Lean Six Sigma Black Belt Study Guide

Name: ________________________________

Print this guide double sided and bind it for a booklet feel
Letter from the Director,

First, let me congratulate you for pursuing your Lean Six Sigma Green Belt certification and welcome to the American Association for Lean Six Sigma Certification (AALSSC). Obtaining a Lean Six Sigma certification is one of the most rewarding and valuable professional accomplishments. You will feel an increase in self-confidence, more capable when leading people and problem-solving abilities well above your peers. The professional opportunities for a Lean Six Sigma Black Belt are vast and across all industries. This is an exciting time for Lean Six Sigma professionals and I welcome you to the community.

The amount of knowledge required for an AALSSC certification is extensive, but not overwhelming. You can do it! The core tenants of AALSSC are relevant and attainable certifications. By focusing on relevance, it drives us to remove some areas of study deemed not relevant enough – making the exam more attainable. As a certified Lean Six Sigma Black Belt you will be expected to effectively facilitate strategic planning sessions, lead change management efforts, and mentor Green Belts. The exam tests your knowledge, skills and abilities across these focus areas.

This is your study guide, treat it as such. Write your name on it, complete it using your words and follow the concepts outlined. By writing you will retain the information and make this study guide a useful part of your reference library. Plus, this study guide can be used when taking an AALSSC Green Belt certification exam.

Good luck and welcome to AALSSC – your road to success.

Reminder: Black Belts are expected to have complete knowledge of the all Green Belt topics in addition to the Black Belt knowledge areas.

Erik Christensen
Mr. Erik Christensen, LSSMBB
Director of Certification
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Section #1 – Overview

Quality and Competitiveness

Concept: Competition is global and requires companies to continuously improve.

Continuous improvement is an ongoing effort to improve products, services, and processes.

Continuous improvement values:

- Customer focus
- Data driven decisions
- Focus on results
- Respect for people
- Performance excellence

Total Quality is an approach to doing business that attempts to maximize an organization’s competitiveness through the continual improvement of the equality of its products, services, people, processes and environments.

Quality is defined as meeting or exceeding customer expectations.

Cost of poor quality (COPQ): Those costs that would disappear if products, services, and processes were perfect.

- Obvious – scrap rate, rejects, re-work, returns, recalls, inspections, overtime wages, etc.
- Hidden – employee turnover, overdue receivables, excess inventory, project delays, lack of referrals, brand, etc.

Notes:
ISO 9000 and Baldrige Award

Concept: Governments and organizations encourage high quality products and try to drive waste reduction efforts by using organizational certifications and awards.

International Standards Organization (ISO) drives organizational improvements by offering certification to companies that meet strict requirements to include: customer focused processes, continuous improvement strategy, and ensuring compliance with regulatory requirements.

Malcom Baldrige National Quality Award was established by the U.S. congress in 1987 to raise awareness of quality. Annual award presented by the President of the United States.

Notes:
Organizational Structure and Role of the Black Belt

**Concept:** For a successful Lean Six Sigma transformation the organization must be organized correctly with defined roles and responsibilities.

Black Belts are technical leaders, mentors, change agents, motivators, continuous learners, and a customer advocate.

**Organizational Roadblocks:**

- Inadequate support from management
- Insufficient commitment of resources
- Organizational culture that cannot deal with defects
  - manipulate definition of defect
- Weak in teamwork and support of teams
- Lack a method to reward team success
- Lack a customer focus
- Cross functional lack of cooperation

**Notes:**

- Select the right project
- Select the right approach
- Align efforts with organizational goals
**Project Selection**

**Concept:** Black Belts need project selection methods given the complicated nature of organizational projects.

PICK Chart is an impact effort chart for simple comparison of projects.

Decision matrix uses weighted project attributes to quantify and compare projects.

Cost/Benefit analysis measures project feasibility by analyzing obvious and hidden costs and benefits. They can be obvious or not obvious, quantifiable or unqualifiable.

**Decision Matrix Template**

<table>
<thead>
<tr>
<th>Prioritize by using an impact rating scale (High=9, Medium=3, Low=1)</th>
<th>Project #1</th>
<th>Project #2</th>
<th>Project #3</th>
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<tbody>
<tr>
<td>Balanced scorecard impact</td>
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<tr>
<td>Starting and ending points are easy to identify</td>
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<td></td>
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<tr>
<td>Potential to reduce cost or increase revenue</td>
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<td></td>
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<tr>
<td>Sufficient resources are available for the effort</td>
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<tr>
<td>Metrics and data exist</td>
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<tr>
<td>Process occurs frequently</td>
<td></td>
<td></td>
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<tr>
<td>Favorable impact on customer</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Management supports the effort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem or goal well defined</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>The process is within our span of control</td>
<td></td>
<td></td>
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<tr>
<td>A process owner is defined</td>
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<td></td>
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<tr>
<td>Duration of project is &lt; 4 months</td>
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<tr>
<td>Rating for project (sum of the column)</td>
<td>( )</td>
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</tr>
</tbody>
</table>
Certifications

Concept: The relevant Lean Six Sigma certifications are Green Belt, Black Belt, and Master Black Belt.

Notes:

- Experienced Black Belt with ability to lead organization through an entire transformation
- Leading strategic level projects/kaizen events and facilitating strategic planning sessions
- Leading tactical level projects/kaizen events at the front line
Business Performance Measures

Concept: Key Performance Indicators (KPI) are quantifiable measures tied to organizational success. What an organization considers a KPI varies by industry, department, or project. Research and calculate KPIs listed below, they are the only testable KPI calculations.

Common Quality KPIs

- Defects per million opportunities (DPMO) – mathematical possibility defect will be produced

\[
DPMO = \frac{D}{N \times O} \times 1,000,000
\]

\[D: \text{number of defects observed}\]

\[N: \text{number of units inspected}\]

\[O: \text{number of defect opportunities}\]

\[*: \text{multiply}\]

- First time yield (FTY) – percentage of product that goes through a process error free

FTY = \(\frac{\text{units leaving process}}{\text{units entered process}}\)

- Rolled throughput yield (RTY) – percentage of product that goes through a process defect free

RTY = \(\frac{\text{units leaving process} - \text{units re-worked}}{\text{units entered process}}\)
Financial Measures

Concept: Lean Six Sigma efforts must translate into a financial benefit for most companies.

Revenue: entire amount of money brought into a company

Unit sales price * number sold

Revenue growth %:

\[
\frac{(\text{Current period revenue} - \text{previous period revenue})}{\text{Previous period revenue}} \times 100
\]

Market Share: portion of sales of a certain product or service in a certain region

\[
\frac{\text{total market sales revenue}}{\text{Company sales revenue}}
\]

Profit margin: what percentage of sales goes to company profit

\[
\frac{(\text{Sales revenue} - \text{cost of goods sold})}{\text{Sales revenue}} \times 100
\]

Cost/benefit analysis: Completed to determine if project has a big enough payoff to justify the costs

Obvious costs:

Hidden costs:

Tangible benefits:

Intangible benefits:

Quantifiable vs. Unquantifiable (measurable vs. not measurable)
Customer Loyalty

Concept: Customers are viewed as long term assets, not short-term cash flow. Therefore, customer retention is a critical success factor for most companies.

Long term customers are beneficial because:

- Price premium effect – existing customers pay more than new customers
- Acquisition costs have already been paid
- Base profit – the longer a customer stays the more profit company makes
- Revenue growth per customer rises over time due to upgrades and replacements
- Operating efficiency – existing customers do not ask as many questions or use as much employee’s time
- Satisfied customers generate new customers by referrals

Not all customers have the same value: Platinum, gold, silver, bronze, and tin.

Knowing customer types assists Black Belts in project selection.
Section #2 Facilitation

Concept: In addition to Green Belt level facilitation tools a Black Belt needs additional methods for strategic planning or other executive level events.

1. Visioning: energize people to see successful outcome two years in the future
   a. How are customers serviced?
   b. What problems have been solved?
   c. How are employees behaving?
   d. What outcomes have been achieved?

Notes:

2. Force field analysis: structured method of looking at two opposing forces acting on a situation
   a. Forces for and forces against
   b. Pros & cons, best case & worst case, opportunities and obstacles, etc.

Notes:

3. Troubleshooting: process of identifying potential roadblocks
   a. Roadblocks will arise as plans move forward
   b. Plan for and develop strategies for anticipated barriers

<table>
<thead>
<tr>
<th>What barrier / issue may hamper action plan</th>
<th>What actions will overcome</th>
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Organizational Change Management

**Concept:** For organizations to successfully change they must go through a process.

Research and understand Kotter’s eight stages of change. Describe stages and challenges of each. What is the difference between management and leadership?

1. Create a sense of urgency
2. Form a powerful coalition
3. Develop a vision and strategy
4. Communicate the vision
5. Empower employees for broad based actions
6. Generate short-term wins
7. Consolidate gains and produce more change
8. Anchor the changes in corporate culture

Notes:
Section #3: Total Quality Management (TQM)

Concept: TQM is the foundation of Lean Six Sigma and Black Belts need to know what it is and the 14 principles.

Process: a set of interrelated or interacting activities that transforms inputs into outputs (ISO definition)
System: interacting group of items forming a unified whole
Stable process is one with no indication of a special cause variation

14 Principles of TQM – research and understand
1. Create constancy of purpose for improving products and services.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on price alone; instead, minimize total cost by working with a single supplier.
5. Improve constantly and forever every process for planning, production and service.
6. Institute training on the job.
7. Adopt and institute leadership.
8. Drive out fear.
9. Break down barriers between staff areas.
10. Eliminate slogans, exhortations and targets for the workforce.
11. Eliminate numerical quotas for the workforce and numerical goals for management.
12. Remove barriers that rob people of pride of workmanship and eliminate the annual rating or merit system.
13. Institute a vigorous program of education and self-improvement for everyone.
14. Put everybody in the company to work accomplishing the transformation.

Notes:
Statistical Process Control (SPC)

Used to measure, monitor, and control processes

99.73% of data will fall within +/- 3 sigma

Variation types:

**Common cause**: built into the system. When all data falls within UCL and LCL the process is stable and predictable over time.

**Special cause**: not part of the system and can typically be traced to a single factor

SPC is achieved by using control charts

Steps:

1. Collect at least 20 data points
2. Calculate the average, known as the X-bar (\( \bar{x} \))
3. Calculate the standard deviation (sigma)
   \[
   \sigma = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_n - \bar{x})^2}{n}}
   \]
4. Add three times standard deviation to X-bar to determine upper control limit (UCL)
5. Subtract three times standard deviation to X-bar to determine lower control limit (LCL)

Example
Control Chart Practice

Data (x1 thru x20)
9, 11, 10, 5, 8, 11, 9, 13, 9, 11, 8, 6, 6, 9, 10, 13, 12, 9, 14, 12

Calculations
Section #4: Strategic Planning

Concept: Organizations use strategy to achieve goals using limited resources. Strategic planning is the process of defining the strategy and making decisions on allocating resources to pursue the strategy.

To develop a strategic plan requires following a process.

Traditional strategic planning process include SWOT analysis, vision statement, mission statement, guiding principles, broad strategic objectives and action plans.

SWOT: Strengths, weaknesses, opportunities and threats
- Strengths and weaknesses are internal to the organization
  - Imbedded in strengths are core competencies
  - Core competencies are difficult for a competitor to replicate and contribute directly to customer satisfaction
- Opportunities and threats are external to the organization

Vision statement: idealized view of the company or organization
- Inspires and energizes
- What the company aspires to be

Mission statement: concise statement stating why the company exists
- Provides motivation and shared sense of purpose
- Define company and purpose in 30 seconds

Guiding principles: organization’s value system
- Framework for how mission is accomplished
- Ethics

Broad strategic objectives: converts mission and vision into measurable terms
- Actual targets for what the organization wants to accomplish

Specific tactics: near term actions to accomplish broad strategic objectives
- SMART goal setting
- Tactical

Notes:
Concept: Hoshin Kanri is a policy deployment process that seeks to align company goals with plans of managers and work performed by employees.

Seven step planning cycle

- Vision
- 3-5 year strategic plan
- Annual objectives
- Deploy annual objectives to departments
- Implement actions (Kaizen events)
- Monthly progress review
- Annual review

“Catchball” is the term to describe efficient communications throughout organization

Aligns activities to strategic objectives

Notes:
Strategic Planning – Balanced Scorecard

**Concept:** View the organization from four perspectives.

- **Financial:** successful strategy equates to financial benefits
- **Customer:** delivering customer value drives financial benefits
- **Internal process:** to deliver customer value organizational processes must work properly
- **Learning and growth:** to accomplish all the above the workforce must be trained and developed

Notes:
Section #5 Related Quality Methods

Benchmarking

**Concept:** Identify effective business practices, efficient operations, and innovative strategies by analyzing other departments or organizations.

Xerox corporation formalized benchmarking in the 1970s

Shows organizations what is attainable, how it can improve, and how to adopt best practices

Best practice or best metrics

Internal benchmarking: within same corporation or entity

External benchmarking: outside the company – can be same or different industry.

Notes:
Systems Thinking

Concept: To understand the complexity of interdependent processes and guide decision making for long term success.

Systems thinking is the 5th discipline of a learning organization.

1. Personal mastery
2. Shared vision
3. Mental models
4. Team learning
5. Systems thinking

Mental models depict how people leap instantly to conclusions

- Ladder of inference

The Ladder of inference

I select “DATA”

Observable “data”

I add MEANINGS

I make ASSUMPTIONS

I draw CONCLUSIONS

The Reflexive Loop

I adopt BELIEFS

I take ACTIONS

Personal Mastery

Shared Vision

Mental Models

Team Learning

Systems Thinking
**Systems Thinking**

Team learning: discipline of group interaction

- Dialogue and skillful discussions
- To effectively explore the systems in which we work people must develop deeper conversational abilities
- Less conversation about the past and more about the future

Systems thinking: discipline to understand interdependencies and change

- System: group of interacting, interrelated or interdependent components that form a complex and unified whole
- Observing the systems:
  - Events: what we see and react to – a snapshot in time – any action is low leverage
    - What is happening?
  - Patterns: collection of events over time – trends – any action is medium leverage
    - What has been happening over time?
  - Structures: the way in which the system’s components are interrelated – high leverage
    - What is causing the events?
  - Mental models are the filters in which we view events – can interfere with the truth
    - How are we thinking and communicating?

- Behavior over time graphs (BoT)
  - Causal loops that connect one event to another event.
    - If X goes up, then Y goes down, when Y goes down so does Z (and so on)
    - Enables better project selection by selecting a high leverage
Theory of Constraints (TOC)

Concept: Decide what to change by focusing on throughput and bottlenecks.

Black belts are expected to have read the book “The Goal” by Eli Goldratt.

Five focusing steps

1. Identify the system’s constraint
2. Exploit the constraint
3. Subordinate everything else to that decision
4. Elevate the constraint
5. If constraint was broken, go to Step 1

Thinking process

- What needs to be changed?
- What should it be changed to?
- What actions will cause the change?

Throughput accounting

- Three core measures
  - Throughput: The rate at which customer sales are generated
  - Investment: Money that is tied up in physical things
    - inventory, machinery and equipment, real estate, etc.
  - Operating expense: Money spent to create throughput

Drum-buffer-rope - method of synchronizing production to the constraint while minimizing inventory and WIP

- Drum: The constraint
  - speed at which the constraint runs sets the “beat” for the process and determines total throughput
- Buffer: Inventory needed to maintain consistent production
  - Constraint buffer
  - Customer buffer
- Rope: signal generated by constraint indicating that some amount of inventory has been consumed
Theory of Constraints

Plant types:

- **I-plant**: (one-to-one)
  - The primary work is done in a sequence
  - The constraint slows entire operation

- **A-plant**: (many-to-one)
  - Many sub-assemblies converge for a final assembly
  - The primary problem is in synchronizing the converging lines

- **V-plant**: (one-to-many)
  - One raw material can make many final products
  - The primary problem “robbing”
    - One operation steals materials meant for the other operation

- **T-plant**: (many-to-many)
  - Most parts are used in multiple assemblies and nearly all assemblies use multiple parts
  - Customized devices, such as computers, are good examples
  - T-plants suffer from both
    - Synchronization problems of A-plants
    - Robbing problems of V-plants

Conflict resolution: TOC believes all conflicts can be resolved

Evaporating cloud

Be an effective team player
Provide people the help they need from me
Complete my work as quickly as it can be done
Multitask
"Yes, I’ll get right on it."
Don’t Multitask
“No, sorry I can’t.”

Be an effective team player
Provide people the help they need from me
Complete my work as quickly as it can be done
Don’t multitask
“I understand the importance of your request. I’ll give it my full attention as soon as I can, which will probably be . . .”
Project management

**Concept:** To complete organizational projects there must me a management process in place.

Black Belts are expected to be able to manage projects through completion

Common tools of the PM:

- Project charter: document that formally authorized existence of project
- Meeting agenda: Describes reason for meeting, time estimates, topics, etc.
- Gantt chart: Converts work breakdown structure into sequential actions with timelines

Critical path: the shortest time a project can be completed

- Precedence diagram

  space for research / practice calculating critical path:
Critical Chain Project Management (CCPM)

**Concept:** Projects compete for resources within the organization just like products being manufactured.

All departments add safety buffer to estimates – buffers add up to lengthy delays

- Parkinson’s law: Work expands to fill the available time
- Student syndrome: effort increases as deadlines approach
- Murphy’s law: if it can go wrong, it will

Apply theory of constraints to project management

Remove all safety buffers and add one project buffer

- Do not use estimates
- Do not multitask – give resources work and instruct them to focus until completed
- Use five focusing steps

Notes:
Section #6: Advanced Lean Six Sigma Methods

Total Productive Maintenance (TPM)

Concept: Prevent disruptions to flow of operations due to machine break downs.

Bathtub curve: Machines breakdown more when new and old

TPM is a holistic approach to equipment maintenance that strives to achieve perfect production

Six big losses:
- Availability losses
  1. breakdowns/failures
  2. setups/changeovers
- Performance losses
  3. minor stoppages
  4. reduced speed
- Quality losses
  5. defects and rework
  6. startup and yield loss

5 step process to implement TPM

1. Identify machine or equipment
   a. Simple, bottleneck, most problematic, etc.
2. Restore to prime operating condition
   a. 5S
   b. Autonomous maintenance
      i. Involve operators in simple maintenance tasks, ownership
3. Measure overall equipment effectiveness (OEE) – metric
   a. Availability x performance x quality
   b. World class OEE is 85
4. Address major losses
   a. Pareto diagram causes
5. Proactive maintenance
   a. Disciplined scheduled maintenance schedules
OEE practice area

Research OEE examples and capture below

Data

Calculations

OEE
Kanban Systems

Concept: To create pull systems a robust, reliable signaling systems is necessary.

Kanban literally means “signboard”

Pull systems put the ownership in the hands of the employees

Pull systems establish one material plan for each part

In-process Kanban and material Kanban

Kanban Board: simple communication board for project teams

- To do, doing, done

Point of use material storage (POU)

- Flow thru racks

Super market: high use items near POU – reduces material handing

Water spider: person assigned to support a production operation, so that others may focus exclusively on value-added work

Notes:
Quality Function Deployment (QFD)

**Concept:** Involve customer preferences against engineering characteristics early in the design stage.

Convert VOC into measurable critical to quality customer requirements

Document created is known as a House of Quality (HOQ)

7 step process

Notes:
Design for Six Sigma (DFSS)

Concept: 75% of quality problems are design related, therefore design new processes or products using Lean Six Sigma to prevent defects.

Design for X
- Manufacturability
- Cost
- Testability
- Maintanance
- Packageing
- Etc.

Production preparation process (3P) – method used to design a production process
- Incorporate waste elimination, flow and collaboration into the design
- “try-storming” – rapid prototyping
- Fail fast and often

Notes:
Data

Concept: Make decisions based on data and facts, there are distinct levels and types of data.

- Date: raw - it simply exists and has no significance beyond its existence
- Information: data that has been given meaning by way of relational connection
- Knowledge: Collection of information so it is useful
- Understanding: synthesize new knowledge or information from what was previously known
- Wisdom: synthesize new knowledge or information from what was previously known

Types of data
1. Continuous – can be measured on infinite scale (temperature, pressure, height, time)
2. Discrete – can be counted (late, male, number of defects, etc.)
3. Locational – data by location or where it happened
   a. Heat map or measles sheet are common locational data tools

Notes:
7 Quality tools

**Concept:** Most Lean Six Sigma professionals are successful using a handful of key tools.

1. Control Chart – see SPC
2. Flow Chart (Green Belt)
3. Cause and Effect Diagram (Green Belt)
4. Pareto Chart (Green Belt)
5. Check sheet: Raw data gathering
6. Histograms: plots frequency of occurrence (bar chart)
   - Shape gives insight
7. Scatter Diagram: determines relationship between two variables
   - Used to prove or disprove a hypothesis

### Telephone Interruptions

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**Histogram**

**Scatter diagram**

Notes:
Section #7: Culture of Quality

Concept: Developing or strengthen a culture of quality is a key to sustainment

Culture: The organization’s culture is the everyday manifestation of its underlying values and traditions

Training: The need for training when attempting to shift culture is essential

Notes:
Past quality leaders

**Concept:** A Lean Six Sigma Black Belt should know the quality pioneers who came before them.

Research and understand core contributions of:

Dr. Joseph Juran

Jim Womack

Dr. Kaoru Ishikawa

Phillip Crosby

Taiichi Ohno

Dr. Walter Shewhart

Malcolm Baldrige

Shigeo Shingo

Dr. Armand Feigenbaum

Dr. Michael Hammer

Dr. W. Edwards Deming
The American Association for Lean Six Sigma Certification

*Your road to success*

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