

3. Accelerate

- Leadership should drive a project to rapid results through tight clock management, training as needed, and shorter deadlines.

- More than 70% of all improvement initiatives fail to achieve desired results in time to make a difference. For projects to make an impact, they must achieve results quickly, and that is what acceleration is all about.

- Accelerate employs the “action learning” methodology to quickly bridge from “learning” to “doing”. Action learning accelerates improvement over traditional learning methods. It requires teams to set deadlines that are reinforced through rigorous reviews.

Leadership Principles

4. Govern

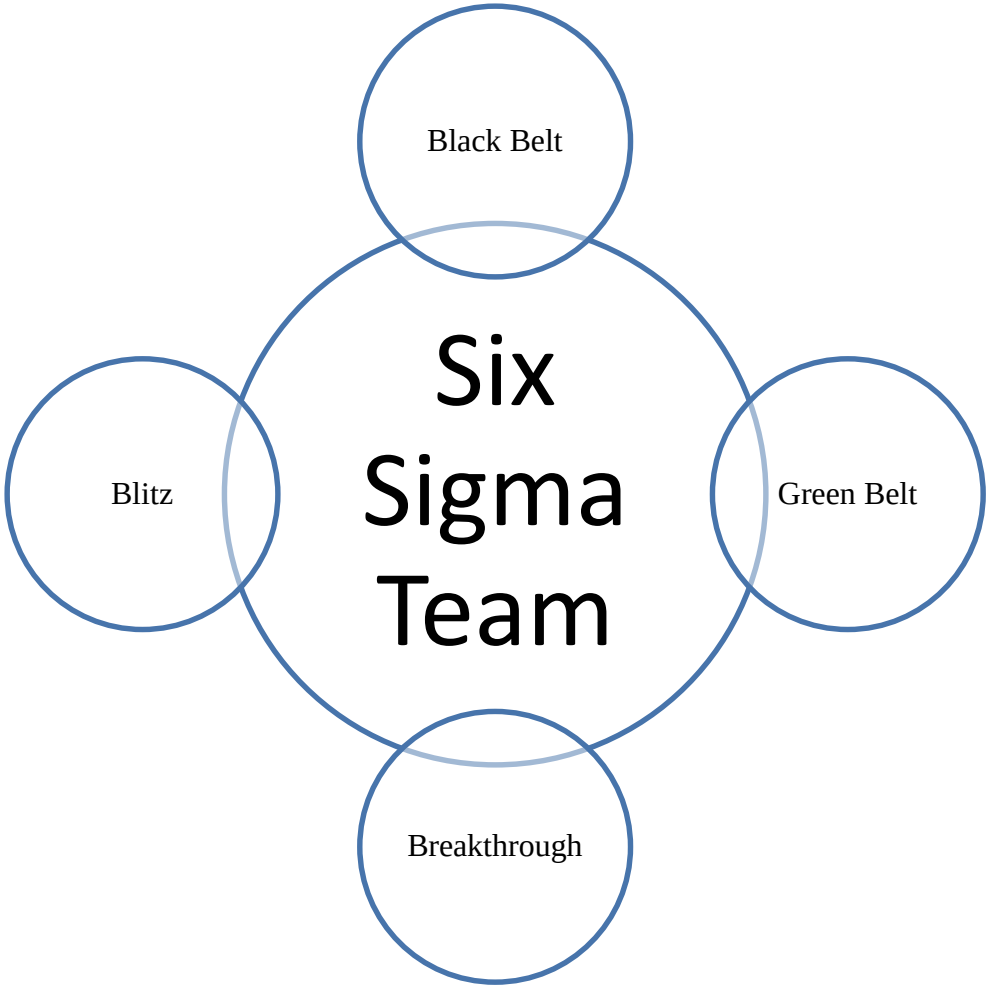
- Leadership must visibly sponsor projects and conduct regular and rigorous reviews to make critical midcourse corrections.

- While governing a Six Sigma project, one needs

  - ✓ A regular communications plan and a clear review process
  - ✓ To actively sponsor teams and their projects
  - ✓ To encourage proactive dialogue and knowledge sharing in the team and throughout the organization

Six Sigma Team

- Teamwork is absolutely vital for complex Six Sigma projects.
- For teams to be effective, they must be engaged—involved, focused, and committed to meeting their goals.



Black Belt

- Black Belts are internal Six Sigma practitioners, skilled in the application of rigorous statistical methodologies, and they are crucial to the success of Six Sigma.

- Their additional training and experience provide them with the skills they need to tackle difficult problems.

- The responsibilities of Black Belts are to
  - ✓Function as Team Leader
  - ✓Integrate their functional discipline with statistical, project, interpersonal skills
  - ✓Serve as internal consultants
  - ✓Tackle complex, high-impact improvement opportunities
  - ✓Mentor and train Green Belts

Green Belt

- Green Belts are trained in basic problem-solving skills and the statistical tools needed to work effectively as members of process improvement teams.

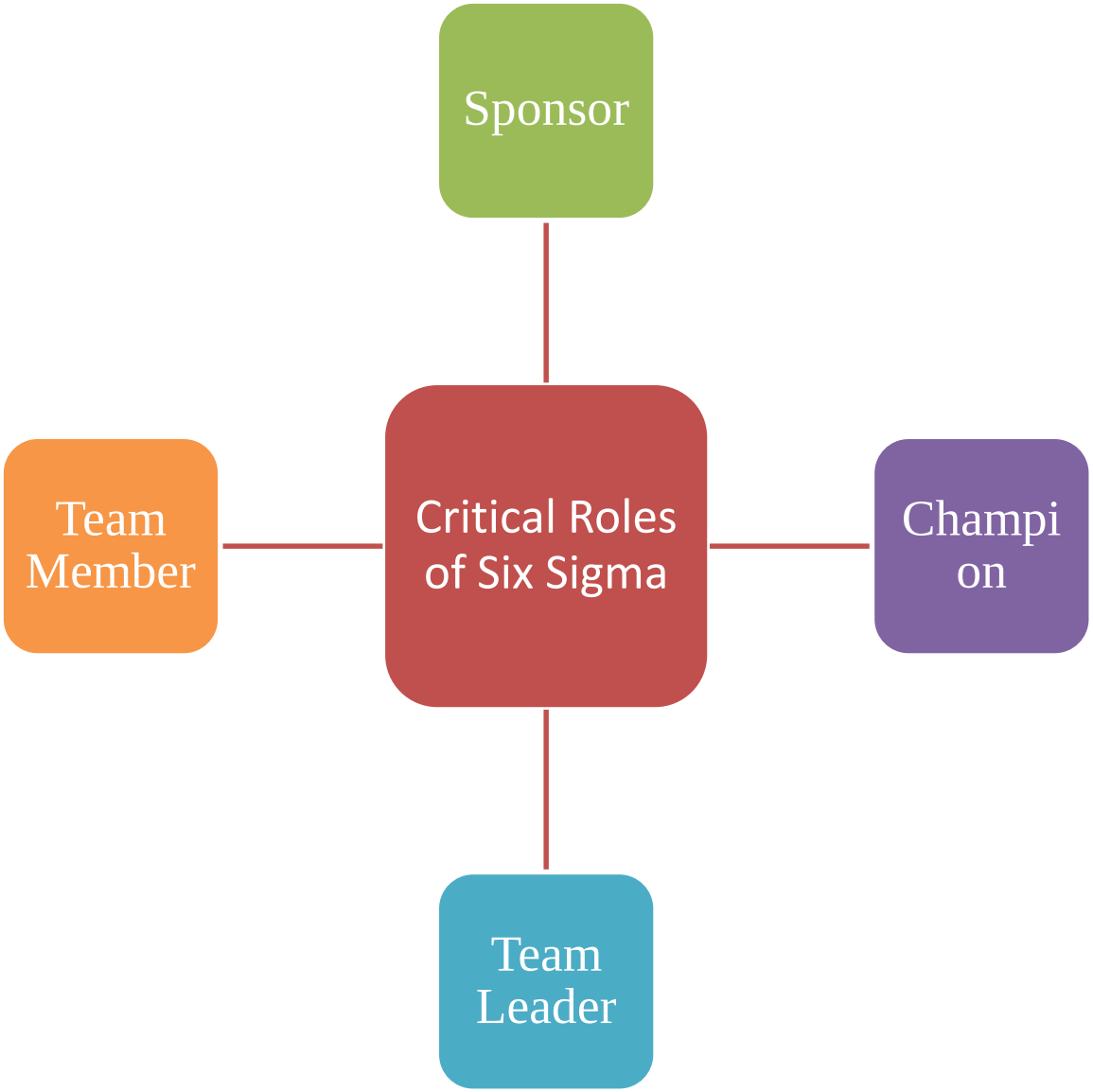
- The responsibilities of Green Belts are to
  - ✓ Acting as Team Leader on business improvements requiring less complex analysis
  - ✓ Adding their unique skills and experiences to the team
  - ✓ Working with the team to come up with inventive solutions
  - ✓ Performing basic statistical analysis
  - ✓ Conferring with a Black Belt as questions arise

Breakthrough & Blitz

- Breakthrough teams are typically used to define low-complexity, new processes.

- Blitz teams are put in place to quickly execute improvements produced by other projects. These teams can also implement digitization for efficiency using a new analytic tool set.

Four Critical Roles for Six Sigma



Four Critical Roles for Six Sigma

1. Sponsor

- Remains ultimately accountable for a project's impact
- Provides project resources
- Reviews monthly and quarterly achievements, obstacles, and key actions
- Supports the project Champion by removing barriers as necessary

2. Champion

- Reviews weekly achievements, obstacles, and key actions
- Meets with the team weekly to discuss progress
- Reacts to changes in critical performance measures as needed
- Supports the Team Leader, removing barriers as necessary
- Helps ensure project alignment

Four Critical Roles for Six Sigma

3. Team Leader

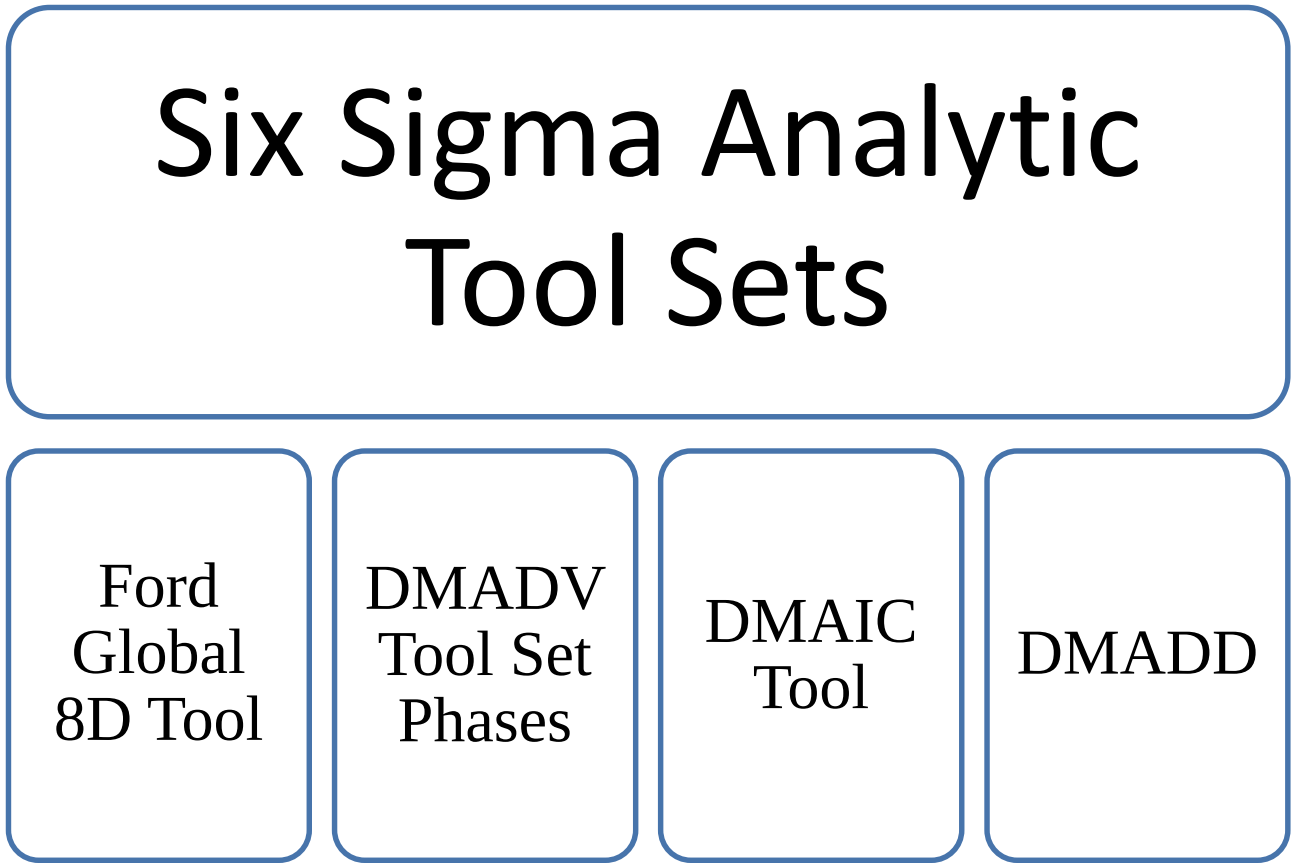
- Leads improvement projects through an assigned, disciplined methodology
- Works with the Champion to develop the Team Charter, review project progress, obtain necessary resources, and remove obstacles
- Identifies and develops key milestones, timelines, and metrics for improvement projects
- Establishes weekly, monthly, and quarterly review plans to monitor team progress
- Supports the work of team members as necessary

Four Critical Roles for Six Sigma

4. Team Member

- Assist the Team Leader
- Follow a disciplined methodology
- Ensure that the Team Charter and timelines are being met
- Accept and execute assignments
- Add their views, opinions, and ideas

Six Sigma – Analytic Tool Sets



Ford Global 8 D Tool

D1: Establish the team

D2: Describe the problem → What Problem Needs Solving?
Who should help solve problem?
How do we quantify symptoms?

D3: Implement and verify containment → How do we contain it?

D4: Identify and verify root causes → What is the root cause?

D5: Choose and verify corrective action → What is the permanent corrective action?

D6: Implement and validate permanent corrective action → How do we implement?

D7: Prevent recurrence → How can we prevent this in future?

D8: Congratulate the team → Who should we reward?

The Ford Global 8D Tool is primarily used to bring performance back to a previous level.

DMADV Tool Set Phases

Tool	Phase	Fundamental Objective
DMADV		
1.	**Define**—What is important?	Define the project goals and customer deliverables (internal and external)
2.	**Measure**—What is needed?	Measure and determine customer needs and specifications
3.	**Analyze**—How will we fulfill?	Analyze process options and prioritize based on capabilities to satisfy customer requirements
4.	**Design**—How do we build it?	Design detailed processes capable of satisfying customer requirements
5.	**Verify**—How do we know it will work?	Verify design performance capability

The DMADV tool is used primarily for the invention and innovation of modified or new products, services, or process. Using this tool set, Black Belts optimize performance before production begins. DMADV is proactive, solving problems before they start. This tool is also called DFSS (Design for Six Sigma).

The DMAIC Model

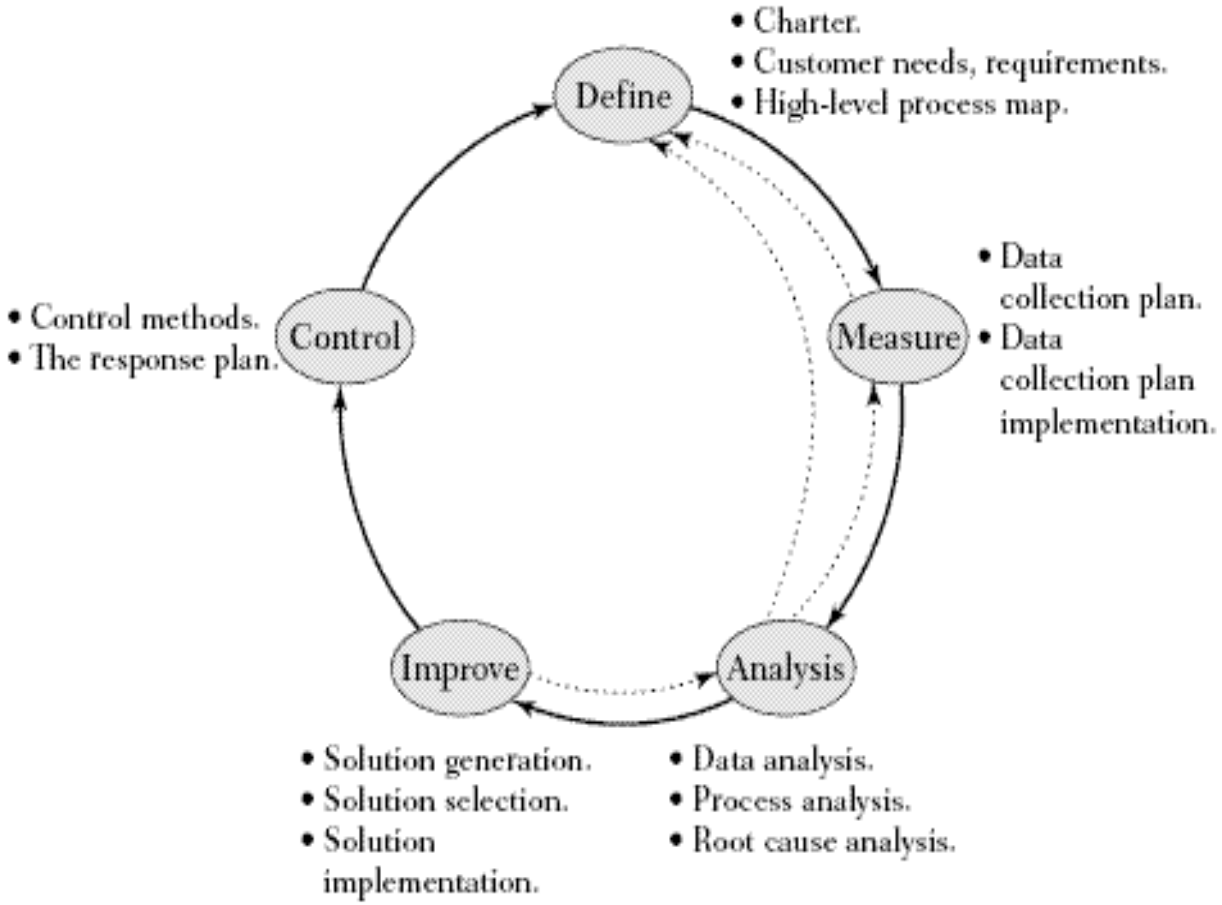
D efine

M easure

A nalyze

I mprov

C ontrol



DMAIC Tool Set

- The DMAIC tool refers to a data-driven quality strategy and is used primarily for improvement of an existing product, service, or process.

DMAIC		
1.	**Define**—What is important?	Define the project goals and customer deliverables (internal and external)
2.	**Measure**—How are we doing?	Measure the process to determine current performance
3.	**Analyze**—What is wrong?	Analyze and determine the root causes of the defects
4.	**Improve**—What needs to be done?	Improve the process by permanently removing the defects
5.	**Control**—How do we guarantee performance?	Control the improved process's performance to ensure sustainable results

DMADDD Tool Set

DMADDD		
1.	**Define**—Where must we be learner?	Identify potential improvements
2.	**Measure**—What's our baseline?	Analog touch points
3.	**Analyze**—Where can we free capacity and improve yields?	Task elimination and consolidated ops Value-added/non-value-added tasks Free capacity and yield
4.	**Design**—How should we implement?	Future state vision Define specific projects Define drawdown timing Define commercialization plans
5.	**Drawdown**—How do we eliminate parallel paths?	Commercialize new process Eliminate parallel path

DMADDD Tool Set

- The DMADDD tool is primarily used to drive the cost out of a process by incorporating digitization improvements.

- These improvements can drive efficiency by identifying non-value-added tasks and use simple Web-enabled tools to automate certain tasks and improve efficiency.

- In doing so, employees can be freed up to work on more value-added tasks.

DMAIC Tool Set

- The DMAIC process contains five distinct steps that provide a disciplined approach to improving existing processes and products through the effective integration of project management, problem solving, and statistical tools.

- D – Define Opportunities
- M – Measure performance
- A – Analyze opportunity
- I – Improve performance
- C – Control Performance

- Each step has fundamental objectives and a set of key deliverables, so the team member will always know what is expected of him or her and his or her team.

DMAIC Tool Set

- D – Define Opportunities (What is important?)

- Objective: To identify and/or validate the improvement opportunities that will achieve the organization's goals and provide the largest payoff, develop the business process, define critical customer requirements, and prepare to function as an effective project team.

- Key Deliverables:
  - ✓Team charter
  - ✓Action plan
  - ✓Process map
  - ✓Quick win opportunities
  - ✓Critical customer requirements
  - ✓Prepared team

DMAIC Tool Set

- M – Measure Performance (How are we Doing?)

- Objective: To identify critical measures that are necessary to evaluate success or failure, meet critical customer requirements, and begin developing a methodology to effectively collect data to measure process performance
- To understand the elements of the Six Sigma calculation and establish baseline sigma for the processes the team is analyzing

- Key Deliverables:
  - ✓ Input, process, and output indicators
  - ✓ Operational definitions
  - ✓ Data collection format and plans
  - ✓ Baseline performance
  - ✓ Productive team atmosphere

DMAIC Tool Set

- A – Analyze Opportunity (What is wrong?)

- Objective: To stratify and analyze the opportunity to identify a specific problem and define an easily understood problem statement
- To identify and validate the root causes and thus the problem the team is focused on
- To determine true sources of variation and potential failure modes that lead to customer dissatisfaction
- Key Deliverables:
  - ✓ Data analysis
  - ✓ Validated root causes
  - ✓ Sources of variation
  - ✓ Failure modes and effects analysis (FMEA)
  - ✓ Problem statement
  - ✓ Potential solutions

DMAIC Tool Set

- I – Improve Performance (What needs to be done?)

- Objective: • To identify, evaluate, and select the right improvement solutions
- To develop a change management approach to assist the organization in adapting to the changes introduced through solution implementation

- Key Deliverables:
  - ✓ Solutions
  - ✓ Process maps and documentation
  - ✓ Pilot results
  - ✓ Implementation milestones
  - ✓ Improvement impacts and benefits
  - ✓ Storyboard
  - ✓ Change plans

DMAIC Tool Set

- C – Control Performance (How do we guarantee performance?)
- Objective: • To understand the importance of planning and executing against the plan and determine the approach to be taken to ensure achievement of the targeted results
- To understand how to disseminate lessons learned, identify replication and standardization opportunities/processes, and develop related plans
- Key Deliverables:
  - ✓ Process control systems
  - ✓ Standards and procedures
  - ✓ Training
  - ✓ Team evaluation
  - ✓ Change implementation plans
  - ✓ Potential problem analysis
  - ✓ Solution results; Standardization opportunities
  - ✓ Success stories; Trained associates; Replication opportunities

Application

- The Six Sigma methodology is not so commonly used in construction projects; however the DMAIC tool can be applied at various stages in construction projects.

1. Detailed design stage—To enhance coordination method in order to reduce repetitive work

2. Construction stage—Preparation of builder's workshop drawings and composite drawings, as it needs much coordination among different trades

3. Construction stage—Preparation of contractor's construction schedule

4. Execution of works

Six Sigma in Construction Projects

- The contractor's construction schedule (CCS) is an important document used during the construction phase.
- It is used to plan, monitor, and control project activities and resources.
- Generally the project interim payment to the contractor is linked to the approval of the CCS.
- In most cases, contractors experience problems with getting the CCS approved, at the very first submission, from the construction manager/project manager/consultant.
- It could be rejected if it does not meet the specifications.
- Therefore, the contractor has to put all effort into collecting relevant data to be fed to develop the CCS.
- The following is an example procedure to develop the CCS using the Six Sigma DMADV analytic tool set.
- The DMADV method is used primarily for the invention of modified or new products, services, or processes.

Define Phase (What is important?)

- The objective of this phase is to define the project goals and customer deliverables.
- The key deliverables of this phase are
  - ✓ Establish the goal
  - ✓ Identify the benefits
  - ✓ Select project team
  - ✓ Develop project plan

- Goal: Develop CCS using Six Sigma tools.

- Benefits: The measurable benefits in adopting this process will result in CCS that will meet all the requirements of the specifications and shall be approved by the construction manager/project manager/ consultant at the first submission itself. This will reduce the repetitive work and help implement the schedule right from the early stage of the project.

Define Phase (What is important?)

- Selection of team: The team shall consist of
  a. Sponsor—Project Manager
  b. Champion—Construction Manager
  c. Team Leader—Planning and Control Manager
  d. Team Members—Planning Engineer, Cost Engineer, and one representative from each subcontractor

- Project plan: Time frame in the form of the Gantt chart shall be prepared to meet the target dates for submitting the contractor's construction schedule (CCS).

Measure Phase (What is needed?)

- The objective of this phase is to measure and determine customer needs and specifications.
- The key deliverable in this phase is
  - ✓ Identify specification requirements

- The following are the requirements listed in most contract documents *"The contractor has to submit the construction schedule in a bar chart time-scaled format to show the sequence and interdependence of activities required for complete performance of all items of work under the contract. The contractor shall use a computerized precedence diagram critical path method (CPM) technique in preparation of CCS."*

- The schedule shall include, but not be limited to, the following:

Measure Phase (What is needed?)

1. Project site layout.
2. Concise description of the work.
3. Milestones (contractual milestones or constraints).
4. Number of working days.
5. Work breakdown structure (WBS) activities shall consist of all those activities that take time to carry out execution/installation and on which resources are expended.
6. Construction network of project phases (if any), including various sub phases.
7. Construction network of the project arrangements (activities) and sequence.
8. Time schedules for various activities in a bar chart format.
9. The minimum work activities to be included in the program shall include items stated in the bill of quantity (BOQ).
10. WBS activities shall consists of all those activities that take time to carry out execution/installation and on which resources are expended.

Measure Phase (What is needed?)

11. Early and late finish dates.
12. Time schedule for critical path.
13. Schedule text report showing activity, start and finish dates, total float, and relationship with other activities.
14. Summary schedule report showing number of activities, project start, project finish, number of relations, open ends, constraints, and milestone.
15. Total float of each activity.
16. Cost loading.
17. Expected progress cash flow S-curve.
18. Resource-loaded S-curve.
19. Manpower loading.
20. Labor and crew movement and distribution.

Analyze Phase (How will we fulfill?)

- The objective of this phase is to analyze process options and prioritize based on capability to satisfy customer requirement.

- The key deliverable in this phase are
  - ✓ Data Collection
  - ✓ Prioritization of data under major variables

- The objectives of data collection are to
  1. *Identify milestone dates and constraints*
  2. *Identify project calendar*
  3. *Identify resource calendar*
  4. *Review contract conditions and technical specifications*
  5. *Identify mobilization requirements*
  6. *Identify project method statement*
  7. *Identify subcontractors/suppliers*
  8. *Identify materials requirements*
  9. *Identify long lead items*
  10. *Identify procurement schedule*

Analyze Phase (How will we fulfill?)

- The objectives of data collection are to

11. *Identify shop drawing requirements*
12. *Identify regulatory/authorities' requirements*
13. *Identify WBS activities using BOQ*
14. *Relate WBS activities with BOQ and contract drawings*
15. *Identify zoning/phasing*
16. *Identify codes for all activities per contract document divisions/sections per the Construction Specifications Institute (CSI) format*
17. *Identify volume of work for each activity*
18. *Identify duration/time schedule of each activity*
19. *Identify early and late finish dates*
20. *Identify critical activities and its effect on critical path*
21. *Identify logical relationship*
22. *Identify sequencing of activities*
23. *Identify project progress cash flow (work in place)*
24. *Identify manpower resources with productivity rate*

Analyze Phase (How will we fulfill?)

- The objectives of data collection are to

25. *Identify equipment and machinery*
26. *Identify project constraints such as access, logistics, delivery, seasonal, national, safety, existing work flow discontinuity, and proximity of adjacent concurrent work*
27. *Identify testing, commissioning, and handover requirements*
28. *Identify special inspection requirements*
29. *Identify closeout requirements*
30. *Identify and include items not listed in the specifications but are important for project scheduling*
31. *Identify suitable software program*
32. *Identify submittal requirements*

Analyze Phase (How will we fulfill?)

- *Arrangement of data: The generated data can be prioritized in an orderly arrangement under the following major variables:*
  1. *Milestones*
  2. *WBS activities*
  3. *Time schedule*
  4. *General requirements*
  5. *Resources*
  6. *Engineering*
  7. *Cost loading*

  - *Figure 1.31 illustrates these variables along with related sub variables arranged in the form of the Ishikawa diagram.*

Analyze Phase (How will we fulfill?)

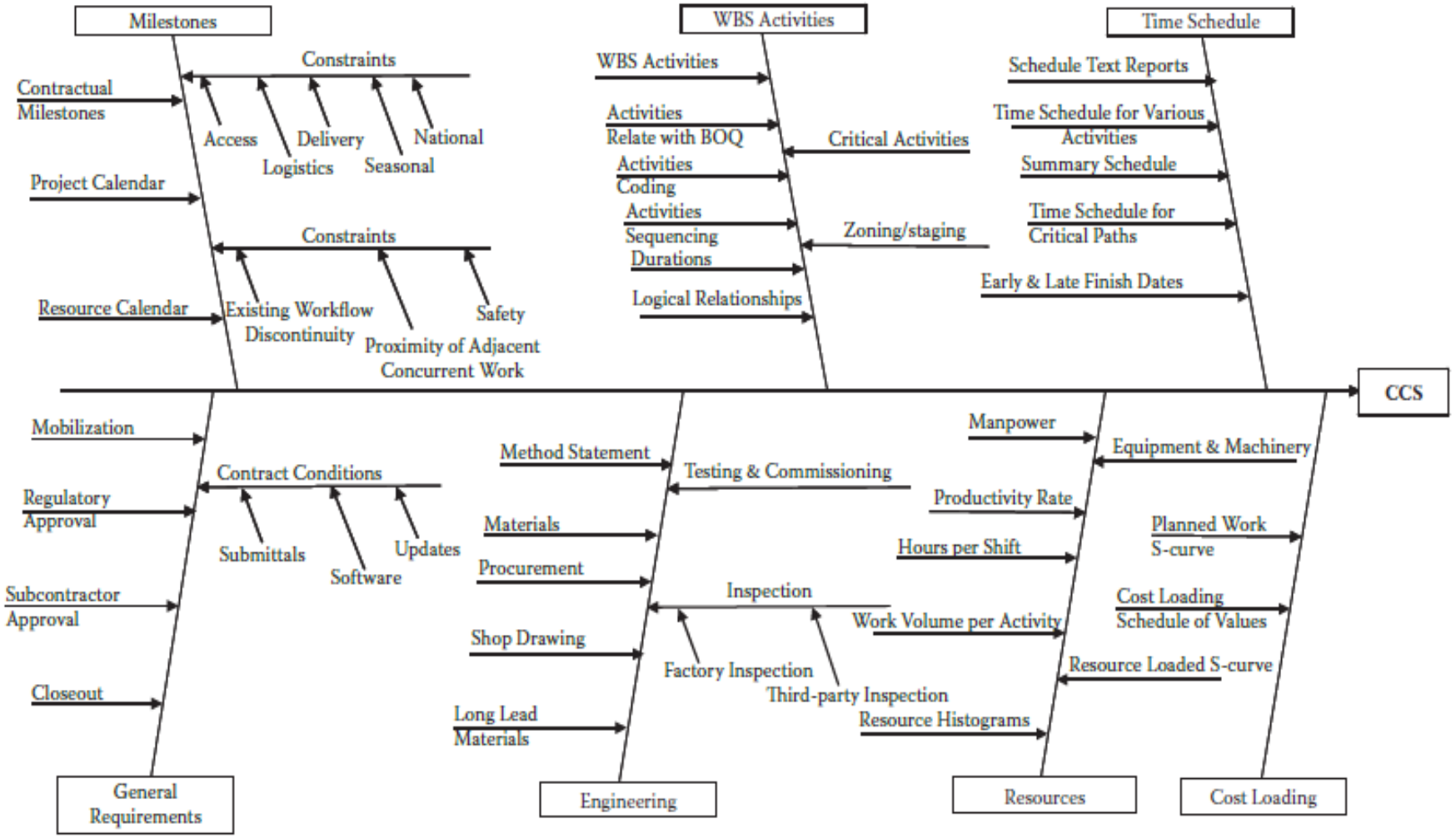


FIGURE 1.31
Ishikawa diagram for CCS data.

Design Phase (How do we build it?)

- *The objective of this phase is to design detailed processes capable of satisfying customer requirement.*
- *The key deliverable in this phase is*
  - ✓ *Preparation of program using suitable (specified) software program*

- *The Project and Control Manager can prepare the CCS based on the collected data and sequence of activities.*

Verify Phase (How do we Know It Will Work?)

- *The objective of this phase is to verify design performance capability*
- *The key deliverables in this phase are*
  - ✓ *Review the schedule by the team members to ascertain that all the required elements are included for compliance with specification requirements.*
  - ✓ *Submit CCS to Construction Manager/Project Manager/Consultant.*
  - ✓ *Update the schedule as and when required.*

THANK YOU