PROJECT MANAGEMENT ANALYTICS

A Data-Driven Approach to Making Rational and Effective Project Decisions

HARJIT SINGH

Project Management Analytics

A Data-Driven Approach to Making Rational and Effective Project Decisions

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To my father, Sardar Puran Singh,

from whom I learned hard work, honesty, and work ethics,

and

to my wife Harjinder and daughters Kavleen and Amanroop
for their patience, unconditional love, and constant inspiration
throughout this project!

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Table of Contents

Part 1 Approach

Chapter 1 Project Management Analytics 1

What Is Analytics? 2
Why Is Analytics Important in Project Management?. 4
How Can Project Managers Use Analytics in Project Management?. 4
Project Management Analytics Approach 8
Summary 20
Key Terms 21
Case Study: City of Medville Uses Statistical Approach to Estimate Costs for Its Pilot Project 21
Case Study Questions 23
Chapter Review and Discussion Questions 23
Bibliography. 24

Chapter 2 Data-Driven Decision-Making 25

Characteristics of a Good Decision 26
Decision-Making Factors 27
Importance of Decisive Project Managers 28
Automation and Management of the Decision-Making Process 30
Data-Driven Decision-Making 31
Data-Driven Decision-Making Process Challenges 33
Garbage In, Garbage Out 34
Summary 34
Key Terms 35
Case Study: Kheri Construction, LLC. 36
Case Study Questions 43
Chapter Review and Discussion Questions 43
Bibliography. 44

Part 2 Project Management Fundamentals

Chapter 3 Project Management Framework 45

What Is a Project? 46
How Is a Project Different from Operations? 52
Project versus Program versus Portfolio 53
Project Management Office (PMO) 55
Project Life Cycle (PLC) 55
Project Management Life Cycle (PMLC) 60
A Process within the PMLC 65
Work Breakdown Structure (WBS) 66
Systems Development Life Cycle (SDLC) 67
Summary 70
Key Terms 72
Case Study: Life Cycle of a Construction Project 72
Case Study Questions 74
Chapter Review and Discussion Questions 75
Bibliography. 75

Part 3 Introduction to Analytics Concepts, Tools, and Techniques

Chapter 4 Chapter Statistical Fundamentals I: Basics and Probability Distributions 77

Statistics Basics 78
Probability Distribution 87
Mean, Variance, and Standard Deviation of a Binomial Distribution 93
Poisson Distribution 95
Normal Distribution 96
Confidence Intervals 99
Summary 101
Key Terms 103
Solutions to Example Problems 103
Chapter Review and Discussion Questions 113
Bibliography. 115

Chapter 5 Statistical Fundamentals II: Hypothesis, Correlation, and Linear Regression. 117

What Is a Hypothesis? 118
Statistical Hypothesis Testing 119
Rejection Region 125
The *z*-Test versus the *t*-Test. 127
Correlation in Statistics 131
Linear Regression 134
Predicting *y*-Values Using the Multiple Regression Equation 140
Summary 142
Key Terms 143
Solutions to Example Problems 143
Chapter Review and Discussion Questions 148
Bibliography. 149

Chapter 6 Analytic Hierarchy Process. 151

Using the AHP. 152
AHP Pros and Cons. 162
Summary 163
Key Terms 164
Case Study: Topa Technologies Uses the AHP to Select the Project Manager 164
Conclusion 179
Case Questions. 180
Chapter Review and Discussion Questions 180
Bibliography. 180

Chapter 7 Lean Six Sigma 183

What Is Lean Six Sigma? 184
How LSS Can Improve the Status Quo. 189
Lean Six Sigma Tools 194
Summary 214
Key Terms 214
Case Study: Ropar Business Computers (RBC) Implements a Lean Six Sigma Project to Improve Its Server Test Process 215
Select PDSA Cycles Explained. 219

Case Questions. 225
Chapter Review and Discussion Questions 225
Bibliography. 226

Part 4 Applications of Analytics Concepts, Tools, and Techniques in Project Management Decision-Making

Chapter 8 Statistical Applications in Project Management 229

Statistical Tools and Techniques for Project Management . . . 230
Probability Theory 231
Probability Distributions 231
Central Limit Theorem. 232
Critical Path Method (CPM) 232
Critical Chain Method (CCM). 235
Program Evaluation and Review Technique (PERT). 237
Graphical Evaluation and Review Technique (GERT). 239
Correlation and Covariance. 241
Predictive Analysis: Linear Regression 245
Confidence Intervals: Prediction Using Earned Value Management (EVM) Coupled with Confidence Intervals . 251
Earned Value Management (EVM) 254
Summary 258
Key Terms 260
Chapter Review and Discussion Questions 260
Bibliography. 262

Chapter 9 Project Decision-Making with the Analytic Hierarchy Process (AHP) 265

Project Evaluation and Selection. 267
More Applications of the AHP in Project Management 283
Summary 287
Key Terms 288
Chapter Review and Discussion Questions 288
Bibliography. 288

Chapter 10 Lean Six Sigma Applications in Project Management 291

Common Project Management Challenges and LSS Remedies 292
Project Management with Lean Six Sigma (PMLSS)—A Synergistic Blend 293
PMLC versus LSS DMAIC Stages 294
How LSS Tools and Techniques Can Help in the PMLC or the PMBOK[4] Process Framework 298
The Power of LSS Control Charts 306
Agile Project Management and Lean Six Sigma 307
Role of Lean Techniques in Agile Project Management 308
Role of Six Sigma Tools and Techniques in the Agile Project Management 310
Lean PMO: Using LSS's DMEDI Methodology to Improve the PMO 310
Summary 312
Key Terms 313
Case Study: Implementing the Lean PMO 313
Case Questions 318
Chapter Review and Discussion Questions 318
Bibliography 319

Part 5 Appendices

Appendix A *z*-Distribution 321

Appendix B *t*-Distribution 325

Appendix C Binomial Probability Distribution (From $n = 2$ to $n = 10$) 327

Index 329

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Harjit Singh earned his MBA from University of Texas and his master's degree in Computer Engineering from California State University, Sacramento. He is a Certified Scrum Master, Lean Six Sigma professional, and holds PMP (Project Management Professional) credentials. He has more than 25 years of experience in the private and public sector as an information technology engineer, project manager, and educator. Currently, he is working as a data processing manager III at the State of California. In addition, he is also a visiting professor/adjunct faculty at Keller Graduate School of Management, DeVry University and Brandman University, where he teaches project management, business management, and information technology courses. Prior to this, he worked at Hewlett-Packard for 15 years as a systems software engineer and technical project manager. He is also a former member of the Board of Directors for the Sacramento Valley Chapter of the Project Management Institute (PMI) where he served in the capacity of CIO and vice president of relations and marketing.

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1

Project Management Analytics

Learning Objectives

After reading this chapter, you should be familiar with the

- Definition of analytics
- Difference between analytics and analysis
- Purpose of using analytics in project management
- Applications of analytics in project management
- Statistical approach to project management analytics
- Lean Six Sigma approach to project management analytics
- Analytic Hierarchy Process approach to project management analytics

> "Information is a source of learning. But unless it is organized, processed, and available to the right people in a format for decision making, it is a burden, not a benefit."
> —*William Pollard (1828–1893), English Clergyman*

Effective project management entails operative management of uncertainty on the project. This requires the project managers today to use analytical techniques to monitor and control the uncertainty as well as to estimate project schedule and cost more accurately with analytics-driven prediction. Bharat Gera, Line Manager at IBM agrees, "Today, project managers need to report the project metrics in terms of 'analytical certainty.'" Analytics-based project metrics can essentially enable the project managers to measure, observe, and analyze project performance objectively and make rational project decisions with analytical certainty rather than making vague decisions with subjective uncertainty. This chapter presents you an overview of the analytics-driven approach to project management.

What Is Analytics?

Analytics (or *data analytics*) can be defined as the systematic quantitative analysis of data or statistics to obtain meaningful information for better decision-making. It involves the collective use of various analytical methodologies, including but not limited to statistical and operational research methodologies, Lean Six Sigma, and software programming. The computational complexity of analytics may vary from low to very high (for example, big data). The highly complex applications usually utilize sophisticated algorithms based on statistical, mathematical, and computer science knowledge.

Analytics versus Analysis

Analysis and analytics are similar-sounding terms, but they are not the same thing. They do have some differences.

Both are important to project managers. They (project managers) can use analysis to understand the status quo that may reflect the result of their efforts to achieve certain objectives. They can use analytics to identify specific trends or patterns in the data under analysis so that they can predict or forecast the future outcomes or behaviors based on the past trends.

Table 1.1 outlines the key differences between analytics and analysis.

Table 1.1 Analytics vs. Analysis

Criterion	Analytics	Analysis
Working Definition	Analytics can be defined as a method to use the results of analysis to better predict customer or stakeholder behaviors.	Analysis can be defined as the process of dissecting past gathered data into pieces so that the current (prevailing) situation can be understood.
Dictionary Definition	Per *Merriam-Webster* dictionary, *analytics* is the method of logical analysis.	Per *Merriam-Webster* dictionary, *analysis* is the separation of a whole into its component parts to learn about those parts.
Time Period	Analytics look forward to project the future or predict an outcome based on the past performance as of the time of analysis.	Analysis presents a historical view of the project performance as of the time of analysis.

Criterion	Analytics	Analysis
Examples	Use analytics to predict which functional areas are more likely to show adequate participation in future surveys so that a strategy can be developed to improve the future participation.	Use analysis to determine how many employees from each functional area of the organization participated in a voice of the workforce survey.
Types of Analysis	Prediction of future audience behaviors based on their past behaviors	Target audience segmentation Target audience grouping based on multiple past behaviors
Tools	Statistical, mathematical, computer science, and Lean Six Sigma tools, and techniques-based algorithms with advanced logic Sophisticated predictive analytics software tools	Business intelligence tools Structured query language (SQL)
Typical Activities	Identify specific data patterns Derive meaningful inferences from data patterns Use inferences to develop regressive/predictive models Use predictive models for rational and effective decision-making Develop a SharePoint list to track key performance indicators Run SQL queries on a data warehouse to extract relevant data for reporting Run simulations to investigate different scenarios Use statistical methods to predict future sales based on past sales data	Develop a business case Elicit requirements Document requirements Conduct risk assessment Model business processes Develop business architecture

Why Is Analytics Important in Project Management?

Although switching to the data-driven approach and utilizing the available analytical tools makes perfect sense, most project managers either are not aware of the analytical approach or they do not feel comfortable moving away from their largely subjective legacy approach to project management decision-making. Their hesitation is related to lack of training in the analytical tools, technologies, and processes. Most project management books only mention these tools, technologies, and processes in passing and do not discuss them adequately and in an easily adaptable format. Even the *Project Management Body of Knowledge Guide* (*PMBOK*), which is considered the global standard for project management processes, does not provide adequate details on an analytics-focused approach.

The high availability of analytical technology today can enable project managers to use the analytics paradigm to break down the processes and systems in complex projects to predict their behavior and outcomes. Project managers can use this predictive information to make better decisions and keep projects on schedule and on budget. Analytics does more than simply enable project managers to capture data and mark the tasks done when completed. It enables them to analyze the captured data to understand certain patterns or trends. They can then use that understanding to determine how projects or project portfolios are performing, and what strategic decisions they need to make to improve the success rate if the measured/observed project/portfolio performance is not in line with the overall objectives.

How Can Project Managers Use Analytics in Project Management?

Analytics finds its use in multiple areas throughout the project and project management life cycles. The key applications of analytics in this context include, but are not limited to, the following:

Assessing feasibility: Analytics can be used to assess the feasibility of various alternatives so that a project manager can pick the best option.

Managing data overload: Due to the contemporary Internet age, data overload has crippled project managers' capability to capture meaningful information from mountains of data. Analytics can help project managers overcome this issue.

Enhancing data visibility and control via focused dashboards: An analytics dashboard can provide a project manager a single view to look at the big picture and determine both how each project and its project team members are doing. This information comes

in handy for prioritizing project tasks and/or moving project team members around to maximize productivity.

Analyzing project portfolios for project selection and prioritization: Project portfolio analysis is a useful application of analytics. This involves evaluating a large number of project proposals (or ideas) and selecting and prioritizing the most viable ones within the constraints of organizational resources and other relevant factors.

Across all project organizations in general, but in a matrix organization in particular, multiple projects compete for finite resources. Organizations must select projects carefully after complete assessment of each candidate project's feasibility based on the organization's project selection criteria, which might include, but not be limited to, the following factors:

- Technical, economic, legal, political, capacity, and capability constraints
- Cost-benefits analysis resulting in scoring based on various financial models such as:
  - Net present value (NPV)[1]
  - Return on investment (ROI)[2]
  - Payback period[3]
  - Breakeven analysis[4]
- Resource requirements
  - Internal resources (only functional department resources, cross-functional resources, cross-organizational resources, or any combination of the preceding)
  - External resources
  - Both internal and external resources
- Project complexity
- Project risks
- Training requirements

[1] NPV is used to compare today's investment with the present value of the future cash flows after those cash flows are discounted by a certain rate of return.

[2] ROI = Net Profit / Total Investment

[3] Payback period is the time required to recoup the initial investment in terms of savings or profits.

[4] Breakeven analysis determines the amount of revenue needed to offset the costs incurred to earn that revenue.

Analytics can help organizations with selecting projects and prioritizing shortlisted projects for optimal allocation of any scarce and finite resources.

Improve project stakeholder management: Analytics can help improve project stakeholder management by enabling a project manager to predict stakeholder responses to various project decisions. Project stakeholder management is both art and science—art because it depends partly on the individual skillset, approach, and personality of the individual project manager, and science because it is a highly data-driven process. Project managers can use analytics to predict the outcomes of the execution of their strategic plans for stakeholder engagement management and to guide their decisions for appropriate corrective actions if they find any discrepancy (variance) between the planned and the actual results of their efforts.

Project stakeholder management is much like customer relationship management (CRM[5]) in marketing because customers are essentially among the top-level project stakeholders and project success depends on their satisfaction and acceptance of the project outcome (product or service). Demographic studies, customer segmentation, conjoint analysis, and other techniques allow marketers to use large amounts of consumer purchase, survey, and panel data to understand and communicate marketing strategy. In his paper "CRM and Stakeholder Management," Dr. Ramakrishnan (2009) discusses how CRM can help with effective stakeholder management. According to him, there are seven Cs of stakeholder management:

1. Concern
2. Communicate
3. Contribute
4. Connect
5. Compound
6. Co-Create
7. Complete

Figure 1.1 illustrates the seven Cs of stakeholder management.

The seven Cs constitute seven elements of the project stakeholder management criteria, which can be evaluated for their relative importance or strength with respect to the goal

[5] *CRM* refers to a process or methodology used to understand the needs and behaviors of customers so that relationships with them can be improved and strengthened.

of achieving effective stakeholder management by utilizing the multi-criteria evaluation capability of the *Analytic Hierarchy Process* (AHP).[6]

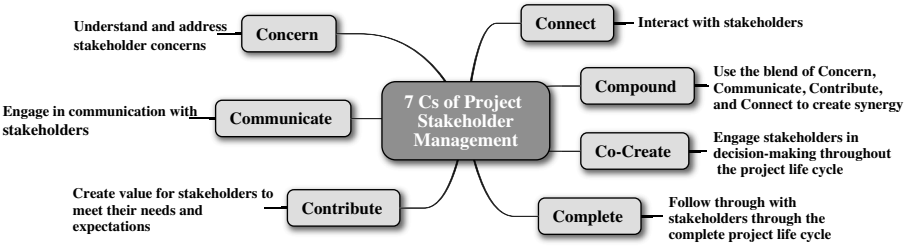

Figure 1.1 Seven Cs of Project Stakeholder Management

Web analytics can also help managers analyze and interpret data related to the online interactions with the project stakeholders. The source data for web analytics may include personal identification information, search keywords, IP address, preferences, and various other stakeholder activities. The information from web analytics can help project managers use the adaptive approach[7] to understand the stakeholders better, which in turn can further help them customize their communications according to the target stakeholders.

Predict project schedule delays and cost overruns: Analytics can tell a project manager whether the project is on schedule and whether it's under or over budget. Also, analytics can enable a project manager to predict the impact of various completion dates on the bottom line (project cost). For example, Earned Value Analytics (covered in Chapter 8, "Statistical Applications in Project Management") helps project managers avoid surprises by helping them proactively discover trends in project schedule and cost performance.

Manage project risks: Another area in a project's life cycle where analytics can be extremely helpful is the project risk management area. Project risk identification, ranking, and prioritization depend upon multiple factors, including at least the following:

- Size and complexity of the project
- Organization's risk tolerance
- Risk probability, impact, and horizon
- Competency of the project or risk manager

[6] Read Chapter 6, "Analytical Hierarchy Process," to learn about AHP.

[7] The process of gaining knowledge by adapting to the new learning for better decision-making.

Predictive analytics models can be used to analyze those multiple factors for making rational decisions to manage the risks effectively.

Improve project processes: Project management involves the execution of a multitude of project processes. Thus, continuous process improvement is essential for eliminating waste and improving the quality of the processes and the product of the project. Improvement projects typically involve four steps:

1. Understand the current situation.
2. Determine the desired (target) future situation.
3. Perform gap analysis (find the delta between the target and the current situations).
4. Make improvement decisions to address the gap.

Analytics can help project managers through all four process improvement steps by enabling the use of a "Project Management —Lean Six Sigma" blended or hybrid methodology for managing the projects with embedded continuous improvement.

Project Management Analytics Approach

The project management analytics approach can vary from organization to organization and even from project to project. It depends on multiple factors including, but not limited to, organizational culture; policies and procedures; project environment; project complexity; project size; available resources; available tools and technologies; and the skills, knowledge, and experience of the project manager or project/business analysts. This book covers the following approaches to project management analytics:

- Statistical
- Lean Six Sigma
- Analytic Hierarchy Process

You will look at the application of each of these approaches and the possible combination of two or more of these approaches, depending upon the project characteristics.

Statistical Approach

> "Lies, damned lies, and statistics!
> Nothing in progression can rest on its original plan."
> *—Thomas S. Monson (American religious leader and author)*

Throughout the project life cycle, project managers must deal with a large number of uncertainties. For instance, project risks are uncertainties that can derail the project if they are not addressed in a timely and effective way. Similarly, all project baselines (plans) are developed to deal with the uncertain future of the project. That's why the project plans are called *living documents* because they are subject to change based on future changes. Because picturing the future precisely is hard, best estimates are used to develop the project plans.

Statistical approach comes in handy when dealing with project uncertainties because it includes tools and techniques that managers can deploy to interpret specific patterns in the data pertaining to the project management processes to predict the future more accurately.

Quantitative measure of a process, when that process is performed over and over, is likely to follow a certain frequency pattern of occurrence. In other words, there is a likelihood or probability of recurrence of the same quantitative measure in the long run. This likelihood or probability represents the uncertainty of recurrence of a certain quantitative value of the process. Statistical analysis can help predict certain behaviors of the processes or systems in the environment of uncertainty, which is fundamental to data-driven decision-making.

We use the following analytical probability distributions to illustrate how a statistical approach can help in effective decision-making in project management:

- Normal distribution
- Poisson distribution
- Uniform distribution
- Triangular distribution
- Beta distribution

Normal Distribution

Depicted in Figure 1.2, the normal distribution is the most common form of the probability density function. Due to its shape, it is also referred to as the *bell curve*. In this distribution, all data values are symmetrically distributed around the mean of the probability. The normal distribution method constitutes a significant portion of the statistical content that this book covers because the project management processes involve a number of normal events.[8]

[8] For example, project selection criteria scores, stakeholders' opinions, labor wages, project activity duration, project risk probability, and so on.

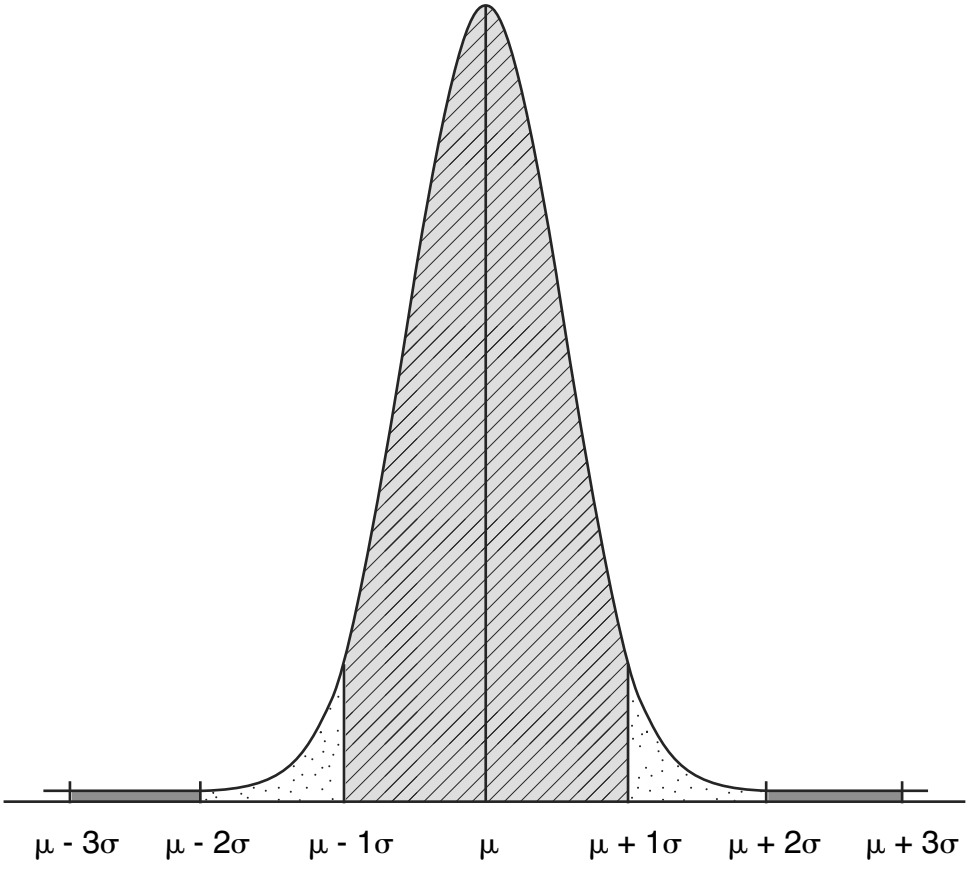

Figure 1.2 Normal Distribution

Normal distribution is the result of the process of accumulation. Usually, the sum or average of the outcomes of various uncertainties constitutes an outcome whose probability distribution is a normal distribution.

For data with a normal distribution, the standard deviation has the following characteristics:[9]

- **68.27%** of the data values lie within one standard deviation of the mean.
- **95.45%** of the data values lie within two standard deviations of the mean.
- **99.73%** of the data values lie within three standard deviations of the mean.

[9] This is also known as the *empirical rule*.

Poisson Distribution

Poisson distribution is the result of the process of counting. Figure 1.3 depicts the shape of a typical Poisson distribution curve.

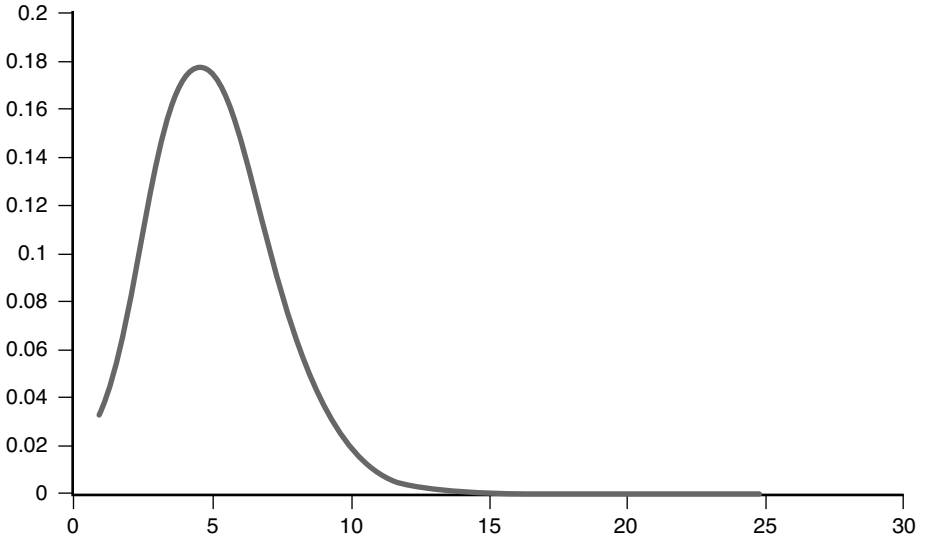

Figure 1.3 Poisson Distribution

This distribution can be used to count the number of successes or opportunities as a result of multiple tries within a certain time period. For example, it can be used to count

- The number of projects human resources acquired in a period of two months
- The number of project milestones completed in a month
- The number of project tasks completed in a given week
- The number of project change requests processed in a given month

Chapter 4, "Statistical Fundamentals I," covers the Poisson distribution in more depth and examines how this distribution can be used in project management to count discrete,[10] countable, independent events.

[10] *Discrete random variables* are small in number and can be counted easily. For example, if a random variable represents the output of tossing a coin, then it is a discrete random variable because there are just two possible outcomes—heads or tails.

Uniform Distribution

Illustrated in Figure 1.4, a uniform distribution is also referred to as a rectangular distribution with constant probability.

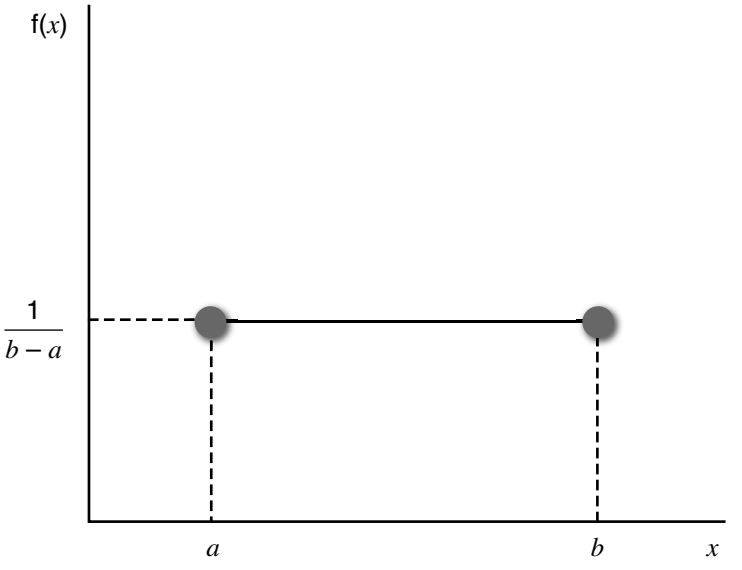

Figure 1.4 Uniform Distribution

The area of the rectangle is equal to the product of its length and its width.

Thus, the area of the rectangle equals $(b - a) * 1/ (b - a) = 1$.

What does this mean? This means that for a continuous[11] random variable, the area under the curve is equal to 1. This is true in the case of a discrete random variable as well provided the values of the discrete random variable are close enough to appear almost continuous.

The unit area under the curve in Figure 1.4 illustrates that relative frequencies or probabilities of occurrence of all values of the random variable, when integrated, are equal to 1. That is:

[11] When there are too many possible values for a random variable to count, such a random variable is called a *continuous random variable.* The spacing between the adjacent values of the random variable is so small that it is hard to distinguish one value from the other and the pattern of those values appears to be continuous.

$$\int_{b-a} \text{all} f(X)\, dX = 1$$

In this equation, *dX* is an increment along the x-axis and *f(X)* is a value on the y-axis.

Uniform distribution arbitrarily determines a two-point estimate of the highest and lowest values (endpoints of a range) of a random variable. This simplest estimation method allows project managers to transform subjective data into probability distributions for better decision-making especially in risk management.

Triangular Distribution

Unlike uniform distribution, the triangular distribution illustrates that the probability of all values of a random variable are not uniform. Figure 1.5 shows the shape of a triangular distribution.

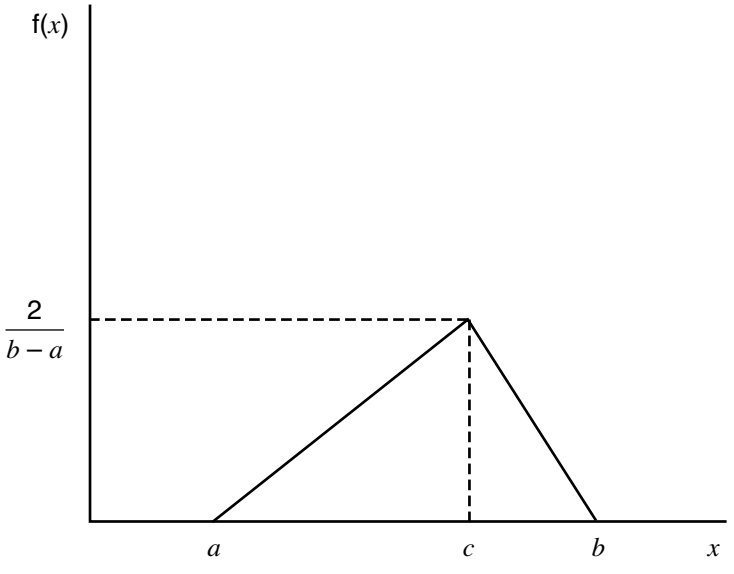

Figure 1.5 Triangular Distribution

A triangular distribution is called so because of its triangular shape. It is based on three underlying values: ***a*** (minimum value), ***b*** (maximum value), and ***c*** (peak value) and can be used estimate the minimum, maximum, and most likely values of the outcome. It is also called *three-point estimation,* which is ideal to estimate the cost and duration associated with the project activities more accurately by considering the optimistic, pessimistic, and realistic values of the random variable (cost or duration). The skewed nature of this

distribution represents the imbalance in the optimistic and pessimistic values in an event. Like all probability density functions, triangular distribution also has the property that the area under the curve is 1.

Beta Distribution

The beta distribution depends on two parameters—α and β where α determines the center or steepness of the hump of the curve and β determines the shape and fatness of the tail of the curve. Figure 1.6 shows the shape of a beta distribution.

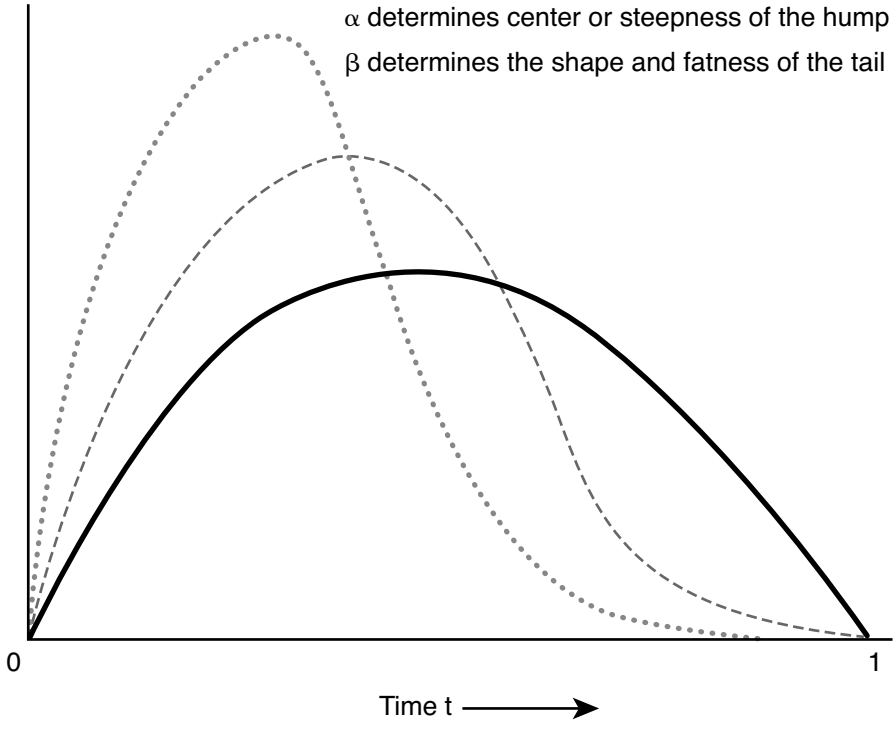

Figure 1.6 Beta Distribution

Like triangular distribution, beta distribution is also useful in project management to model the events that occur within an interval bounded by maximum and minimum end values. You will learn how to use this distribution in PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) for three-point estimation in Chapter 8.

Lean Six Sigma Approach

The *Lean*[12] *Six Sigma*[13] approach encompasses reduction in waste and reduction in variation (inaccuracy). For decisions to be rational and effective, they should be based on an approach that promotes these things. That is the rationale behind the use of the Lean Six Sigma approach in project management analytics.

NOTE

"Lean-Six Sigma is a fact-based, data-driven philosophy of improvement that values defect prevention over defect detection. It drives customer satisfaction and bottom-line results by reducing variation, waste, and cycle time, while promoting the use of work standardization and flow, thereby creating a competitive advantage. It applies anywhere variation and waste exist, and every employee should be involved."

Source: American Society of Quality (ASQ). http://asq.org/learn-about-quality/six-sigma/lean.html

The goal of every project organization in terms of project outcome is SUCCESS, which stands for

SMART[14] Goals Established and Achieved

Under Budget Delivered Outcome

Communications Effectiveness Realized

Core Values Practiced

Excellence in Project Management Achieved

Schedule Optimized to Shorten Time to Delivery

Scope Delivered as Committed

The projects are typically undertaken to improve the status quo of a certain prevailing condition, which might include an altogether missing functionality or broken functionality. This improvement effort involves defining the current (existing) and the target conditions, performing gap analysis (delta between the target and the current condition),

[12] The *Lean* concept, originated in Toyota Production System, Japan, focuses on reduction in waste.

[13] The *Six Sigma* concept, originated in Motorola, USA, focuses on reduction in variation.

[14] **S**pecific, **M**easurable, **A**chievable, **R**ealistic, and **T**imely

and understanding what needs to be done to improve the status quo. The change from the current condition to the target condition needs to be managed through effective change management. Change management is an integral part of project management and the Lean Six Sigma approach is an excellent vehicle to implement changes successfully.

The DMAIC Cycle

Like the project management life cycle, Lean Six Sigma also has its own life cycle called the *DMAIC cycle*. DMAIC stands for the following stages of the Lean Six Sigma life cycle:

Define

Measure

Analyze

Improve

Control

The DMAIC is a data-driven process improvement, optimization, and stabilization cycle. All stages of the DMAIC cycle are mandatory and must be performed in the order from "define" to "control." Figure 1.7 depicts a typical DMAIC cycle.

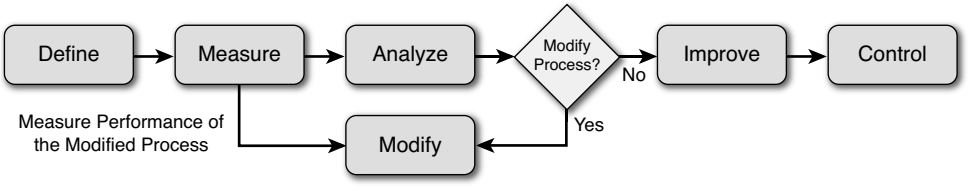

Figure 1.7 DMAIC Cycle

The various stages of the DMAIC cycle are briefly described here (refer to Chapter 7, "Lean Six Sigma," for detailed discussion on the DMAIC cycle):

- **Define:** Define the problem and customer requirements.
- **Measure:** Measure the current performance of the process (establish baseline), determine the future desired performance of the process (determine target), and perform gap analysis (target minus baseline).
- **Analyze:** Analyze observed and/or measured data and find root cause(s). Modify the process if necessary but re-baseline the performance post-modification.

- **Improve:** Address the root cause(s) to improve the process.
- **Control:** Control the future performance variations.

The PDSA Cycle

Project quality is an integral part of project management. The knowledge of Lean Six Sigma tools and processes arms a project manager with the complementary and essential skills for effective project management. The core of Lean Six Sigma methodology is the iterative PDSA (**P**lan, **D**o, **S**tudy, **A**ct) cycle, which is a very structured approach to eliminating or minimizing defects and waste from any process.

Figure 1.8 shows the PDSA cycle. We discuss this cycle as part of our discussion on the applications of the Lean Six Sigma approach in project management.

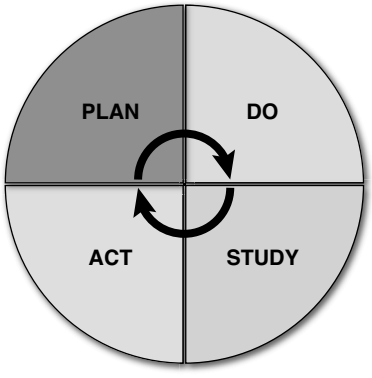

Figure 1.8 PDSA Cycle

Brief explanations of the building blocks of the PDSA cycle follow (refer to Chapter 7 for detailed discussion on the PDSA cycle):

- **Plan:** The development of the plan to carry out the cycle
- **Do:** The execution of the plan and documentation of the observations
- **Study:** The analysis of the observed and collected data during the execution of the PDSA plan
- **Act:** The next steps based on the analysis results obtained during study

Lean Six Sigma Tools

The Lean Six Sigma processes involve a lot of data collection and analysis. The various tools used for this purpose include the following:

- **Brainstorming:** To collect mass ideas on potential root causes
- **Surveys:** To collect views of the individuals who are large in number and/or outside personal reach
- **Five whys:** A method that asks five probing questions to identify the root cause
- **Value stream mapping:** Process map analysis to identify wasteful process steps
- **Cause and effect or fishbone or Ishikawa diagram:** A tool to help with brainstorming on the possible root causes
- **Control charts:** To identify "common" and "special" causes in the stream of data observed over a period of time
- **Correlation:** To study the correlation between two variables
- **Cost-benefits analysis:** To estimate the cost of implementing an improvement plan and the benefits realized
- **Design of experiments:** To identify the recipe for the best possible solution
- **Histograms:** Unordered frequency (of defects) map
- **Pareto charts:** Ordered (descending) frequency (of defects) map
- **Regression analysis:** To study the effect of one variable with all other variables held constant
- **Root cause analysis:** Analysis to find the "cure" for a problem rather than just "symptoms treatment"
- **Run charts:** Observed data over a period of time
- **SIPOC[15] chart:** Process analysis to identify input and output interfaces to the process

These tools are discussed in more detail in Chapter 7.

The Goal of Lean Six Sigma–Driven Project Management

Executing only those activities that are value adding, when they are needed, utilizing minimum possible resources, without adversely impacting the quality, scope, cost, and delivery time of the project.

[15] SIPOC (**S**upplier, **I**nput, **P**rocess, **O**utput, **C**ustomer) is a process analysis tool.

How Can You Use the Lean Six Sigma Approach in Project Management?

We will examine a hybrid approach by blending the DMAIC cycle with the project management life cycle, which project managers can use to find the root cause(s) of the following project path holes and recommend the appropriate corrective actions to fix them.

- Schedule delays
- Project scope creep
- Cost overruns
- Poor quality deliverables
- Process variation
- Stakeholder dissatisfaction

Analytic Hierarchy Process (AHP) Approach

Proposed by Thomas L. Saaty in 1980, the AHP is a popular and effective approach to multi-criteria-driven decision-making. According to Saaty, both tangible and intangible factors should be considered while making decisions. "Decisions involve many intangibles that need to be traded off. To do that, they have to be measured alongside tangibles whose measurements must also be evaluated as to how well they serve the objectives of the decision maker," says Saaty.

You can use the AHP approach in any scenario that includes multiple factors in decision-making. For example:

- Deciding which major to select after high school
- Deciding which university to select after high school
- Deciding which car to select for buying
- Deciding which projects to select for inclusion in the portfolio

Often in decision-making, the intangible factors are either overlooked or the decisions are just made based on subjective or intuitional criteria alone. The AHP approach is a 360° approach, which includes both subjective and objective criteria in decision-making. The key characteristic of this approach is that it uses pairwise comparisons[16] of all the possible factors of the complex problem at hand and evaluates their relative importance to the decision-making process. For example, project management decision-making

[16] Pairwise comparisons include comparison of each factor in the decision-making criteria against every other factor in the criteria.

criteria may include three factors: schedule flexibility, budget flexibility, and scope flexibility. To make a decision, the project manager must consider the relative importance of each of the three factors against every other factor in the criteria. Schedule, budget, and scope are the triple constraints of project management and a tradeoff often has to be made to find the right balance among them based on the business need and/or the project environment. For instance, less flexibility in scope requires schedule, budget, or both to be relatively more flexible.

Chapter 6 covers the AHP approach in more detail. This book makes extensive use of this approach in recommending data-driven methodology for making the most effective and rational project management decisions, including the following:

- Project selection and prioritization
- Project risk identification and assessment
- Selection of project risk response strategy
- Vendor selection
- Project resource allocation optimization
- Project procurement management
- Project quality evaluation

Summary

The mind map in Figure 1.9 summarizes the project management analytics approach.

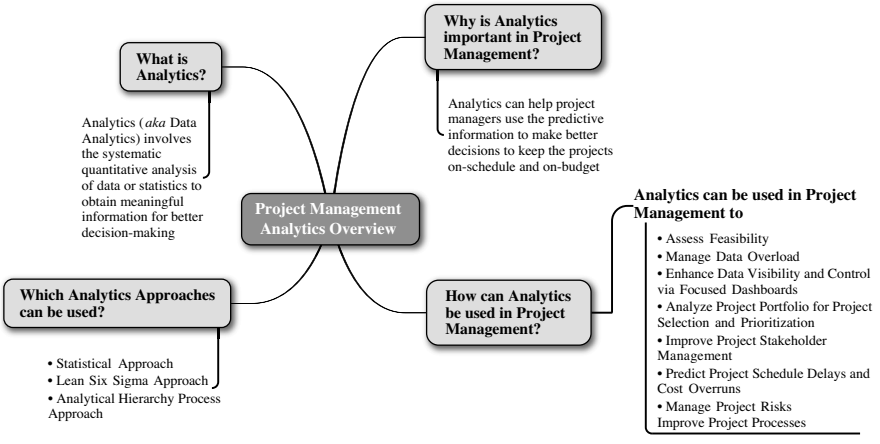

Figure 1.9 Project Management Analytics Approach Summary

Key Terms

Analytic Hierarchy Process (AHP)

Analytics

Beta Distribution

Breakeven Analysis

Continuous Random Variable

Cost-Benefit Analysis

Critical Path Method (CPM)

Customer Relationship Management (CRM)

Discrete Random Variable

DMAIC Cycle

Earned Value Analysis

Empirical Rule

Lean Six Sigma

Net Present Value (NPV)

Normal Distribution

NORMDIST

Payback Period

PDSA Cycle

Poisson Distribution

Program Evaluation and Review Technique (PERT)

Return on Investment (ROI)

SIPOC

Three-Point Estimating

Triangular Distribution

Uniform Distribution

Value Stream Mapping

Case Study: City of Medville Uses Statistical Approach to Estimate Costs for Its Pilot Project

To encourage sports and fitness among students from kindergarten to 12th grade, the education department of the city of Medville, Pennsylvania, conceived a 12-month pilot project to provide special free training, nutrition, and sports gear to the students of a select 10 schools. The goal of this project was to cover 70% of the student population under the new program. The initial challenge was to figure out the funds required to run this project and also the plan to carry out the project work.

For scope management, the project management committee divided the student population in different age groups and estimated the cost for students in each age group. Table 1.2 depicts the various student age groups and the cost estimates.

Table 1.2 Estimated Project Cost for Various Student Age Groups

Student Age Group	Estimated Cost Per Student
Less than 10 years old	$2,000
10 to 15 years old	$5,000
More than 15 years old	$3,000

The project assumed that the total population of students (2,000 students) was normally distributed with a mean age of 12 and a standard deviation of 3. The following statistical calculations for normal distribution were used to make decisions.

Determine Target Age Group for Initial Project Pilot

For normal distribution,

- 1 σ covers roughly 68% of the population, which implies 68% of the total 2,000 students fall in the age group 9 to 15 (12 +/– 3).
- 2 σ covers roughly 95% of the population, which implies 95% of the total 2,000 students fall in the age group 6 to 18 (12 +/– 6).

Because the goal of the pilot project was to cover 70% of the student population, students in age group 6 to 18 were selected for the initial pilot.

Estimate Project Costs for the Target Age Group

The target age group contained student population from all three population bands listed in Table 1.2. Thus, cost estimates pertaining to those population bands or age groups had to be considered for calculating costs for the target age group (6 to 18 years old). The project figured it out using the Excel NORMDIST[17] function as follows:

> Percentage of target students belonging to age group under 10 years (6 to 10 years old) = NORMDIST (10, 12, 3, 1) – NORMDIST (6, 12, 3, 1) = 22.97%
>
> Cost Allocation for 6- to 10-year old students = (2000 * 22.97% * 2000) = $918,970
>
> Percentage of target students belonging to age group 10 to 15 years (10 to 15 years old) = NORMDIST (15, 12, 3, 1) – NORMDIST (10, 12, 3, 1) = 58.89%

[17] **NORMDIST(x, μ, σ, 1)**, where x = random variable (upper or lower end of the age-group range), μ = mean age in the age-group, σ = standard deviation, and 1 stands for cumulative.

Cost Allocation for 10- to 15-years-old students = (5000 * 58.89% * 2000) = $5,888,522

Percentage of target students belonging to age group over 15 years = 1 – (22.97% + 58.89%) = 18.14%

Cost Allocation for over 15-year-old students = (3000 * 18.14% * 2000) = $1,088,432

Total Estimated Cost for All Target Students for the Initial Pilot = $918,970 + $5,888,522 + $1,088,432 = $7,895,924

Case Study Questions

1. What approach was used by the city of Medville to estimate the overall project cost?
2. Define the scope of this project.
3. Do you think the city made a wise decision to use this approach for cost estimation? Why do you think so?

Chapter Review and Discussion Questions

1. Define analytics.
2. What is the difference between analytics and analysis?
3. What are advantages of using analytics in project management?
4. How can analytics be used in project selection and prioritization?
5. Describe briefly the 7 Cs of project stakeholder management.
6. What are the characteristics of normal distribution in terms of standard deviation?
7. When can Poisson distribution be used for project management? Provide some examples.
8. Which statistical distribution is used for three-point estimation in project management?
9. Describe briefly the various stages of the DMAIC cycle.
10. What does PDSA stand for?
11. What is the primary purpose of using the Lean Six Sigma approach in project management?
12. List some of the applications of the AHP approach.

13. What is the *empirical rule* in normal distribution?
14. The mean duration of the activities of a project is 10 days with a standard deviation of 2 days. Using the empirical rule estimate the percentage of project activities with duration between 7 and 10 days.
15. Solve the preceding problem using Excel's NORMDIST function.

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Index

A

Activity on Note (AON), 233-235
Affinity Diagram, 302
Agile project management
defined, 307
vs. Lean, 307-308
Lean techniques in, 308-309
Six Sigma tools in, 310
AHP. *See* Analytic Hierarchy Process (AHP)
Alternative hypothesis, defined, 120
American Society for Quality (ASQ), 184
Analysis. *See also* Analytic Hierarchy Process (AHP)
vs. analytics, 2
analyze phase, DMAIC tools, 190, 206-209
comparison matrix, creation and normalization, 271
criteria *vs.* sub-criteria analysis, 273
definition, 2
goal *vs.* criteria mind map, 270
Analysis paralysis, 27
Analysis toolset, Microsoft Excel, 247-250
Analytic Hierarchy Process (AHP)
advantages and disadvantages, 162
analysis, performance of, 154-159, 269-277
change requests, prioritization of, 285
comparison matrix, creation and normalization, 271
criteria *vs.* sub-criteria analysis, 273
decision hierarchy, development of, 153-154, 268-269
decision-making and, 31, 161-162, 265-266, 281-283
Eigen (Priority) vector calculation, 272-273
evaluation criteria, 153, 267-268
goal *vs.* criteria mind map, 270
overview of, 152
procedures for use, 152-162
project complexity estimation, 283-284
project evaluation and selection, 267-283
project management approaches, 19-20
project risk assessment, 284-285
Saaty Scale, use of, 154-155
strategic alignment criteria, 273-277
summary mind map, 163, 287
synthesizing and ranking priorities, 159-161, 279-281
Analytics *vs.* analysis, 2
applications for project management, 4-8
defined, 2
project metrics, value of, 1-2
value in project management, 4

B

Backward pass, float of activity, 234-235
Bar (GANTT) chart, 213
Bell curve, 9-10
Beta distribution, 14
BETA distributions, 232
Big data, decision-making and, 31
Binomial distributions, 94-95, 232
Black Belts, LSS, 194
Brainstorming
decision-making factors, 28
DMAIC tools, 201-202
Lean Six Sigma tools, 18
nominal group technique, 203

use in Executing stage of PMLC, 303
use in Initiating stage of PMLC, 299-300
use in Planning stage of PMLC, 301
Breakeven analysis, 5
Brynjolfsson, Erik, 32
Budget
AHP evaluation criteria, 267-268
Budget at Completion (BAC) calculations, 255
Budgeted Cost of Work Performed (BCWP), 255
Budgeted Cost of Work Schedule (BCWS), 255
Cost Performance Index (CPI), 258
Cost Variance (CV), calculation of, 257
linear regression, predictions and, 245-251
predictions, EVM and confidence intervals, 251-254
predictions, EVM applications, 254-258
project charter and, 61-62
project closing stage, 59-60
project constraints, overview, 48-49
project definition stage, 57-58
project execution stage, 59
project failure, reasons for, 51-52
project management life cycle (PMLC), 60-65
project planning stage, 58
work breakdown structure, overview of, 66
Buffers, critical chain method and, 235-236
Business architecture, 2
Business case, 2, 57
Butler Analytics, 31

C

Capability analysis, DMAIC tools, 200-201
Cause and effect
correlation and causation, 133-134
Lean Six Sigma tools, 18
Cause-and-effect diagram, DMAIC tools, 206-207
Central limit theorem, 98, 232
Central tendency, measures of, 83-87
mean, 84, 86
median, 84-85
mode, 85-86
weighted mean, 86-87
Champions, LSS, 194
Change Control Board (CCB), 63-65
Change management
change log, 63
change requests, prioritization of, 285
Lean Six Sigma and, 16
Project Management Life Cycle (PMLC) and, 63-65
Check sheet, DMAIC tools, 203-204
Classical probability, 80
Closing stage, PMLC, 305-306
Communication plan, 58
Comparison matrix, AHP process
creation and normalization, 271
strategic alignment decisions, 273-277
Complexity estimations, projects, 283-284
Conditional probability, 81-82
Confidence intervals, 99-101, 251-254
Confidence limits (CL), 252-253
Confirmatory data analysis, 119. ***See also*** **Hypothesis testing**
Consistency Index (CI), 161
Consistency Ratio (CR), 161
Continuous random variables, 87-94
Control charts
benefits of, 306-307
DMAIC tools, 211
Lean Six Sigma tools, 18
Project Management Life Cycle (PMLC) tools, 305
Control phase, DMAIC tools, 210-213
Correlation
applications of, 240-245
causation and, 133-134
Lean Six Sigma tools, 18
linear correlation, 132
no correlation, 132
nonlinear correlation, 132-133
overview of, 131
Correlation coefficient, 133, 240-245
Cost-benefit analysis
analytics, applications of, 5
feasibility study and, 67-68
Lean Six Sigma tools, 18

Cost considerations, AHP evaluation criteria, 267-268
Cost Performance Index (CPI), 258
Cost Variance (CV), 257
Covariance, applications of, 240-245
Critical chain method (CCM), 235-236
Critical Path Method (CPM), 14, 232-235
Critical values, 121, 125
Current state of process, DMAIC tools, 197-198
Customer acceptance documentation, 59-60
Customer relationship management (CRM), 6-8
Cycle time, DMAIC and, 189

D

Dashboards, analytics and, 5, 305
Data
qualitative, defined, 79
quantitative, defined, 79
range, 87
statistical studies, designing of, 82-83
Data analytics
data quality, questions for, 34
defined, 2
Data collection
experiments, 83
observations, 83
surveys, 83
Data-driven decision-making. *See* Decision-making
Data overload
analysis paralysis, 27
managing with analytics, 4-5
Davenport, Thomas H., 34
Decision-making. *See also* Analytic Hierarchy Process (AHP); Statistics, applications of
analytics, value of, 4
analytics *vs.* analysis, 2
automation and management of process, 30-31
data-driven decision-making, 31-33
data quality and, 34
decision hierarchy, AHP, 268-269
decision log, 63
decisive project managers, value of, 28-30
factors for decision-making, 27-28
good decisions, characteristics of, 26
Lean Six Sigma approach, 15-19
nominal group technique, 203
project management decisions, types of, 25-26
statistical approaches, project management, 8-9
summary of process, 34
Defect prevention and detection, 15-19
Define phase, DMAIC, 190, 194-200, 295
Degrees of freedom, defined, 129
Deliverables, project
closing stage, 59-60
conceptual stage, 56-57
defined, 57
definition stage, 57-58
evaluation stage, 60
execution stage, 59
planning stage, 58
project life cycle, overview, 55-56
project management life cycle (PMLC), 60-65
Deming, Edward, 191
Deming cycle, 191-194
Design, development and implementation (DDI), 59. *See also* Systems development life cycle (SDLC)
Design of experiment
DMAIC tools, 210
Lean Six Sigma tools, 18
Project Management Life Cycle (PMLC) tools, 303
Deviation
for population data, 91
for sample data, 92-93
Discrete variables, probability distributions and, 87-94
Distribution curve, rejection region, 125
DMAIC cycle (Define, Measure, Analyze, Improve/Implement, Control). *See also* Lean Six Sigma (LSS)
analyze phase, tools for, 206-209
define phase, tools for, 190, 194-200
improve phase, tools for, 210

measure phase, tools for, 200-206
overview of, 16-17, 184, 189-191
PDSA (Plan, Do, Study, Act) cycle, 191-194
project management and, 19
vs. Project Management Life Cycle (PMLC), 294-297
summary figure, LSS, 214
DMEDI (Define, Measure, Explore, Develop, and Implement), 310-311
Dubois, Sirah, 118

E

Earned Value Management (EVM)
applications of, 254-255
confidence intervals and, 251-254
sample problem, 255-258
Efficiency, cost (spending), 258
Eigen value, 157-158
Eigen Vector
calculation of, 159-161, 272-273
making decisions and, 161-162
pairwise comparisons, 157-158
synthesizing and ranking priorities, 279-281
80-20 rule, 31
Einstein, Albert, 151-152
Empirical probability, 80
Empirical rule, 10, 93-94
Equipment costs, 267-268
Estimates
level of confidence, 99-100
point and interval estimates, 99
Euler's number, 254
Evaluation
AHP and, 267-268
PERT and, 237-239
project life cycle, 60
Event, statistics, defined, 80
Excel, Analysis toolset (Microsoft), 247-250
Executing stage, PMLC, 303
Expected value (EV), 90-91
Experiment design, Lean Six Sigma tools, 18
Experiments, data collection and, 83

F

Failure modes and effects analysis (FMEA), 209, 302
Feasibility assessments, 4, 67-68
Feasibility Study Report (FSR), 57
Feedback, 60
Feeding buffer, 237
Fermi, Enrico, 119
Fishbone diagram
DMAIC tools, 206-207
Lean Six Sigma tools, 18
Project Management Life Cycle (PMLC) tools, 299, 303
5Ss (visual management), 212-213
5 Whys
Lean Six Sigma, 18
root cause analysis, 207-208
use in Executing stage of PMLC, 303
use in Initiating stage of PMLC, 300
Float of activity, 234-235
Forecasting. *See* Predictions; Predictive analytics models; Statistics, applications of
Forward pass, float of activity, 234
Frick, Walter, 32, 34

G

Gantt, Henry, 213
GANTT chart, 213
Gera, Bharat, 1
GERT (Graphical Evaluation and Review Technique), 239-240
Goals
goal *vs.* criteria mind map, 270
long- and short-term, strategic alignment and, 273-277
Goatham, Robert, 50-51
Goldratt, Eliyahu M., 236, 302
Graphical Evaluation and Review Technique (GERT), 239-240
Green Belts, LSS, 194

H

Harrington, H. James, 183, 291-292
Histograms, 18, 204-206
Holmes, Sherlock, 25
Human resources, cost of, 267-268
Hypothesis testing
alternative hypothesis, defined, 120
critical values, 121
defined, 118
left-, right-, and two-tailed tests, 122-124
level of significance, 121
null hypothesis, defined, 120
overview of, 119-125
p-value, 121-122
rejection region, 125
test decisions and conclusions, 124-125
test statistic, defined, 121
t-test, overview of, 129-131
Type I and II errors, 120
z-test, overview of, 127-129

I

Improve phase, DMAIC tools, 210
Inferences, 2
Information, data and, 79
Initiating stage, PMLC, 295, 298-300
Interoperability, defined, 69
Interval estimate, 99
Interviews, use in PMLC, 299
Inventory control
DMAIC and, 189-190
Just-In-Time, 307
Kanban, 307
Iron Triangle, 48-49
Ishikawa diagram, 18, 206-207

J

Joint Application Development (JAD), 69
Just-In-Time process, 307

K

Kaizen, 210
Kanban, 307
Kano Analysis (Model), 302
Kawakita, Jiro, 302
Key performance indicators, 2
KJ Method, 302

L

Langley, G. J., 191
Lead time, DMAIC and, 181, 186
Lean, overview of, 185
vs. Agile, 308
use in Agile project management, 308-309
Lean PMO, 310-311
Lean Six Sigma (LSS)
Agile project management and, 307-308
analyze phase, DMAIC tools, 206-209
applications, overview of, 292-293
control charts, benefits of, 306-307
control phase, DMAIC tools, 210-213
define phase, DMAIC tools, 194-200
DMAIC cycle, 16-17, 189-191
expert levels, 194
improve phase, DMAIC tools, 210
measure phase, DMAIC tools, 200-206
overview of, 15-16, 184-194
PDSA cycle, 17, 191-194
PMLC *vs.* DMAIC stages, 294-297
Project Management with LSS (PMLSS), overview, 291-292
role of tools in PMLC process, 298-306
summary mind map, 214, 312
tools, overview of, 17-18
uses for, 2, 184
Left-tailed test, 122-125
Lessons learned documentation, 59-60, 305-306
Level of confidence, 99-100
Level of significance, 121
Linear correlation, 132

Linear regression
applications of, 245-251
Lean Six Sigma tools, 18
multiple regression equation, 140-141
process for, 134
regression line equation, 135-136
single variable predictions and, 136-140
Lipke, Walt, 230
Lower specification limit, 200-201

M

Markov Chains Model, 303
Matrix diagram, DMAIC tools, 195-196
McAfee, Andrew, 32
Mean
of binomial distributions, 94-95
defined, 84
of discrete probability distribution, 89
for population data, 91
for sample data, 92-93
use of, 86
weighted mean, 86-87
Measure phase, DMAIC tools, 200-206, 296-297
Measures of central tendency, 83-87
mean, 84, 86
median, 84-85
mode, 85-86
weighted mean, 86-87
Median, 84-85
Microsoft Excel, Analysis toolset, 247-250
Milestones. *See also* Schedules, project
defined, 61
project charter and, 61-62
Minitab, 140
Mode, 85-86
Monitoring and Controlling stage, PMLC, 296-297, 304-305
Monson, Thomas S., 8-9
Monte Carlo Simulation, 303
Multiple regression equation, 140

N

Negative linear correlation, 132
Net present value (NPV)
AHP evaluation criteria, 267-268
analytics, applications of, 5
No correlation, defined, 132
Nominal group technique (NGT), 203
Nonlinear correlation, 132-133
Normal distribution
applications of, 232
central limit theorem, 98
overview of, 9-10, 96-98
standard normal distribution, 96-98
Null hypothesis. *See also* Hypothesis testing
defined, 120
rejection region, distribution curve, 125

O

Observations, data collection, 83
Operations *vs.* projects, 52-53
Optimization techniques, decision-making and, 30-31
Oster, Emily, 229-230
Outcome, defined, 79

P

Pairwise comparisons, 154-162, 271, 273-277
Pareto charts
DMAIC tools, 205-206
Lean Six Sigma tools, 18
Project Management Life Cycle (PMLC) tools, 300, 303
Payback period, 5, 267-268
PDSA (Plan, Do, Study, Act) cycle, 17, 191-194
Performance measures
Cost Performance Index (CPI), 258
Earned Value Management (EVM), 254-258
project management life cycle (PMLC), 63-65
project planning stage, 58
systems development life cycle (SDLC), 69-70

PERT (Program Evaluation and Review Technique)
applications of, 237-239
beta distribution, 14
weighted mean, 86-87
Planning stage, PMLC, 296-297, 301-302
Point estimate, 99
Poisson distribution, 11-12, 95-96, 232
Population, statistics
correlation coefficient for, 133
defined, 79
mean, deviation, variance, and standard deviation calculations, 91-92
Portfolio, project, 5, 54-55
Positive linear correlation, 132
Pragmatism, decision-making and, 27
Precedence Diagramming Method (PDM), 233-235
Prediction error, defined, 136-137
Predictions
confidence intervals and, 251-254
Earned Value Management (EVM) and, 254-258
linear regression, applications of, 245-251
linear regression, prediction intervals, 137-140
multiple variable predictions, 140-141
PDSA cycle and, 192
single variable predictions, 136-140
Predictive analytics models
analytics, applications of, 8
analytics *vs.* analysis, 2
decision-making process and, 30-31
statistical approaches, project management, 8-9
Prescriptive analytics, 30-31
Priorities, synthesizing and ranking of, 279-281. *See also* Project selection and prioritization
Priority vector. *See* Eigen Vector
Pritsker, Alan B., 239
Probability. *See also* Statistics, fundamentals of
classical or theoretical probability, 80
conditional probability, 81-82
confidence intervals, 99-101
empirical or statistical probability, 80
measures of central tendency, 83-87
Poisson distribution, 95-96
probability distributions, 231-232
probability theory, use of, 231
p-value, defined, 121-122
range of, 81
Probability distributions
beta distribution, 14
normal distributions, 9-10, 96-98
overview of, 87-94
Poisson distribution, 11-12
triangular distribution, 13-14
uniform distribution, 12-13
Probability trial, defined, 79
Process improvement, 8. *See also* Lean Six Sigma (LSS)
Process map, DMAIC tools, 200
Process mapping, PMLC
use in Executing stage, 303
use in Initiating stage, 299-300
Process variation, DMAIC and, 189-191
Program Evaluation and Review Technique (PERT), 14
Programs, defined, 53-54
Project buffer (PB), 236
Project charter, 61-62, 195, 295, 298-300
Project life cycle (PLC). *See also* Systems development life cycle (SDLC)
closing stage, 59-60
conceptual stage, 56-57
definition stage, 57-58
evaluation stage, 60
execution stage, 59
overview of, 55-56
planning stage, 58
Project management analytics
analytic hierarchy process (AHP) approach, 19-20
analytics, possible applications for, 4-8
analytics, value of, 4
control charts, benefits of, 306-307
Lean Six Sigma approach, 15-19
statistical approach, 8-14
summary of, 20

Project Management Body of Knowledge Guide (PMBOK), 4
Lean Six Sigma tools and, 298-306
project charter definition, 46
Project management (PM) framework
defined, 45-46
process map for, 65
project, characteristics and constraints, 46-49
project life cycle, overview of, 55-60
project management life cycle (PMLC), 60-65
Project Management Office, role of, 55
projects, success and failure of, 50-52
projects *vs.* operations, 52-53
projects *vs.* programs or portfolios, 53-55
summary of, 70
systems development life cycle (SDLC), 67-70
work breakdown structure (WBS), overview of, 66
Project Management Life Cycle (PMLC). *See also* Systems development life cycle (SDLC)
closing stage, 65, 305-306
executing and controlling stage, 63-65, 303
initiating stage, 61-62, 298-300
vs. Lean Six Sigma DMAIC, 294-297
Lean Six Sigma tools and, 298-306
monitoring and controlling stage, 304-305
overview of, 60-61
planning stage, 62-63, 301-302
summary mind map, LSS and, 312
Project Management Office, role of, 55
Project Management with Lean Six Sigma (PMLSS)
overview of, 291-292
PMLC *vs.* DMAIC stages, 294-297
role of LSS tools in PMLC process, 298-306
Project managers
analytics applications to project management, 4-8
decisive managers, value of, 28-30
selection of, Lean Six Sigma tools for, 298-300
soft competencies, measurement of, 27
Project network diagram, 232-235
Project Office, role of, 55
Projects. *See also* Schedules, project; Scope of project
characteristics and constraints of, 46-49
complexity, estimations of, 283-284
project metrics, value of, 1-2
project plans, 58
project portfolios, 5, 54-55
project reports, 59-60
projects *vs.* operations, 52-53
success and failure, reasons for, 50-52
work breakdown structure, overview of, 66
Project selection and prioritization
analytic hierarchy process (AHP), 19-20, 267-283
analytics, applications of, 4-8
evaluation criteria, determination of, 267-268
making the final decisions, 281-283
synthesizing and ranking priorities, 279-281
p-value, defined, 121-122

Q

QFD (Quality Function Deployment), 311
Qualitative data, 27, 79
Quality. *See also* Lean Six Sigma (LSS)
analytic hierarchy process (AHP) approach, 19-20
data quality, questions for, 34
DMAIC, use of, 184
integration and testing, systems development, 69
Lean Six Sigma, overview, 15-19
project execution stage, 59
project management life cycle (PMLC), 60-65
QFD (Quality Function Deployment), 311
quality plan, project planning stage, 58
Quality Function Deployment (QFD), 311
Quantitative data, defined, 79
Quantitative measures, project management, 8-9

R

Random Consistency Index (RI), 161, 272-273
Random variables, probability distributions and, 87-94
Range, data sets, 87
Range, probability, 81
Ranking, Analytic Hierarchy Process and, 159-161
Raw materials costs, 267-268
Rectangular distribution with constant probability, 12-13
Regression analysis
applications of, 245-251
Lean Six Sigma tools, 18
linear regression, process for, 134
multiple variable predictions, 140-141
regression line equation, 135-136
single variable predictions, 136-140
Relative frequency, 231
Relative weight matrix, 156-162
Requirements
analytics *vs.* analysis, 2
project failure, reasons for, 51-52
project planning stage, 58
systems development life cycle (SDLC) and, 68-69
Requirements traceability matrix (RTM), 58
Resource buffer, 236
Resource requirements
analytic hierarchy process (AHP) approach, 19-20
analytics, applications of, 5-16
cost considerations, 267-268
project definition stage, 57-58
project execution stage, 59
project management life cycle (PMLC), 60-65
project planning stage, 58
projects *vs.* operations, 52-53
work breakdown structure, overview of, 66
Responsibility assignment matrix (RAM), 58
Result, defined, 79
Return on investment (ROI), 5, 267-268
Right-tailed test, 122-125
Risk assessment and management
AHP and risk assessments, 284-285
analytic hierarchy process (AHP) approach, 19-20
analytics *vs.* analysis, 2
feasibility study and, 67-68
project charter and, 61-62
project execution stage, 59
project management life cycle (PMLC), 60-65
risk register, 63
uniform distributions and, 12-13
Roles and responsibilities, project planning, 58
Root cause analysis, 18, 189, 207-208
Rouse, Margaret, 69
Run charts, 18

S

Saaty, Thomas, 19, 152, 154
Saaty Scale, 154-155, 270
Sample, statistics
correlation coefficient for, 133
defined, 79
mean, deviation, variance, and standard deviation calculations, 92-94
Sample space, defined, 80
Scatter diagram, DMAIC tools, 207
Scatter plots, 240-245. *See also* Linear regression
Schedules, project
analytics, applications of, 7-8
Budgeted Cost of Work Performed (BCWP), 255
Budgeted Cost of Work Schedule (BCWS), 255
critical chain method (CCM), 235-236
critical path method and, 232-235
GANTT chart, 213
linear regression, predictions and, 245-251
PERT, application of, 237-239
predictions, EVM and confidence intervals, 251-254
predictions, EVM applications, 254-258
project constraints, overview, 48-49
project definition stage, 57-58

project execution stage, 59
project failure, reasons for, 51-52
project planning stage, 58
Schedule Performance Index (SPI), 256-257
Schedule Variance (SV) calculations, 256
status reports, 59
work breakdown structure, overview of, 66
Scope of project
linear regression, predictions and, 245-251
project charter and, 61-62
project closing stage, 59-60
project constraints, overview of, 48-49
project definition stage, 57-58
project failure, reasons for, 51-52
project management life cycle (PMLC), 60-65
project planning stage, 58
scope statement, 63
Scorecards, 305
Seven Cs of project stakeholder management, 6-7
Significance, level of, 121
Simulations, 2
SIPOC chart, 18, 195-196, 300
Six Sigma, 184-189, 310
68-95-99.7 rule, 93-94
Skulmoksi, Gregory J., 27
Specification limits (SL), 200-201
Stakeholder analysis
DMAIC tools, 195, 295
Lean Six Sigma tools, 298-300
PMLC tools, 295
SIPOC analysis, 300
Stakeholder management
analytics, applications of, 6-8
decisive project managers, value of, 28-30
feasibility study and, 67-68
project failure, reasons for, 51-52
project management life cycle (PMLC), 60-65
stakeholder identification, project charter, 61-62
stakeholder register, 57-58
Standard deviation
of binomial distributions, 94-95
of discrete probability distribution, 89
empirical rule (68-95-99.7 rule), 93-94
overview of, 10
for population data, 91
for sample data, 92-94
Standard error of estimate, 137-140
Standard error of the mean, 98
Standard normal distribution, 96-98
Standard score, 94
Statement of work (SOW), 57-58
Statistical approach, project management
beta distribution, 14
decision-making process and, 30-31
normal distributions, 9-10
overview of, 8-9
Poisson distribution, 11-12
triangular distribution, 13-14
uniform distribution, 12-13
Statistical probability, defined, 80
Statistics, applications of. *See also* Statistics, fundamentals of
central limit theorem, 232
confidence intervals, 251-254
correlation and covariance, 240-245
critical chain method (CCM), 235-236
critical path method (CPM), 232-235
Earned Value Management (EVM), 254-258
GERT (Graphical Evaluation and Review Technique), 239-240
linear regression, 245-251
PERT (Performance Evaluation and Review Technique), 237-239
probability distributions, 231-232
probability theory, 231
summary mind maps, 258-259
Statistics, defined, 79
Statistics, fundamentals of. *See also* Statistics, applications of
alternative hypothesis, 120
binomial distributions, 94-95
confidence intervals, 99-101
correlation, types of, 131-133
correlation and causation, 133-134
correlation coefficient, 133
critical values, 121
degrees of freedom (df), 129
designing statistical studies, 82-83

hypothesis, defined, 118
hypothesis, rejection region, 125
hypothesis, testing of, 119-125
left-, right-, and two-tailed tests, 122-124
level of significance, 121
linear regression, overview of, 134-140
measures of central tendency, 83-87
multiple regression equation, 140-141
normal distribution, 96-98
null hypothesis, 120
Poisson distribution, 95-96
probability, classical or theoretical, 80
probability, conditional, 81-82
probability, empirical or statistical, 80
probability distributions, 87-94
probability range, 81
p-value, 121-122
range, 87
summary mind map of, 101, 120-142
terminology, 78-80
test statistic, defined, 121
t-test, 129-131
Type I and II errors, 120
value of statistics, 78
z-test, 127-129
Status reports, 59
Stockburger, David W., 117
Strategic decisions
AHP, sub-criteria analysis, 273-277
AHP evaluation criteria, 267-268
analytics, applications of, 6-8
applications of analytics, 4-8
Strategy Updates, 306
Subjective information, measurement of, 27
SUCCESS mnemonic, 15
Supply chain management, DMAIC and, 189-194
Surveys
Lean Six Sigma tools, 18
overview of, 83
Project Management Life Cycle (PMLC) tools, 299, 305
SWOT analysis, 30, 196-197
Synthesizing priorities, AHP and, 159-161
Systems development life cycle (SDLC)
design stage, 69
development, integration, and testing stages, 69
evaluation stage, 70
feasibility study, 67-68
implementation, operations, and maintenance stages, 70
overview of, 67
requirements and analysis planning, 68-69

T

Target state, DMAIC tools, 199
Tasks, work breakdown structure, 52, 58, 66
Team members, project planning, 58
Test statistic, defined, 121
***The Improvement Guide* (1996), 191**
Theoretical probability, 80
Theory of Constraints, 302
Three-Point Estimation, 237-239
Training requirements, 5
Transition criteria, 306
Trend analysis, DMAIC tools, 204-205
Triangular distribution, 13-14, 232
Triple constraints of projects, 48-49
t-test, 129-131
Two-tailed test, 122-125
Type I and II errors, defined, 120

U

Uniform distribution, 12-13, 232
Upper specification limit, 200-201

V

Value stream map (VSM)
DMAIC tools, 197-199, 213
Lean Six Sigma tools, 18
overview of, 197-199
use in Planning stage of PMLC, 302
Variables, probability distributions and, 87-94

Variance
of binomial distributions, 94-95
central limit theorem, 232
Cost Variance (CV), calculation of, 257
covariance, applications of, 240-245
of discrete probability distribution, 89
for population data, 91
for sample data, 92-93
Schedule Variance (SV) calculations, 256
Variation
common causes and special cases of, 211-212
Lean Six Sigma, overview, 15-19
Vendor selections
analytic hierarchy process (AHP) approach, 19-20
Visual management (5Ss), 212-13
Voice of Customer (VOC), 200, 311

W

Waste reduction, 15-19, 185-186. *See also* Lean Six Sigma (LSS)
Web analytics, 7
Weighted mean, defined, 86-87
Williams, John T., 78
Work breakdown structure (WBS), 52, 58, 66
Workflow, 303
Work packages, project planning, 58
Work schedule. *See* Schedules, project

X-Y-Z

Z-score, 94, 96-98
z-test, 127-129