CPIM

Certified in Production and Inventory Management

Master Planning of Resources

Version 4.5—January 2016

Instructor Upgrade Packet

APICS

Master Planning of Resources
Version 4.5 – January 2016
Net Change Document

All material can be downloaded from the instructor community by selecting the file ***MPR v4.5 IG Download Packet.pdf***

Page	Change	Page Replaced	Visual Number (if Updated)
n/a	NOTE: The dates given for the Wallace, Wallace et al., and Wallace & Stahl references in the course have been modified throughout to match the copyright dates shown on Amazon.com and to correct the authorship to "Wallace and Stahl." The date for "*Sales Forecasting: A New Approach*" changed from "2004" to "2002," and the date for the "*Master Scheduling in the 21st Century"* reference changed from "2007" to "2003." Wallace and Stahl reference changes occurred on the following pages: 1-8, 1-28, 2-6, 2-16, 2-19, 2-28 (References and Visual 2-24), 2-30 and 2-32 (Visual 2-25), 2-34 and 2-36 (Visual 2-26), 2-52, 3-6, 3-24, 3-36, 4-6, 4-36, 5-6, 5-8, 5-12, 5-30, 6-6, 6-12, 6-18, 6-39, 7-6, 7-8, 7-30, 7-54, 7-68, 7-72, 8-6, and 8-24 (including Visual 8-22). These pages are NOT included in the update packet due to the minor nature of the changes.	n/a	n/a
All pages of About This Guide	In "About This Guide," page I-iii, under "Exam Content Manual," second paragraph, delete the last sentence: "Candidates should understand the definitions of the key terms in the content outline, as well as the outlined techniques – why and how to apply them and which ones to select for different situations." Add the following new fourth paragraph to this section: "Candidates should understand the definitions of the key terms in the ECM, why and how to apply them, and which ones to select for different situations. The CPIM courseware covers many, but not all, of the key terms in the ECM. Therefore, candidates should supplement their learning by studying the ECM key term list using the *APICS Dictionary* or other ECM references as a guide." On page I-viii, at the bottom, add a section describing the APICS CPIM Study Tools.	All pages of About This Guide	n/a
1-15	On page 1-15, add a note to the bottom of the page stating: "Note: "Logistics resource requirements planning" is referenced in Ross, *Distribution Planning and Control*, 2nd ed., chap. 5."	1-15	n/a

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Page	Change	Page Replaced	Visual Number (if Updated)
1-18, 1-19	On page 1-18 and 1-19, in the table, and on Visuals 1-12 and 1-13, change the line "Labor, overtime, and subcontracting needs" to "Future labor, overtime, and subcontracting needs"	1-18, 1-19	1-12, 1-13
1-41	On page 1-41, change the last bullet on the page from "S&OP results in several plans that provide input to master scheduling." to "The only plan that has direct input into master scheduling is the production plan."	1-41	n/a
2-35, 2-36, 2-37	On page 2-35, in the "Historical (intrinsic) data" row, last sentence, change "bookings" to "booked orders" On page 2-36, in the second question, change "bookings" to "booked orders." In the answer to the second question, change the first sentence from "Bookings ..." to "Booked orders ..." and change the second sentence from "Booking records ..." to "Booked orders ..." On page 2-37, in the second question, change "bookings" to "booked orders"	2-35, 2-36, 2-37	n/a
2-56	On Visual 2-43, change the values in the bottom table, right column from "469" to "470;" from "748" to "749;" from "992" to "995;" and from "554" to "556."	2-56	2-43
2-58, 2-59	On page 2-58, last section, remove the last bullet beginning with "Historical analogy" On Visual 2-44, in the upper right box, remove the bullet "historical analogy" On Visual 2-45, delete the last row of the table. On page 2-59, in the last paragraph on the page, change "... cause and effect, leading indicators, and historical analogy." to "... cause and effect and leading indicators." Delete the last bullet point on the page, beginning with “In the absence of ….”	2-58, 2-59	2-44, 2-45

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Page	Change	Page Replaced	Visual Number (if Updated)
3-18	On page 3-18, in the Answer to the question, change the second sentence from "…for product C in period 5." to "… for product C in period 4." Change the third sentence and formula from "The calculation for product C in period 5 is as follows: RFSE ÷ MAD = 100 ÷ 27.5 = 3.6" to "The calculation for product C in period 4 is as follows: RSFE ÷ MAD = 75 ÷ 19 = 3.9"	3-18	n/a
3-26	On Page 3-26, in the note at the bottom of the page, change "Note: You may find it useful to review the third module of APICS Certified Supply Chain Professional course." to "Note: You may find it useful to review the content on CRM in the APICS Certified Supply Chain Professional course."	3-26	n/a
3-27	On page 3-27, under "Profitability Segmentation," change the first sentence from "ABC Analysis is used …" to "Pareto analysis is used …"	3-27	n/a
3-44	On page 3-44, first bullet, last sentence, change "Note that the upside flexibility of a firm …" to "Note that the upside flexibility of a supply chain …"	3-44	n/a
3-46	On Visual 3-39, right side, first line, change "Number of days of from …" to "Number of days from …"	3-46	3-39
3-55	On page 3-55, first sentence, change "Now let's refer to the visual …" to "Now let's refer to Visual 3-45 …"	3-55	n/a
3-58, 3-59	On pages 3-58 and 3-59, modify the content to improve the wording related to forecast horizon and forecast interval. On page 3-59, in the note at the bottom of the page, first sentence, change "forecast internal" to "forecast interval"	3-58, 3-59	n/a

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Page	Change	Page Replaced	Visual Number (if Updated)
4-6	On page 4-6, in the references at the top of the page, change the chapter referenced in Jacobs et al. from "4" to "14" and change the date for the "*Master Scheduling in the 21st Century*" reference from "2007" to "2003" On Visual 4-7, right side, change the second bullet from "storage/break-bulk/cross docking" to "storage, break-bulk, cross docking, and consolidation" and change the third bullet from "consolidation" to "returns and post-manufacturing services"	4-6	4-7
4-17	On page 4-17, under "Network Configuration," change the second bullet from "storage, break-bulk, cross docking, and returns" to "storage, break-bulk, cross docking, and consolidation" Change the third bullet from "consolidation" to "returns and post-manufacturing services"	4-17	n/a
4-26	On Visual 4-22 and page 4-26, in the solution to #3, change "Replenishment of DCs can be made in a day or two" to "Replenishment of DCs can be made in a short period of time."	4-26	4-22
4-44	On Visual 4-36, under the main diagram, add "Time" as an x-axis label	4-44	4-36
4-45	On page 4-45, third bullet, first sentence, change "… factors in the releasing …" to "… factors in releasing …"	4-45	n/a
4-49	On page 4-49, under "Distribution Requirements Planning," first line, change "... implementing centralized pull systems ..." to "... implementing pull systems ..."	4-49	n/a
4-70	On page 4-70, first sentence, change "Explain that of performance measurements …" to "Explain that performance measurements …"	4-70	n/a
4-81	On page 4-81, change the vocabulary term "distribution channel" to "distribution requirements planning" and modify the definition given for #1 to “The function of determining the need to replenish inventory at branch warehouses”	4-81	n/a

APICS CPIM
Exam Content Manual

Version 5.0

Visit **apics.org/ecmerrata** for APICS CPIM Exam Content Manual errata.
Internet links cited in the bibliographic references can be found in a more usable format on the APICS website at **apics.org/cpim**.

The references in this manual have been selected solely on the basis of their educational value to the APICS CPIM certification program and on the content of the material. APICS does not endorse any service or other materials that may be offered or recommended by the authors or publishers of books and publications listed in this manual.

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Letter to Candidates

Dear Candidate:

For more than a generation, the Certified in Production and Inventory Management (CPIM) program has been recognized as the international standard for individual assessment in the field of operations managements as it relates to transformation of products and services. Initiated by APICS in 1973, it provides a standard for individuals and organizations to evaluate their knowledge of this evolving field. APICS has administered more than 1 million tests in over 40 countries, and more than 100,000 professionals have earned the APICS CPIM designation—3,000 of them at the Fellow level. The mission of the APICS CPIM program is to be the premier professional certification for supply chain and operations management that tests the candidate's knowledge and understanding of the principles and practices of operations and inventory management. The APICS CPIM program is designed to educate individuals in the various concepts, methodologies, terminology, and integration of topics within the supply chain and operations manage- ment function and to test candidates' in-depth knowledge of these concepts. APICS has worked to ensure that APICS CPIM exams are consistently reliable and that the highest professional standards are used to develop and administer the program.

Because organizations operate in a changing and challenging international environment, the APICS body of knowledge continues to grow to include recognized concepts and tools to improve competiti- veness and effectiveness organizations. The CPIM Exam Content Manual (ECM) is updated regularly to reflect these changes in the body of knowledge and to assist candidates in their understanding of the scope of material covered in the program.

Using a typical business process orientation, the APICS CPIM program integrates individual modules in a progression of increased understanding.
It is **highly** recommended that candidates follow this sequence of examinations to increase both understanding and success:

1. Entry module—Basics of Supply Chain Management: Terminology and basic concepts related to managing the flow of materials from suppliers to customers both internal and external throughout the supply chain
2. Core competency modules—Master Planning of Resources, Detailed Scheduling and Planning, Execution and Control of Operations: Available methodologies and techniques to drive processes and the application of these techniques
3. Capstone module—Strategic Management of Resources: Choosing the appropriate structures and methodologies to achieve organizational strategic objectives and an understanding of the integration of operations within the greater context of the organization

The following is a summary of each of the APICS CPIM modules.

Basics of Supply Chain Management (BSCM)
As the introductory module, Basics of Supply Chain Management introduces the material presented in depth in the other four modules. **Experience has shown us that APICS CPIM candidates who master the material in Basics of Supply Chain Management first find the other modules easier to understand; therefore, we strongly recommend that all APICS CPIM candidates start with this module.**

This module introduces the definitions and concepts for planning and controlling the flow of products and services into, though, and out of an organization. Many of the key terms in this module are expanded in the other modules. This module explains funda- mental relationships among the various activities that may occur in the supply chain network from suppliers to customers. In addition, the module covers types of manufacturing and service systems, forecasting, master planning, material requirements planning, capacity management, production activity control, purchasing, inventory management, and distri- bution. Four main management philosophies are covered: enterprise resources planning, lean, quality management, and the theory of constraints.

Master Planning of Resources (MPR)

In Master Planning of Resources, candidates explore processes used to develop sales and operations plans, identify and assess internal and external demand management requirements, planning and replenishment in a networked distribution environment, and gain an understanding of the importance of producing feasible master schedules that are consistent with business policies, objectives, and resource constraints. The module focuses on developing and validating a plan of supply; relating management of demand to manufacturing, distribution and service environments; and developing and validating the master schedule.

Detailed Scheduling and Planning (DSP)

In Detailed Scheduling and Planning, candidates focus on the various techniques for inventory, procurement, and material and capacity scheduling. This module includes detailed descriptions of material requirements planning, capacity requirements planning, inventory management practices, and procurement and supplier planning. Techniques, such as material and capacity-constrained scheduling, are included and applicable to a variety of manufacturing and service organizations. Candidates will also become familiar with sustainable practices, supplier partnerships, lean principles, and outsourcing strategies and techniques.

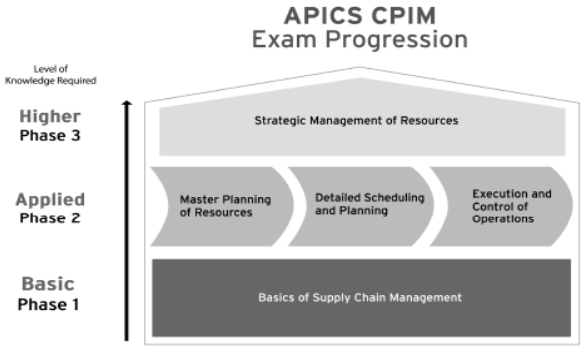
Execution and Control of Operations (ECO)

Execution and Control of Operations focuses on four main areas: execution of operational plans and schedules, control of the work completed and the analysis of results, the management of and communication in the workplace, and the importance of utilizing appropriate design principles. The module explains techniques for scheduling and controlling operations within available capacity and deals with the execution of quality initiatives, cost management, and problem solving. Finally, this module presents techniques for making the most of resources, the environment, and continuous improvement activities.

Strategic Management of Resources (SMR)

In Strategic Management of Resources, candidates explore the relationship of existing and emerging processes and technologies to operations strategy and supply chain-related functions for both manufacturing and service organizations. The module addresses three main topics: understanding the business environment, developing operations strategy, and implementing operations strategy. For maximum comprehension, candidates are strongly encouraged to be familiar with the information and concepts outlined in the other APICS CPIM modules before taking this course. **Historical performance data confirms that candidates who successfully complete the other four modules approximately double their chances of passing the Strategic Management of Resources capstone module.**

The APICS CPIM program continues to evolve, incorporating relevant and current concepts and techniques into the body of knowledge, such as supply chain management, lean, service industries, globalization, theory of constraints, sales and operations planning, outsourcing, critical chain, and sustainability. APICS CPIM is an outstanding educational program, and APICS relies on your comments and suggestions to maintain and improve the program for future candidates. We wish you success in your pursuit of your operations management knowledge.



William R. Leedale, CFPIM, CIRM, and CSCP
Chair, CPIM Subcommittee

Introduction

This ECM provides assistance for those studying in the production and inventory management field, developing and conducting educational courses and workshops, and preparing for the certification examinations. The objective of this manual is to outline the APICS CPIM body of knowledge, which the APICS Certification Committee has organized into five modules:

- Basics of Supply Chain Management
- Master Planning of Resources
- Detailed Scheduling and Planning
- Execution and Control of Operations
- Strategic Management of Resources

In this manual, each exam module begins with a statement of the scope of the subject matter, followed by a descriptive outline of the content as well as a bibliography of the references. Key terminology for the particular exam modules is provided on pages 9-29. Each exam module concludes with sample questions typical of those that appear on the examinations. The correct answers for the sample questions, with brief explanations of why they are correct, appear at the end the manual.

The recommended procedure for mastering the subject matter is to review the content outline, which defines the material, and then to study each topic, using the references. At the end of each major section is a list of the references that apply to the topics in that section. The first number indicates the sequence number for the reference in the Bibliography section, and the numbers in parentheses indicate the chapter(s) within that reference. These outlines form the content and structure for the certification examinations. Candidates should understand the definitions of the key terms in the content outline, as well as the outlined techniques—why and how to apply them and which ones to select for different situations.

New developments in the state of the industry may be described in current literature. Sufficient references are given for each topical area to provide different approaches to material covered in each module and different styles of presenting it. Reading the available APICS periodical material, including *APICS magazine*, the *Production and Inventory Management Journal*, and the *APICS Operations Management Now* e-newsletter will help you maintain an awareness of changes in the state of this discipline.

About the APICS CPIM Examinations

Candidates answer a predetermined number of questions to assess their knowledge in key areas. Each of the APICS CPIM exams (except Basics of Supply Chain Management) consists of 75 multiple-choice questions. The Basics exam consists of 105 multiple-choice questions. There is a three-hour time limit for each APICS CPIM exam. For more information about testing and registration policies and procedures you can download the bulletins from the APICS website at **apics.org/cpim**, or call APICS Customer Service at 1-800-444-2742 (United States and Canada) or +1-773-867-1777.

Students who successfully complete CPIM examinations may be eligible to receive hours of college credit recommendations from the New York State Regents Research Fund, National College Credit Recommendation Service, based on an academic evaluation of student learning outcomes. The semester hours of undergraduate credit per exam are as follows:

- BSCM: 3 semester hours
- MPR: 2 semester hours
- DSP: 2 semester hours
- ECO: 2 semester hours
- SMR: 3 semester hours

Detailed information about the outcomes and credit recommendations is available at **www.nationalccrs.org**. Transcripts are available through APICS.

Question Format

The questions on the CPIM examination are intended to test a candidate's understanding of the CPIM body of knowledge. In addition, it is helpful to understand the various formats of questions on the examination. The following seven examples illustrate the types of multiple-choice questions that may be found on the examination.

For Example 1, choose the response that best completes the statement.

> **Example 1:** The key to a successful production plan is:
>
> (A) capacity requirements planning.
> (B) material requirements planning.
> (C) dynamic priority planning.
> (D) adequate production capacity.
> (The correct answer is D.)

For Example 2, choose the response that best answers the question.

> **Example 2:** Which of the following approaches enables MRP techniques to be used for planning and controlling independent demand items?
>
> (A) pegged orders
> (B) two-bin system
> (C) time-phased order point
> (D) reorder point
> (The correct answer is C.)

For Example 3, choose the one response that does **NOT** correctly complete the statement.

> **Example 3:** Group technology identifies the similarities among all of the following **EXCEPT**:
>
> (A) costs
> (B) parts
> (C) shapes
> (D) processes
> (The correct answer is A.)

For Example 4, another type of multiple-choice question, there are two or more statements, or possibilities. The question, and the statements, are always followed by four-answer choices labeled A, B, C, and D. When answering multiple-choice questions of this type, read each question and the statements carefully to determine whether each statement (I through IV) is true or false.

Next, look at the four choices. While this form of question is increasingly less common, the correct response requires determining if one or a combination of choices best answers the question. In Example 4, you should choose option A if you believe statements I and III are true. You should choose option B if you believe statements I and IV are true. You should choose option C if you believe statements II and III are true. Finally, you should choose option D if you believe statements II and IV are true.

> **Example 4:** If a company changes from make-to-stock to assemble-to-order, the effects on inventory levels are which two of the following?
>
> I. Lower finished-goods inventory
> II. Higher finished-goods inventory
> III. Lower work in process
> IV. Higher work in process
>
> (A) I and III
> (B) I and IV
> (C) II and III
> (D) II and IV
> (The correct answer is B.)

Example 5 is similar to Example 4, but the number of possible combinations is greater. The best strategy for answering these questions is to consider each statement, decide whether it is true, and then search for the correct combination. If the combination you seek is not given, reconsider each statement carefully.

> **Example 5:** Management policies and decisions about which of the following have a direct impact on investment?
>
> I. Customer service levels
> II. Intra-company transportation modes
> III. Placement of distribution centers
> IV. Types of production processes

(A) I and II only
(B) III and IV only
(C) I, II, and IV only
(D) I, II, III, and IV
(The correct answer is D.)

Examples 6 and 7 ask for a judgment or evaluation of the **MOST** or **LEAST** appropriate choice. The judgment is not one person's opinion, but is the accepted choice according to the APICS body of knowledge. Example 6 asks for the **MOST** appropriate choice. Example 7 calls for the **LEAST** appropriate choice.

Example 6: The **MOST** significant advantage of aggregating demand data before they are stored is that:

(A) information about demand is lost.
(B) there is risk of input error in the aggregation process.
(C) data will usually be inconsistent with financial information.
(D) the processing time required to aggregate is extensive.
(The correct answer is A.)

Example 7: Which of the following lot-sizing calculations would be **LEAST** sensitive to changes in unit costs?

(A) least total cost
(B) period order quantity
(C) part period balancing
(D) lot-for-lot
(The correct answer is D.)

Taking the Test

The test is designed to evaluate a candidate's knowledge of the subject matter. Therefore, the key to success is a thorough understanding of the subject matter. All questions are based on the current CPIM body of knowledge as defined in the exam content manual.

When you start your exam, read all the directions carefully. Be sure you understand the directions before you begin to answer any questions.

Read each question carefully and thoroughly. If a question includes stimulus material, such as a table, graph, or situation, be sure to study it before you answer the question. Take care to avoid assuming information not given, as well as assuming you know what is being asked without reading the question completely, or second-guessing the question. Every effort has been made to avoid misleading wording and to provide sufficient information for each question.

Choose the best answer from the choices given. Do not look for hidden tricks or exceptions to the norm. For each question, one and only one of the four choices represents the correct answer.

Once you begin the test, approach the questions in order, but do not waste time on those that are unfamiliar or seem difficult to you. Go on to the other questions and return to the difficult ones later if you have time. If you have some knowledge about a particular question, you may be able to eliminate one or more choices as incorrect. Your score on the test will be based on the number of questions you answer correctly, with no penalty for incorrect answers; therefore, it is to your advantage to guess rather than not answer a question. Avoid changing an answer unless you are absolutely certain that you marked the wrong answer.

Interpreting Test Scores

Scoring is based on your correct responses. There is no penalty for incorrect answers. The omission of an answer will be counted the same as an incorrect answer.

The CPIM scaled score range is 265–330:

265–299: Fail

300–330: Pass

320 and greater: Fellow level

For each examination, you receive a score for the total test. All candidates will also receive diagnostic information on their performance.

Studying for the APICS CPIM Exam

APICS offers a number of resources to help individuals prepare for the APICS CPIM examinations.

APICS CPIM References

Bibliography. The APICS CPIM examination subcommittees have identified a number of references for each APICS CPIM module. These are listed in the bibliography section of each module. All references contain excellent material that will assist in test preparation. For additional information on the APICS CPIM references, visit the APICS website at apics.org/cpim, or call APICS Customer Service at1-800-444-2742 (United States and Canada) or +1-773-867-1777.

A candidate may discover that the material covered in one reference duplicates material covered in another reference. Both sources are included as references to provide candidates some discretion in selecting test preparation materials that they find accessible and understandable. For instance, a candidate who uses a specific reference in preparing for a certification exam that he or she passed may feel comfortable using that same reference to prepare for other certification exams. In deciding if a single reference is sufficient, candidates should assess their own levels of knowledge against both the descriptive examination specifications and the detailed topic list contained in the respective module's content outline. If there are any areas of weakness, the candidate should consult another reference as part of the test preparation process.

References for CPIM Exam Modules

While these references do not cover the CPIM body of knowledge extensively, they do cover the material a successful candidate is required to know.

References	Author(s)	BSCM	MPR	DSP	ECO	SMR
APICS Dictionary, 14th ed., 2013	APICS	X	X	X	X	X
APICS CPIM Detailed Scheduling and Planning Reprints, 2010	APICS Exam Committee			X		
APICS CPIM Execution and Control of Operations Reprints, 2015	APICS Exam Committee				X	
APICS CPIM Master Planning of Resources Reprints, 2010	APICS Exam Committee		X			
Accounting Handbook, 5th ed. 2010	Siegal, Shim					X
Crafting and Executing Strategy: Concepts and Readings, 19th ed. 2014	Thompson, Peteraf, Strickland, Gamble					X
Designing and Managing the Supply Chain, 3rd ed., 2008	Simchi-Levi, Kaminsky, Simchi-Levi			X		
Distribution Planning and Control, 2nd ed. 2004	Ross		X			
Introduction to Materials Management, 7th ed., 2012	Arnold, Chapman, Clive	X		X	X	
Juran's Quality Handbook, 6th ed., 2010	Juran, DeFeo				X	
Leading Change, 2012	Kotter					X
Lean Production Simplified, 2nd ed., 2007	Dennis	X			X	
The Lean Toolbox, 4th ed., 2009	Bicheno, Holweg			X		
Making Sustainability Work, 2nd ed. 2014	Epstein, Buhovac			X		X
Manufacturing Planning and Control for Supply Chain Management, APICS/CPIM Certification Edition, 2011	Jacobs, Berry, Whybark, Vollmann		X	X	X	
Operations Strategy, 3rd ed., 2011	Slack, Lewis					X
Project Management, 11th ed., 2013	Kerzner			X		

It is not practical to list all texts that contain excellent material. Although not currently primary references for the exams, the following chart shows texts that have been used previously for both the CPIM body of knowledge and APICS CPIM courseware. These are still excellent and viable references for APICS CPIM candidates to study.

References	Author(s)	BSCM	MPR	DSP	ECO	SMR
APICS CPIM Basics of Supply Chain Management Reprints, 2009		X				
APICS CPIM Execution and Control of Operations Reprints, 2011					X	
Capacity Management, 2008	Blackstone			X		
A Guide to the Project Management Body of Knowledge, 4th ed., 2008	Project Management Institute Standards Committee			X		
Introduction to Materials Management, 6th ed., 2008	Arnold, Chapman, Clive	X		X	X	
Juran's Quality Planning and Analysis, 5th ed., 2007	Gryna, Chua, DeFeo				X	
Lean Six Sigma, 2002	George			X		
Mainstreaming Corporate Sustainability, 2013	Farver					X
Making Sustainability Work, 2008	Epstein, Buhovac			X		
Manufacturing Planning and Control Systems for Supply Chain Management, 5th ed., 2005	Vollmann, Berry, Whybark, Jacobs		X	X	X	
Master Scheduling in the 21st Century, 2003	Wallace, Stahl		X			
Project Management, 7th ed., 2008	Meredith, Mantel			X		
Project Management, 10th ed., 2009	Meredith, Mantel			X		
Sales & Operations Planning: The How-to Handbook, 3rd ed., 2008	Wallace, Stahl		X			
Sales Forecasting: A New Approach, 2002	Wallace, Stahl		X			
Service Management and Operations, 2nd ed., 2000	Haksever, Render, Russell, Murdick			X		
Strategic Management of Resources References Sourcebook, 2009						X

Content outline. The content outline for each module provides an overview of the major topics included in that module. Each major topic is denoted by a Roman numeral and is followed by a list of the references that are particularly relevant to that topic.

APICS Dictionary. The *APICS Dictionary*, 14th edition, is an essential publication that applies to the exam content manual and exams. Within the profession, terminology varies among industries, companies, and the academic community. Each examination uses standard terminology as defined in the *APICS Dictionary*. Recognizing the terms and understanding their definitions are essential.

Reprints. The committee responsible for the exam content manual and examination selects articles that are particularly applicable to the curricula and exam preparation. These articles then are reprinted in module-specific collections. The reprints are included in the references for each module.

Terminology

Candidates are encouraged to be familiar with all key terms listed below for the corresponding modules. The *APICS Dictionary* is the primary guideline for all definitions of the key terms. Definitions for those terms followed by an * are included in the supplemental glossary listed below the key terms.

In studying for the APICS CPIM certification, candidates may discover multiple terms used to denote the same technique. Examples of this include "sales and operations planning" versus "production planning" and "master production schedule" versus "master schedule." APICS has attempted to provide consistency across all modules with recognized and preferred terminology. However, synonyms are often used by authors in the various references used to compile the body of knowledge.

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
14 Points (Deming's)				X	
A3 method				X	
ABC classification	X				
abnormal demand		X			
absorption costing				X	X
acceptable quality level (AQL)				X	
acceptance sampling				X	
action message			X		
activation			X		
activity-based cost accounting				X	X
activity based management (ABM)					X
actual costs				X	
actual demand		X			
adaptive smoothing		X			
adjustable capacity				X	
advanced planning and scheduling (APS)	X	X		X	
advanced planning system (APS)		X			
advance ship notice (ASN)	X				
aggregate forecast		X			
aggregate plan		X			
agility					X
allocation		X	X	X	
alpha factor		X			
alternate operation				X	
alternate routing			X	X	
analysis of variance (ANOVA)				X	
andon	X			X	
anticipated delay report				X	
anticipation inventories	X				
appraisal costs				X	
assemble-to-order	X				
assembly line	X				
assignable cause	X			X	
attribute data				X	
availability			X		

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
available capacity				X	
available inventory	X				
available time			X		
available-to-promise (ATP)	X				
average cost per unit				X	
average inventory	X				
average outgoing quality limit (AOQL)				X	
back scheduling	X				
backflush	X				
backflush costing				X	
backhauling	X				
backlog	X				
backorder	X				
backward integration					X
backward scheduling				X	
balanced scorecard					X
balance sheet	X				
balancing operations				X	
bar code	X				
baseline measures					X
base series		X			
basic seven tools of quality (B7)				X	
batch	X			X	
batch picking	X				
batch processing				X	
benchmarking		X		X	X
benchmark measures					X
bias	X				
bill of distribution		X			
bill of labor				X	
bill of lading (uniform)	X				
bill of material (BOM)	X				
bill of resources		X			
block scheduling				X	
bonded warehouse	X				
bottleneck	X			X	
bottleneck operation				X	
bottom-up replanning		X			
break-bulk	X				
break-even point	X				X
bucketed system		X			
bucketless system		X			
budgeted capacity			X		
buffer	X			X	
buffer management	X			X	
buffer stock			X		

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
bullwhip effect	X				X
business plan	X				
business process reengineering (BPR)					X
business-to-business commerce (B2B)			X		
by-product		X	X		
calculated capacity			X		
capable-to-promise (CTP)	X	X			
capacity available	X			X	
capacity-constrained resource (CCR)				X	
capacity control				X	
capacity management	X			X	
capacity planning	X				
capacity planning using overall factors (CPOF)		X			
capacity-related costs				X	
capacity requirements				X	
capacity requirements planning (CRP)	X				
capacity strategy					X
capacity utilization				X	
carrying cost	X				
cash conversion cycle					X
cash flow	X				
cash-to-cash cycle time		X			X
cause-and-effect diagram	X			X	
cell				X	
cellular manufacturing	X			X	
centralized inventory control	X				
central point scheduling			X		
certificate of compliance				X	
certification audits				X	
certified supplier	X			X	
changeover				X	
changeover costs				X	
chase production method	X	X			
chase strategy					X
check sheet				X	
closed-loop MRP	X				
collaborative planning, forecasting, and replenishment (CPFR)		X			
common carrier	X				
common causes				X	
common parts bill of material		X			
competitive advantage					X
competitive analysis					X
component	X				
concurrent design				X	
concurrent engineering			X		X

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
conformance				X	
consignment	X				
constraint	X			X	
constraints management				X	
consuming the forecast		X			
continuous improvement				X	
continuous manufacturing				X	X
continuous process control				X	
continuous process improvement (CPI)	X				
continuous production	X	X		X	
continuous replenishment	X				
contract carrier	X				
contribution				X	
contribution margin					X
control chart	X			X	
control limit	X			X	
control points				X	
co-product		X	X		
core competencies					X
core process					X
corporate culture					X
corrective action				X	
correlation		X		X	
cost center				X	
cost of goods sold	X				
cost of poor quality	X				
cost of quality				X	
cost variance				X	
cost-volume-profit analysis				X	
count point				X	
critical chain method	X				
critical characteristics				X	
critical path method (CPM)	X			X	
critical point backflush				X	
critical ratio				X	
critical-to-quality characteristics (CTQs)				X	
cross-docking	X				
cumulative available-to-promise		X			
cumulative lead time	X				
current ratio					X
curve fitting		X			
customer relationship management (CRM)	X	X			
customer service	X				
customer service level				X	
customer-supplier partnership		X		X	X
customs broker	X				

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
cycle counting	X				
cycle stock	X				
cycle time	X				
data governance*	X				
days of supply	X				
decentralized inventory control	X				
decision matrix				X	
decision support system (DSS)					X
decomposition		X			
decoupling				X	
decoupling inventory	X				
dedicated capacity			X		
dedicated line			X		
de-expedite				X	
define, measure, analyze, improve, control (DMAIC) process				X	
delivery lead time	X	X			X
delivery schedule				X	
Delphi method		X			
demand filter		X			
demand forecasting			X		
demand lead time	X				
demand management	X				
demand planning	X				
demand time fence (DTF)		X			
demonstrated capacity	X			X	
demurrage	X				
dependent demand	X				
design for manufacturability					X
design for manufacture and assembly (DFMA)				X	
design of experiments (DOE)				X	
design-to-order		X			
detention	X				
deviation		X			
direct costs				X	
direct labor	X				
direct material	X				
discounted cash flow					X
discrete available-to-promise		X			
discrete manufacturing	X				
discrete order picking	X				
disintermediation					X
dispatching	X				
distressed goods			X		
distribution	X			X	
distribution center	X	X			

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
distribution channel	X	X			
distribution inventory	X				
distribution network structure		X			
distribution of forecast errors		X			
distribution requirements planning (DRP)	X				
distribution warehouse	X				
divergent point				X	
dock-to-stock	X				
downtime				X	
drop ship	X				
drum-buffer-rope (DBR)	X			X	
drum schedule	X				
duty	X				
early manufacturing involvement				X	
early supplier involvement (ESI)				X	
earned hours				X	
echelon		X			
e-commerce			X		
econometric model		X			
economic order quantity (EOQ)	X				
economic value added					X
effective date			X		
efficiency	X			X	
electronic data interchange (EDI)	X				
employee empowerment	X			X	
employee involvement (EI)	X			X	
engineer-to-order	X				
enterprise resources planning (ERP)	X				X
environmentally responsible business				X	
excess capacity				X	
expedite				X	
explode	X				
exponential smoothing forecast		X			
external failure costs	X				
external setup time	X			X	
extrapolation		X			
extrinsic forecasting method	X				
fabricator				X	
failsafe work methods				X	
failure mode effects analysis (FMEA)				X	X
feature		X			
feedback				X	
feeder workstations				X	
field service	X				
fill rate				X	
final assemble schedule (FAS)	X			X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
finished goods inventory	X				
finishing lead time		X			
finite forward scheduling	X				
finite loading	X			X	
finite scheduling				X	
firm planned order (FPO)	X				
first-article inspection				X	
first in, first out (FIFO)			X	X	
first-order smoothing		X			
first pass yield				X	
fishbone analysis				X	
fitness for use				X	
five focusing steps	X				
five forces model of competition					X
five Ss	X			X	
five whys	X				
fixed cost				X	
fixed-location storage	X				
fixed order quantity	X				
fixed overhead	X				
fixed-position manufacturing	X				
flexibility			X		X
flexible workforce				X	
floor stocks				X	
flowchart	X			X	
flow control				X	
flow processing	X				
flow rate				X	
flow shop	X				
fluctuation inventory	X				
focused factory				X	X
focus forecasting		X			
forecast	X				
forecast consumption		X			
forecast error	X				
forecast horizon		X			
forecast interval		X			
forecast management		X			
form-fit-function				X	
forward flow scheduling			X		
forward integration					X
forward scheduling	X			X	
four Ps	X				
freight consolidation	X				
freight forwarder	X				
frequency distribution		X			

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
functional layout	X			X	
functional product*			X		
funnel experiment				X	
Gantt chart	X			X	X
gatekeeping				X	
gateway work center			X	X	
gemba	X				
gemba walk*				X	
genchi genbutsu	X				
general and administrative expenses (G&A)	X				
generally accepted accounting principles (GAAP)	X				X
global measurements					X
global reporting initiative (GRI)			X		
global trade identification number (GTIN)*			X		
go/no-go				X	
green manufacturing				X	
green reverse logistics	X				
gross margin	X				
gross requirement	X				
group technology (GT)				X	
hansei	X				
hazmat				X	
hedge		X			
hedge inventory	X				
heijunka	X			X	
histogram	X			X	
horizontal dependency			X		
horizontally integrated firm					X
hoshin	X			X	
hoshin planning	X				
house of quality (HOQ)				X	X
hurdle rate					X
hybrid production method		X			
hypothesis testing				X	
idle capacity	X			X	
idle time			X		
inactive inventory			X		
inbound stockpoint				X	
income statement	X				
incoterms	X				
indented bill of material	X				
independent demand	X				
indirect costs				X	
infinite loading	X			X	
information system architecture					X
input/output control (I/O)	X			X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
insourcing					X
intangible costs				X	
intellectual property					X
intermittent production	X				
intermodal transport	X				
internal customer				X	
internal failure costs	X				
internal rate of return					X
internal setup time	X			X	
interoperation time				X	
interplant demand	X	X			
in-transit inventory	X				
intrinsic forecast method	X				
inventory accounting			X		
inventory accuracy	X				
inventory adjustment	X				
inventory buffer	X				
inventory control	X				
inventory investment			X		
inventory management	X				
inventory ordering system	X				
inventory policy			X		
inventory turnover	X			X	
inventory valuation				X	
Ishikawa diagram				X	
ISO 14000 Series Standards					X
ISO 9000					X
ISO 26000			X		
item master record				X	
jidoka	X			X	
jishuken	X				
job analysis				X	
job costing	X			X	
job enlargement					X
job enrichment					X
job sequencing rules				X	
job shop	X			X	
job shop scheduling	X			X	
job status				X	
joint replenishment			X		
Juran trilogy				X	
Just-in-Time (JIT)				X	
kaizen	X			X	
kaizen blitz				X	
kaizen event				X	
kanban	X			X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
keiretsu				X	
key performance indicator (KPI)	X				X
key success factors					X
kit				X	
knowledge-based system					X
labor efficiency				X	
labor productivity				X	
labor standard				X	
lag capacity strategy					X
landed cost	X		X		
last in, first out (LIFO)			X	X	
lead capacity strategy					X
leading indicator	X				
lead time	X			X	
lead-time offset	X				
lean enterprise				X	
lean metric				X	
lean production	X	X		X	
lean six sigma*	X				
learning curve					X
learning organization					X
least changeover cost				X	
least-squares method		X			
least total cost				X	
level loading				X	
level of service	X				
level production method	X				
level schedule	X	X		X	
liabilities	X				
life cycle assessment (LCA)			X		
lifecycle analysis		X			
lifecycle costing					X
limiting operation				X	
line				X	
line balancing				X	
line haul costs	X				
Little's law*				X	
load	X				
load leveling	X			X	
load profile			X	X	
load projection			X		
local measures					X
logistics	X			X	
lot	X				
lot control	X			X	
lot cost				X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
lot-for-lot	X				
lot size	X				
lot-size inventory	X				
lot sizing				X	
lot splitting			X	X	
lot traceability				X	
lower control limit (LCL)				X	
lower specification limit (LSL)				X	
low-level code			X		
machine center			X		
machine hours			X		
machine-limited capacity				X	
machine loading			X		
maintenance, repair, and operating (MRO) supplies	X			X	
make-or buy decision	X				
make-to-order	X				
make-to-stock	X				
management by walking around (MBWA)				X	
managerial accounting					X
manufacturing calendar	X				
manufacturing environment		X			
manufacturing execution systems (MES)				X	X
manufacturing layout strategies				X	
manufacturing lead time	X			X	
manufacturing order	X				
manufacturing order reporting				X	
manufacturing philosophy	X				
manufacturing process	X				
manufacturing resource planning (MRP II)	X				
manufacturing strategy					X
market driven	X				
marketing strategy	X				
mass customization	X	X			
master planning	X				
master planning of resources		X			
master production schedule (MPS)	X				
master schedule	X				
master schedule item		X			
master scheduler		X			
material-dominated scheduling (MDS)			X		
material requirements planning (MRP)	X				
material safety data sheet (MSDS)				X	
materials handling	X				
materials management	X				
mean		X			
mean absolute deviation (MAD)	X				

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
mean absolute percent error (MAPE)		X			
mean squared error (MSE)		X			
mean time between failures (MTBF)				X	
mean time to repair (MTTR)				X	
measure phase				X	
median		X			
milk run	X				
min-max system	X				
mixed-flow scheduling			X	X	
mixed-model production	X			X	
mixed-model scheduling	X	X			
mix forecast		X			
mode		X			
modular bill of material		X			
modularization	X				
move card				X	
move time	X			X	
moving average		X			
muda (waste)	X			X	
multilevel bill of material	X				
multilevel master schedule		X			
multisourcing	X				
mura	X				
muri	X				
nesting	X				
net present value					X
net requirements	X				
network planning			X		X
nominal group technique				X	
nonconformity				X	
nonevident failure					X
nongovernmental organization (NGO)			X		
non-value-added				X	
normal distribution		X		X	
obsolete inventory			X		
one-card kanban system	X				
one less at a time				X	
one-piece flow				X	
on-hand balance	X				
on-time schedule performance	X				
open order	X			X	
operating expense	X				
operation				X	
operational performance measurements				X	X
operation costing				X	
operation due date				X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
operation duration				X	
operation overlapping				X	
operation/process yield				X	
operations management	X				
operations plan		X			
operations scheduling				X	
operations sequence				X	
operations sequencing			X		
operation start date				X	
operations strategy					X
operation time				X	
operator flexibility	X				
opportunity cost				X	
option		X			
option overplanning		X			
order entry	X				
ordering cost	X				
order picking	X				
order point	X				
order policy			X		
order priority				X	
order promising	X				
order qualifiers	X				
order release				X	
order winners	X				
outbound stockpoint				X	
outlier		X			
outsourcing	X				X
overall equipment effectiveness (OEE)				X	
overhead	X			X	
overhead allocation				X	
overlapped schedule	X			X	
overload				X	
overstated master production schedule		X			
owner's equity	X				
pacemaker	X			X	
package to order	X				
pallet positions	X				
panel consensus		X			
parent item	X				
Pareto's law	X			X	
participative design/engineering	X			X	X
participative management				X	X
payback					X
P:D ratio		X		X	
pegging	X				

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
people involvement				X	
perceived quality				X	
performance measure				X	
performance measurement system					X
performance objectives					X
performance standard	X				
periodic replenishment	X				
period order quantity	X				
perpetual inventory record	X				
phantom bill of material			X		
physical inventory	X				
physical supply	X				
picking list	X				
pickup and delivery costs	X				
pipeline stock	X				
plan-do-check-action (PDCA)	X			X	
plan for every part (PFEP)			X		
planned load			X		
planned order	X				
planned order receipt	X				
planned order release	X				
planning bill of material	X	X			
planning horizon	X	X			
planning time fence		X			
point of sale (POS)	X	X			
point-of-use delivery			X		
point-of-use inventory				X	
poka-yoke (mistake-proof)				X	
post-deduct inventory transaction processing				X	
postponement	X	X			X
pre-deduct inventory transaction processing				X	
prevention costs	X				
preventive maintenance	X			X	X
primary work center				X	
priority		X			
priority control	X			X	
priority planning	X			X	
private carrier	X				
probability		X			
probability distribution		X			
probable scheduling			X		
problem-solving storyboard				X	
process batch	X				
process capability				X	X
process capability index				X	
process control					X

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
process costing				X	X
process flexibility	X			X	
process flow				X	
process flow analysis				X	
process flow diagram	X				
process flow production		X			
process flow scheduling			X		
process focused					X
process manufacturing		X	X		
processor-dominated scheduling			X		
process train			X		
procurement	X				
procurement lead time	X				
product configuration catalog		X			
product cost	X			X	
product differentiation	X				
product family	X				
product focused					X
product group forecast		X			
production activity control (PAC)	X			X	
production capability				X	
production forecast		X			
production level		X			
production line	X				
production plan	X	X			
production planning	X				
production rate		X			
production schedule		X			
production scheduling				X	
productive capacity	X		X		
productivity	X			X	
product layout	X				
product life cycle	X				
product line		X			
product load profile		X			
product mix	X	X			
product-mix flexibility					X
product positioning		X			X
product profiling					X
product/service hierarchy		X			
profit margin	X				
program evaluation and review technique (PERT)			X	X	X
project costing				X	X
projected available balance	X				
project management	X		X	X	
project manufacturing		X			

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
project phase			X		
project plan			X		
protective capacity	X				
protective inventory	X				
protective packaging	X				
prototyping					X
pull signal				X	
pull system	X			X	
purchase order	X				
purchase requisition	X				
purchasing lead time	X				
push system	X			X	
pyramid forecasting		X			
QS 9000					X
qualitative forecasting techniques		X			
quality	X				
quality at the source	X				
quality circle				X	
quality control	X			X	
quality costs	X			X	
quality function deployment (QFD)	X			X	X
quantitative forecasting techniques		X			
quantity discount	X				
queue	X			X	
queue time			X	X	
quick asset ratio					X
quick changeover	X				
radio frequency identification (RFID)	X				
random cause				X	
random-location storage	X				
random sample		X			
random variation	X				
rate-based scheduling				X	
rated capacity	X			X	
raw material	X				
receiving	X				
record accuracy	X				
redundancy					X
regression analysis		X			
released order				X	
remanufacturing	X			X	
remedial maintenance				X	
reorder quantity	X				
repair order				X	
repetitive manufacturing	X			X	
replanning frequency			X		

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
replenishment lead time	X				
request for quote (RFQ)	X				
required capacity				X	
requirements explosion	X				
requisition			X		
rescheduling			X		
residual income					X
resiliency					X
resource				X	
resource-constrained schedule				X	
resource leveling				X	
resource-limited scheduling				X	
resource planning	X			X	
resource profile		X			
responsible procurement			X		
return on investment (ROI)					X
reverse auction	X				
reverse logistics	X				
rework			X	X	
risk management*	X				
risk pooling			X		
robust design				X	
root cause analysis	X			X	
rough-cut capacity planning (RCCP)	X				
routing	X			X	
running sum of forecast errors		X			
run time	X			X	
safety capacity		X	X		
safety lead time			X		
safety stock	X				
sales and operations planning (S&OP)	X				
sales plan	X				
sales promotion		X			
sample		X			
sampling distribution		X			
sawtooth diagram	X				
scatter chart	X			X	
scatterplot	X				
scheduled downtime				X	
scheduled load			X		
scheduled receipt	X				
scheduling	X				
scheduling rules				X	
scrap	X				
scrap factor				X	
seasonal index		X			

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
seasonal inventory	X				
seasonality	X				
second-order smoothing		X			
self-directed work team				X	
semifinished goods			X		
sensei	X				
service	X				
service function		X			
service industry	X				
service level agreement (SLA)					X
service parts	X				
setup	X				
setup costs				X	
setup time	X			X	
shelf life			X		
Shingo's seven wastes	X			X	
shipping manifest	X				
shitsuke				X	
shojinka				X	
shrinkage			X		
single-card kanban system				X	
single exponential smoothing		X			
single-level bill of material	X				
single-minute exchange of die (SMED)				X	
single-source supplier	X				
six sigma	X			X	
small group improvement activity				X	
SMART	X				
smoothing constant		X			
smoothing factor		X			
social responsibility					X
special cause				X	
specification				X	
specific identification			X		
split lot	X				
spread	X				
standard				X	
standard costs	X			X	
standard deviation		X	X		
standard time	X				
standardized work*				X	
start date	X				
statistical process control (SPC)	X			X	
statistical quality control (SQC)				X	
stockkeeping unit (SKU)	X				
stockout costs	X				

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
stockout percentage	X				
store	X				
strategic drivers					X
strategic performance measurements					X
strategic plan	X				
strategic planning		X			
strategic sourcing					X
subcontracting	X				
substitution		X			
summarized bill of material	X				
sunk cost					X
super bill of material		X			
supermarket approach			X		
supplier	X				
supplier certification	X				
supplier-input-process-output-customer (SIPOC) diagram				X	
supplier lead time	X				
supplier measurement			X		
supplier partnership	X				
supplier relationship management (SRM)	X				
supplier scheduling				X	
supply chain	X				
supply chain management	X				
surge capacity					X
sustainability	X				X
SWOT analysis					X
synchronized production				X	X
tactical plan(s)	X				
tactical planning		X			
Taguchi methodology				X	
takt time	X			X	
target inventory level			X		
tariff	X				
terminals	X				
terminal-handling costs	X				
terms and conditions	X				
theoretical capacity			X	X	
theory of constraints (TOC)	X			X	
theory of constraints accounting	X				
third-party logistics (3PL)	X		X		
throughput	X			X	
throughput time				X	
time-based competition (TBC)					X
time bucket	X				
time buffer	X				
time fence	X				

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
time-phased order point (TPOP)	X	X			
time series				X	
time series analysis		X			
time standard				X	
tolerance	X			X	
total cost curve	X				
total cost of ownership (TCO)	X				
total costs	X				
total factor productivity					X
total line-haul cost	X				
total productive maintenance (TPM)	X			X	
total quality control (TQC)				X	
total quality management (TQM)	X			X	
traceability	X	X			
tracking capacity strategy					X
tracking signal	X				
trading partner					X
traffic	X				
transaction channel	X				
transfer batch				X	
transfer pricing				X	
transient state			X		
transit inventory	X				
transit time	X				
transportation	X			X	
transportation inventory	X				
trend	X				
trend forecasting models		X			
truckload carriers	X				
two-bin inventory system	X				
two-card kanban system	X			X	
two-level master schedule		X			
U-lines	X				
uniform plant loading	X				
unit cost	X				
UN Global Compact Management Model	X				
United Nations Global Compact	X				
unitization	X				
unit load	X				
unit of measure	X				
unplanned repair			X		
upper control limit (UCL)				X	
upper specification limit (USL)				X	
upstream	X				
usage variance				X	
utilization	X			X	

CPIM Key Terminology

	BSCM	MPR	DSP	ECO	SMR
value added	X			X	
value analysis	X				
value chain					X
value chain analysis	X				
value perspective				X	
value stream	X			X	
value stream mapping	X				
variable cost	X			X	
variable costing					X
variance	X				
VATI Analysis	X				
velocity	X				
vendor-managed inventory (VMI)	X				
vertical dependency			X		
vertical integration					X
virtual cell					X
virtual organization					X
visual control				X	
visual management*				X	
visual review system	X				
voice of the customer (VOC)	X				X
wait time	X				
wall-to-wall inventory	X				
warehouse demand		X			
warehousing	X				
waste	X			X	
wave picking	X				
waybill	X				
ways	X				
weighted moving average		X			
what-if analysis	X				
where-used list	X				
work cell	X				
work center	X			X	
work in process (WIP)	X			X	
work order	X				
workplace organization				X	
yield	X			X	
zone	X				
zone picking	X				

Supplemental Glossary

The following key terms are not found in the *APICS Dictionary*, 14th edition, so definitions have been provided below.

Data governance—The overall management of the accessibility, usability, reliability, and security of data used to ensure data record accuracy.

Gemba walk—The word "Gemba" is a Japanese term meaning the place where value is created and the actual work is done, such as the shop floor in a manufacturing plant. The aim of Gemba walk is to provide a leader with the opportunity to observe floor activities as they happen and ask questions about them, thus becoming more aware of what is going on in the organization.

Global Trade Identification Number (GTIN)—GTINs uniquely identify all products and services that are sold, delivered and invoiced at any point in the supply chain. GTINS are typically found at point of sale and on cases and pallets of products in a distribution or warehouse environment.

Functional product— Goods that are widely available from a range of sources. Typically, they have stable design, low profit margins, steady and predictable demand and long life cycles.

Lean six sigma—A combined approach for process improvement and problem solving based on lean and six sigma methodologies.

Little's Law—Over the long term, inventory equals the process rate (i.e., cycle time) multiplied by the throughput.

Risk management—Risk management is a systematic approach to identifying, analyzing, and addressing an organization's exposure to uncertainty within the supply chain.

Standardized work—Standardized work identifies, defines and documents current best practices for achieving consistent results and forms the baseline for continuous improvement. The standardized work is presented using a combination of pictures and text, which are placed at each workstation where the activity or process is performed and employees are trained to do the tasks as defined in the Standard Work document.

Visual Management—The concept of making the current condition of a workplace obvious at a glance, and hence more effective, by providing real-time information on work status using a combination of visual signs. Examples of Visual Management include kanban cards, tool shadow boards, and storyboards.

Additional Resources for APICS CPIM Candidates

In addition to the cited references, it may be helpful for you to pursue chapter-sponsored courses, college courses, APICS workshops, self-study courses, or courses offered by the APICS network of Authorized Education Providers (AEPs) as a means of learning the body of knowledge that is tested in the certification program. A wide variety of courses are available. As with any investment, you should research various courses before choosing one.

For courses, visit the Partner and Event Finder on the APICS website at **apics.org/finder** or call APICS Customer Service at 1-800-444-2742 (United States and Canada) or +1-773-867-1777.

APICS CPIM Instructor-Led Review Courses

Available for each module of the APICS CPIM program, APICS CPIM review courses are designed for classroom review of the key principles and concepts for each content area. This ECM is used as the basis for the content in the CPIM review courses. It is important to understand that CPIM review courses are intended to assist the candidate in reviewing the body of knowledge and are not necessarily education. There will likely be some content in APICS review courses not covered by the exams. Course developers and/or instructors may believe that additional material needs to

be taught or included in the glossary to ensure understanding of the body of knowledge that can be tested. They also may decide that a concept or term is adequately covered by the definitions in the *APICS Dictionary* or the CPIM ECM Glossary and not cover it in the course. These differences sometime lead candidates to perceive a potential disconnect between the courseware and the exam, when in fact they are both covering the same body of knowledge.

APICS CPIM review courses do not "teach the test" and, in many areas, they review but do not teach concepts. All APICS review courses provide a thorough review of the subject matter, but none should be used without the most current CPIM ECM as a means to direct the candidate's study.

Note: The Review Course Participant Workbook is not a stand-alone reference or comprehensive single source and should be used only by a participant attending an instructor-led review course.

For courses, visit the Partner and Event Finder on the APICS website at apics.org/finder or call APICS Customer Service at 1-800-444-2742 (United States and Canada) or +1-773-867-1777.

Independent Study Courses

APICS correspondence courses offer professionals a unique home-study alternative to the classroom. Correspondence courses are designed and conducted for APICS by the MGI Management Institute. For more information on course availability, contact APICS Customer Service at 1-800-444-2742 (United States and Canada), or +1-773-867-1777.

APICS Educational Programs

APICS offers a variety of educational programs, including workshops in supply chain and operations management and an annual international conference and exposition. For a complete list of APICS learning opportunities and information on course availability, call APICS Customer Service at 1-800-444-2742 (United States and Canada), or +1-773-867-1777.

APICS Online Study Tools

The new APICS CPIM Study Tools are an online resource for APICS CPIM students to complement self-study or instructor-led courses. APICS CPIM Study Tools can be accessed at apics.org. For more information, please contact APICS Customer Service at 1-800-444-2742 (United States and Canada), or +1-773-867-1777.

CPIM Exam Simulator

The CPIM Exam Simulator is designed to increase candidates' learning potential and assist in preparation for the CPIM exams. With over 300 online practice questions for each module, candidates can study with self-paced, timed and final exam simulations. For more information please contact APICS Customer Service at 1-800-444-2742 (United States and Canada), or +1-773-867-1777.

APICS Certified Fellow in Production and Inventory Management (CFPIM)

The distinguishing characteristic of a Certified Fellow in Production and Inventory Management (CFPIM) is the willingness to share acquired knowledge with others through presenting, teaching, publishing, and participating in APICS educational activities. This knowledge sharing must take place above and beyond a candidate's normal job duties and be directly related to the APICS CPIM body of knowledge.

To obtain the APICS CFPIM designation, an application form must be filled out and submitted to the APICS corporate office. Points are awarded based on the following criteria: APICS CPIM exams passed, presentations, high scores on APICS CPIM exams (320 or greater), published works, classroom teaching, and various volunteer or practitioner activities. To apply for the CFPIM Certification visit apics.org/cfpim.

APICS CPIM Certification Maintenance: Continuing Professional Development

The Importance of Certification Maintenance

The growing number of individuals choosing to pursue professional development through the APICS CPIM program indicates a strong awareness that continuing education and skills development are essential to meeting the information and technological challenges in today's rapidly evolving workplace and global marketplace. Professional development opens doors to individual career opportunities and organizational success.

Although APICS CPIM recognition and maintenance are voluntary programs, they equally demonstrate one's commitment to achieving the highest level of professional development and standards of excellence.

Both the APICS CPIM certification and APICS CPIM certification maintenance programs demonstrate one's commitment to achieving the highest level of professional development and standards of excellence.

The APICS CPIM certification maintenance program upholds both the objectives of the APICS CPIM program and the APICS vision to promote lifelong learning. This flexible program recognizes that individuals are at various levels in their careers, come from many industries, have different educational needs and career goals, and have varying degrees of access to continuing education. Thus, requirements for maintaining certification can be met through multiple sources and a variety of professional development activities intended to help prepare for the challenges ahead and maintain a professional edge by:

- preserving the currency of hard-earned certification credentials
- expanding your knowledge of the latest industry practices
- exploring new technology solutions
- reinforcing skills
- improving job performance
- demonstrating commitment to excellence
- increasing competitive advantage

To promote professional growth and lifelong learning, APICS CPIM and CFPIM designees must complete the certification maintenance program every five years. Complete details on how to maintain your designation will be mailed to candidates upon successful completion of the certification requirements.

APICS Code of Ethics

When you start an examination, you will be asked to pledge to abide by the APICS Code of Ethics. Once certified, you pledge to continue your education to increase your contribution to the supply chain and operations management profession. After achieving the fellow level of certification (CFPIM), you pledge also to share your APICS CPIM knowledge with others by participating in APICS research and educational activities at local, district, national, and international levels.

The APICS Code of Ethics is as follows:

- Maintain exemplary standards of professional conduct.
- Not misrepresent your qualifications, experience, or education to APICS or others you serve in a professional capacity.
- Respect and not violate the United States Copyright of all APICS materials, including but not limited to courseware, magazine articles and other APICS publications, APICS conference presentations, and CPIM, CSCP and SCOR-P examination resources. In this same spirit, you must not violate the copyright of other organizations and individuals in your professional capacity.
- Not engage in or sanction any exploitation of one's membership, company, or profession.
- Encourage and cooperate in the interchange of knowledge and

techniques for the mutual benefit of the profession.

- In your professional capacity, respect the fundamental rights and dignity of all individuals. You must demonstrate sensitivity to cultural, individual, and role differences, including those due to age, gender, race, ethnicity, national origin, religion, sexual orientation, disability, language, and socio-economic status.
- In your professional capacity, not engage in behavior that is harassing or demeaning to others based on factors including, but not limited to, age, gender, race, ethnicity, national origin, religion, sexual orientation, disability, language, or socio-economic status.
- Adhere to this Code of Conduct and its application to your professional work. Lack of awareness or misunderstanding of an ethical standard is not itself a defense to a charge of unethical conduct.
- Contact the Ethics Committee when uncertain whether a particular situation or course of action violates the Code of Conduct.
- Not become the subject of public disrepute, contempt, or scandal that affects your image or goodwill.

Failure to abide by APICS Code of Ethics policy may result in sanctions up to and including decertification.

Master Planning of Resources

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Scope of the Subject Matter

Please read the introductory material in this manual for essential information pertaining to the examination.

The subject matter of Master Planning of Resources includes demand management, sales and operations planning, master scheduling, and distribution planning.

Demand management is the function of recognizing and influencing all demands for goods and services to support the marketplace. It includes forecasting, order servicing, demand shaping, and customer relationship management.

Sales and operations planning is a process that brings together all plans for the business, including operations, sales, sourcing, marketing, product development, and finance. The result is an integrated set of plans for each product family.

Master scheduling is the process of disaggregating the production plan into an executable schedule that links shipment of customer orders to materials management. Distribution planning is the process of planning the distribution network and replenishment in the distribution environment. In each of these areas, collaboration within the organization and with direct customers and suppliers is addressed.

The successful candidate will understand and be able to apply the principles of demand management, sales and operations planning, master scheduling, and distribution planning, and to identify conditions that require action. The candidate must be able to apply the concepts and techniques in the content outline, as well as analyze situations to determine which approaches are applicable. Specific techniques required include:

- creating and evaluating a quantitative forecast
- calculating performance measurements relating to customer service policy
- preparing month-end reports and responding appropriately
- calculating a production plan and master schedule
- creating a distribution plan

Master Planning of Resources Content

The following table identifies the four main topics of the exam. The relative importance of these topics varies among industries, but the figures show the percentage designated for each section of the exam.

Diagnostic part	Main topic	Percentage of exam
I	Demand Management	25%
II	Sales and Operations Planning	25%
III	Master Scheduling	25%
IV	Distribution Planning	25%

Content Outline

I. Demand Management

This section covers the interrelationship of strategic and business planning with the management of demand. The aspects of demand management addressed in this section are forecasting and managing the customer interface. This subject matter includes elements related to the following areas:

A. *General Concepts and Purposes*: Successful planning requires an understanding of how components, concepts, and linkages of the strategic plan, the business plan, and the master planning of resources interact. Knowledge in this area includes:

1. The planning hierarchy
2. Relating the planning process to manufacturing and service environments

B. *Forecasting Demand*: Effective demand forecasting requires an understanding of the uses of a forecast, methods of forecasting, fitting a forecast to the situation, and tracking its performance over time. Knowledge in this area includes:

1. Demand forecasting concepts
2. The relationship between the purpose of the forecast and required timeliness, and accuracy of the data
3. Management considerations related to forecast method selection
4. How to select a time horizon and interval, and a level of aggregation
5. The application of basic qualitative and quantitative techniques
6. Evaluation of forecasting performance
7. Collaboration with customers and suppliers to improve forecast accuracy

C. *Management of the Customer Interface*: Effective management of the customer interface requires an understanding of how to make realistic order delivery promises and maintain positive customer relationships. Knowledge in this area includes:

1. Customer relationship management concepts
2. How to set customer service policies, safety stock, and performance targets
3. How to maintain effective customer communications
4. Techniques for measuring order delivery performance
5. Influence demand to better align with supply

References: 1; 2; 3 (chapters 3–4)

II. Sales and Operations Planning (S&OP)

This section covers the processes, concepts, and techniques used to link strategic goals to operations and coordinate the various planning efforts of the functional areas, including operations, sales, sourcing, product development, marketing, and finance in a variety of business environments. This subject matter includes elements related to the following areas:

A. *General Concepts and Purpose*: S&OP coordinates the various business functions to ensure they support the overall organizational strategy and enhance customer service. At the center of the process are two fundamental issues. First, what is the best way to balance supply and demand? Second, what is the appropriate production volume and mix between product families? The answers depend heavily on the specific type of business environment. Knowledge in this area includes:

1. The role of S&OP in the planning and control hierarchy

2. The key linkages to the S&OP process

3. The different methods for balancing supply and demand

4. The trade-offs related to different volume/mix combinations

5. How to carry out the S&OP process in different business environments including manufacturing and services

B. *Management Considerations*: S&OP is the process executive management uses to control and guide the business. It integrates the multiple plans developed within a business and provides direction for more detailed short-term to medium-term planning. Knowledge in this area includes:

1. How to evaluate alternative plans and associated risks

2. How to assess the financial implications of the plan

3. How to identify stakeholders and their responsibilities in the process

4. How to identify the planning horizon and the appropriate aggregation level

5. The trade-offs between customer service levels and the inventory or backlog levels

C. *S&OP Process*: There are several steps involved in the process of establishing a sales and operations plan. Effective S&OP requires proper execution of each of these steps. Knowledge in this area includes:

1. The various levels of management involved and their roles

2. The sequential steps of the S&OP process and their interactions

3. The various inputs and outputs of each of the S&OP steps

4. The performance measures of the S&OP process

D. *Developing and Validating the Production Plan*: A key output of S&OP is the production plan. Effective S&OP requires an understanding of this key planning document. Knowledge in this area includes:

1. How to develop and validate a production plan in a variety of production environments

2. How to carry out resource planning

3. How to assess the desirability of alternative production plans

References: 1; 2; 3 (chapters 5, 10)

III. Master Scheduling

This section covers the processes of translating higher-level aggregate plans into feasible schedules that operations and suppliers can execute. This subject matter includes elements related to the following areas:

A. *General Concepts and Purpose*: The master scheduling process disaggregates the production plan into an executable schedule that links shipment of customer orders to material management. Knowledge in this area includes:

1. The role of master scheduling in the planning and control hierarchy

2. The linkages with other planning processes within the planning and control hierarchy

3. The relationships between master scheduling, capacity management, and materials management

B. *Linking the Master Scheduling Process to the Business Environment*: The mechanics of master scheduling vary according to the business environment. In every environment, it is necessary to link the master scheduling process with the production plan and the S&OP process. Knowledge in this area includes:

1. How to carry out the master scheduling process in different business environments including manufacturing and services

2. The relationship between the manufacturing environment and product structure

3. How to determine the level in the bill of material where the master schedule should be developed

C. *Master Scheduler Roles and Responsibilities*: The role of the master scheduler is to implement the production plan as agreed upon during the S&OP process. It is the responsibility of the master scheduler to develop a master schedule that promotes operational stability and good customer service while maintaining realistic priorities. Knowledge in this area includes:

1. How to plan and coordinate changes in inventory levels, backlog, capacity, major customer orders, time fences, product and process designs, and suppliers

2. How to maintain the integrity of the master schedule

3. How to deal with the consequences of an unrealistic master schedule

4. Measuring performance against the master schedule

D. *Master Scheduling Process*: The process of developing a master schedule involves numerous decisions related to the mechanics and the selection of techniques and tools. Effective master scheduling requires significant insights into each of these choices. Knowledge in this area includes:

1. How to identify and quantify sources of demand to be considered in the master scheduling process

2. The mechanics of creating, maintaining, and using the master schedule

3. Reviewing capacity requirements and the role of rough-cut capacity planning

4. Developing and using a final assembly schedule

5. Measuring performance of the master scheduling process

E. *Advanced Planning and Scheduling (APS)*: APS systems employ advanced computer capabilities and algorithms to perform many of the functions related to master planning of resources in real time. Knowledge in this area includes:

1. Major components of an APS system

2. Impact of APS techniques on master production schedules

3. APS techniques based on simulation, optimization, or constraints management approaches

References: 1; 2; 3 (chapters 7, 10)

IV. Distribution Planning

This section covers the planning of distribution networks and replenishments in the distribution environment. It also covers concepts and techniques used to plan the location of distribution centers, the transportation logistics between supply sources and outlying locations, and the replenishment of these locations in a variety of business environments. This subject matter includes elements related to the following areas:

A. *Distribution Network Planning*: The methods and elements for logistics planning to establish the supply channel locations and transportation schemes. Knowledge in this area includes:

1. Various distribution strategies and network configurations

2. Transportation planning, controlling and scheduling activities

3. Inventory levels and locations required within the distribution channel

4. Risk management and sustainability considerations

B. *Distribution Requirements Planning*: Knowledge in this area includes:

1. Techniques for developing a distribution location-specific product forecast

2. Techniques for developing the replenishment planning parameters for each stockkeeping unit within the distribution network

3. Methods and techniques of time-phased planning logic inherent in distribution requirements planning

4. Methodologies for linking distribution requirements planning to the S&OP and master scheduling processes

5. Support specific marketing efforts and manage supply shortages

C. *Other Distribution Replenishment Methods:* Approaches to replenishing distribution network inventories and where each is appropriate. Knowledge in this area includes:

1. Pull systems

2. Push systems

D. *Measuring Distribution Performance*: Various approaches and techniques are used to evaluate performance of the distribution network and planning process. Knowledge in this area includes:

1. Data collection methods for effective feedback

2. Key distribution performance indicators

3. Feedback on distribution network design decisions, distribution planning process improvements, and execution of the plan

References: 1; 2; 3 (chapters 14–16); 4 (chapters 6-14)

Key Terminology

An understanding of the list of terms on pages 9–29 of this document is strongly recommended. The list is intended to be thorough but not exhaustive. The candidate is also expected to be familiar with the definitions of terms identified in the content outline. Definitions of these terms can be found in the *APICS Dictionary*, 14th edition.

Bibliography

All test candidates should familiarize themselves with the following references for this examination. The recommended references pertaining to the diagnostic areas are listed at the end of each section of the content outline. Please see page 8 in the introduction to this manual for a list of past references that can also be used for study. Also, candidates who have not yet passed the suggested first module—Basics of Supply Chain Management—should familiarize themselves with the basic concepts of materials management presented in this exam content manual. All of these references are available at **apics.org/shopapics**.

References

1. APICS CPIM Master Planning of Resources Reprints, 2010.
2. *APICS Dictionary*, 14th ed., 2013.
3. Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, Manufacturing Planning and Control for Supply Chain Management, APICS/CPIM Certification Edition, McGraw-Hill, 2011.
4. Ross, David F., Distribution Planning and Control, 2nd ed. Springer, 2004.

*Internet links cited in the bibliographic references above can be found at **http://www.apics.org/careers-education-professional-development/certification/cpim/primary-references**.

Sample Questions

The following ten questions are similar in format and content to the questions on the exam. These questions are intended for practice—that is, to enable you to become familiar with the way the questions are asked. The degree of success you have in answering these questions is not related to your potential for success on the actual exam, and should not be interpreted as such.

Read each question, select an answer, and check your response with the explanation on pages 41-42.

1. The forecast interval would typically be longest for forecasts used as input to which of the following processes?

   (A) Business planning
   (B) Final assembly scheduling
   (C) Sales and operations planning (S&OP)
   (D) Master scheduling

2. Normal uses of a master schedule include which of the following?

   I. To provide a means of planning future production
   II. To drive rough-cut capacity planning
   III. To establish the production plan

   (A) I only
   (B) I and II only
   (C) II and III only
   (D) I, II, and III

3. Producing exactly to demand should result in

   (A) minimum change in inventory
   (B) least total cost
   (C) minimum capacity requirements
   (D) maximum machine utilization

Use the information below to answer questions 4 and 5.

Lead time: 2	Lot size: 30
Demand time fence: 3	On hand: 15
Planning time fence: 7	Safety stock: 6

Period	1	2	3	4	5
Forecast	10	22	20	24	28
Customer orders	5	26	15	6	30
Projected available balance					
Available-to-promise					
Master production schedule					

4. For the master schedule, what is the available-to-promise for Period 4 if the discrete method is used?

   (A) 22
   (B) 24
   (C) 35
   (D) 37

5. Using the same table, what is the projected available balance for Period 5?

   (A) 30
   (B) 35
   (C) 5
   (D) 7

6. In a distribution environment, which of the following will occur if the planner fails to address exception messages during the planning cycles?

   (A) Planned orders are not converted on time
   (B) Replenishment lead times are incorrect
   (C) The statistical order point is increased
   (D) The planning horizon is too short

7. Which of the following would be the most appropriate smoothing constant for a fashion clothing item?

   (A) 0.10
   (B) 0.20
   (C) 0.50
   (D) 1.00

8. Which of the following is an output of the distribution requirements planning process?

   (A) Product forecast
   (B) Statistical order point
   (C) Planned orders
   (D) Safety stock by product

9. The focus of the sales and operations planning (S&OP) process is to balance customer demand and:

   (A) Inventory investment
   (B) Capacity utilization
   (C) Supply plans
   (D) Master scheduling

10. The production plan is performed at which level?

    (A) Product family
    (B) Work center
    (C) End-item level
    (D) Product option level

Answers to Sample Questions

Note: *References to the content outline appear in parentheses.*

Master Planning of Resources

1. A IB4) Business planning is performed at the highest level of aggregation and over the longest horizon and would typically be done for fiscal quarters or years. The other processes would have shorter horizons and intervals. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 4.)

2. B (IIIB) The master schedule is a plan of future production and drives the rough-cut capacity plan. The production plan is used as a basis for preparing the master schedule, rather than the master schedule being used as a basis for the production plan. Answer A is incorrect because it excludes option II, which is a valid normal use of the master schedule. Answers C and D are individually incorrect because they include option III, which is not a valid normal use of the master schedule. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 7.)

3. A (IID) In a chase strategy, production output is changed to "chase" or equal sales demand, which results in minimal changes in inventory levels. The opposite is a level policy, in which production is at a constant rate of output with inventory buildups and depletions. Answer B is incorrect because changing production output to chase demand results in costs of changing the workforce level, overtime, and subcontracting in addition to maintaining plant capacity to meet maximum demand. Answers C and D are incorrect because producing exactly to demand will maximize capacity requirements as capacity will be required to meet the highest demand level, yet this capacity (including machine time) will go unused when the demand is low, resulting in low utilization of capacity. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management* APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 5.)

4. B (IIID) Available-to-promise for Period 4 is the master production schedule (MPS) of 30 for that period, less the customer orders of 6 for that period. Because another MPS of 30 will occur in Period 5, demand for that period is not considered by the available-to-promise for Period 4. Based on the explanation for the calculation for discrete available to promise, Answers A, C, and D are incorrect. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 7.)

5. B (IIID) The projected available balance for Period 5 uses the greater of customer orders or forecast since it is after the demand time fence. The prior period projected available balance of 35, plus the MPS of 30, less the orders of 30, results in a projected available balance of 35 for Period 5. Based on the explanation for the calculation for projected available balance, answers A, C, and D are incorrect. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 7.)

Lead time: 2	Lot size: 30
Demand time fence: 3	On hand: 15
Planning time fence: 7	Safety stock: 6

Period	1	2	3	4	5
Forecast	10	22	20	24	28
Customer orders	5	26	15	6	30
Projected available balance	10	14	29	35	35
Available-to-promise	10	4	15	24	0
Master production schedule	0	30	30	30	30

6. A (IVB) Answers B, C, and D refer to system parameters that exception messages would not address. Answer (A) is a condition and exception messages address conditions. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 14.)

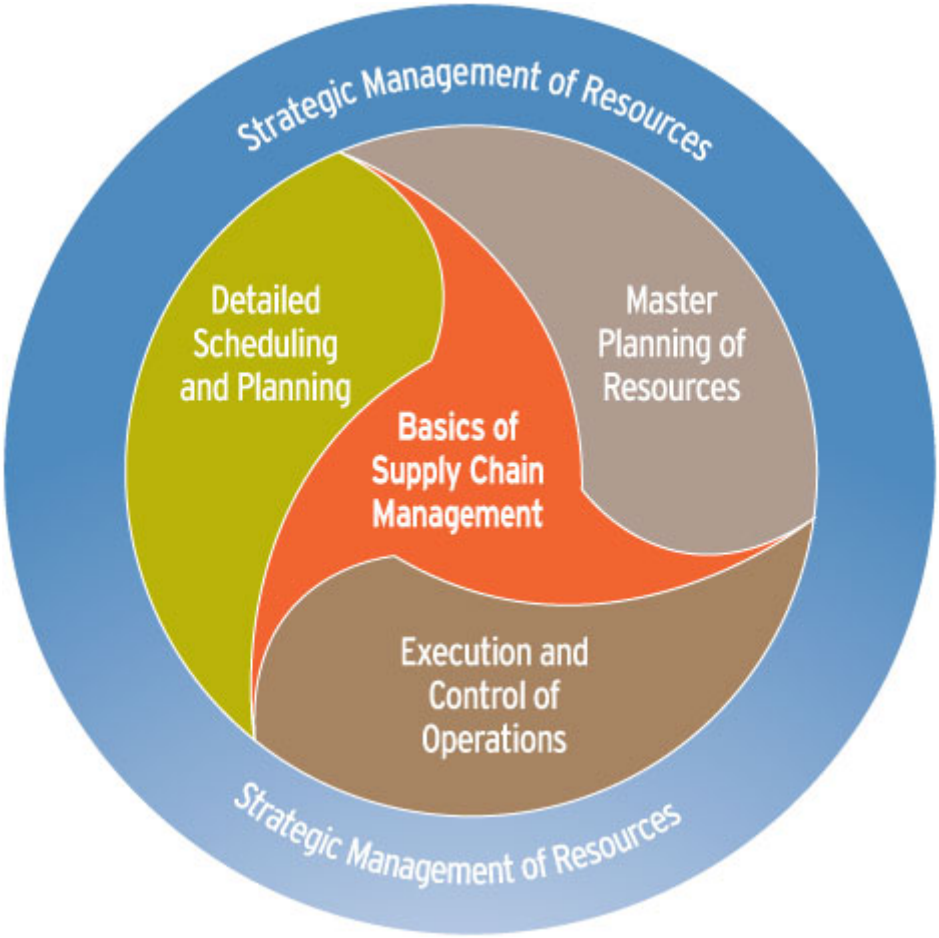
7. C (IB5) Theoretically, the valid range for the smoothing constant is 0.0 to 1.0. The higher the smoothing constant, the more responsive the forecast is to the latest demand. Therefore, the highest smoothing constant within the valid range is most appropriate in this situation. (See *APICS Dictionary*, 14th edition, 2013)

8. C (IVB) Answers A, B, and D are parameters, not outputs. C is an output. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS CPIM Certification Edition, McGraw-Hill, 2011, chapter 14.)

9. C (IIA1) S&OP is the process that executive management uses to control and guide the business. The demand and production plans are developed and significant differences are reconciled in the process. Production is one of the sources of supply. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 5.)

10. A (IIC) The production plan, also referred to as the operations plan, is an output of the S&OP process and specifies the overall manufacturing output level (volume) to be produced—usually as a monthly rate for each product family. Planning at the work center level is done as part of shop floor scheduling and control, which is a more detailed level of planning than production planning. Planning at the end-item and product option levels is done as part of master production scheduling. (See Jacobs, F.R., W.L. Berry, D.C. Whybark, and T.E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition, McGraw-Hill, 2011, chapter 5.)

About This Guide



Instructor Guide

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CPIM

Certified in Production and Inventory Management

Master Planning of Resources

Version 4.5 – January 2016

Certification Review Course

Instructor Guide

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APICS

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Module Description

In *Master Planning of Resources*, participants explore processes used to develop production plans; identify and assess internal and external demand and forecasting requirements; and effect an achievable master production schedule consistent with business policies, objectives, and resource constraints. The course focuses on developing and validating a plan of supply, relating management of demand to environment, and developing and validating the master production schedule.

In addition, the course encompasses concepts for transforming sales, marketing, and business requirements into a feasible and economic production plan in various business environments. It also addresses concepts and methodologies for managing projected and actual demands from distribution networks and external customers. Finally, the course presents methods for integrating production plans, forecasts, and customer demand into a specific master production schedule.

Exam Content Manual

The APICS CPIM Exam Content Manual (ECM) is an important document that all exam candidates should study and review in preparation for each CPIM exam. Therefore, we are providing the appropriate ECM in every Participant Workbook. The objective of this manual is to outline the APICS CPIM body of knowledge that the APICS Certification Exam Committee has defined for each CPIM exam.

The recommended procedure for mastering the subject matter covered in each certification exam is to review the content outline, which defines the material, and then to study each topic, using the references. At the end of each major section is a list of the references that apply to the topics in that section. The first number indicates the sequence number for the reference in the Bibliography section, and the numbers in parentheses indicate the chapter(s) within that reference. These outlines form the content and structure for the certification examinations. As such, having the most current exam content manual is essential as it is revised annually.

The Participant's workbook has been developed based on the exam content outline and the references listed. Using the exam content manual in conjunction with a CPIM class and this Participant Workbook will help better prepare candidates for the CPIM certification exams.

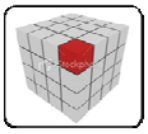
Candidates should understand the definitions of the key terms in the ECM, why and how to apply them, and which ones to select for different situations. The CPIM courseware covers many, but not all, of the key terms in the ECM. Therefore, candidates should supplement their learning by studying the ECM key term list using the *APICS Dictionary* or other ECM references as a guide.

Class Problems and Activities

Throughout the course, there are class demonstrations (in which instructors can introduce/explain concepts), as well as activities for participants. These activities are designed to review, enhance, and deepen the participants' knowledge. The activities may be performed individually, in pairs, or in small groups as indicated.

Several symbols associated with activities/problems and solutions are used throughout the course:

This cube with the question mark in the corner indicates an activity, class problem, or optional homework problem.



This cube with the solid corner indicates a solution to a problem.

This symbol on a slide indicates that the solution is filled in sequentially using the build feature of PowerPoint. Simply advance as you would to move through the visuals and the slide will sequentially build. Build slides offer you a way to explain the solution one part at a time, and to fill in a partial solution and then ask for participant input before completing the solution. If you prefer to modify the sequence of the build slides, use the custom animation feature in PowerPoint.

This symbol indicates learning objectives. The learning objectives have been designed to be measurable, to give participants a guide to what knowledge they will have after taking the course, and to serve as review topics for the instructor at the end of each class.

* An asterisk beside a visual indicates that the visual does NOT appear in the participant workbook. These are typically seen beside solution visuals reserved for the instructor.

Instructor Preparation

Instructors should expect to spend an average of two to four hours of preparation for each hour of instruction. They should also read the current Exam Content Manual section on MPR and be familiar with the references for MPR. As a review course for exam preparation, it is important to provide an objective presentation of the material, without bias. It is always an excellent idea to provide practical examples of the concepts being taught.

The instructor community is available for communicating with and asking questions of fellow instructors. To be added to this community, please email your request to pdadmin@apics.org.

APICS requires Instructor Development Program (IDP) participation for instructors who teach CPIM courses on behalf of APICS Partners. For additional information, please contact IDPapps@apics.org.

All instructors are also encouraged to attend an APICS sponsored Train-the-Trainer program to enhance their instructor skills. Check with your local APICS partner for more information.

Instructor Materials

Instructors will need:

- A copy of the complete eight-session instructor guide
- The CD-ROM of PowerPoint visuals for each session

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Equipment Needed

- Projector and screen
- Two flipcharts with stands, paper, and markers (recommended)
- Whiteboard and markers (recommended)

Guide and Workbook Formats

This instructor guide contains all eight sessions of the MPR course.

The left-hand instructor pages, or even-numbered pages, in this guide contain images of the visuals to accompany the lecture, notes to shape the content of the lecture, and questions to pose to participants to stimulate discussion. In the participant workbook these left-hand pages contain only the visuals and space to take notes.

The participant pages, or odd-numbered pages, contain the content of the course. These right-hand pages are the same in the instructor guide and participant workbook. This facing-page layout allows an instructor to see what the participants are referencing.

Icons are used throughout the instructor text to give visual cues and draw attention. A list of the icons and their uses appears below.

Instructor Guide Icons and Cues

The following is a list of icons and cues that will indicate upcoming tasks.


Ask: Identifies a question to ask the class


Discuss: Identifies a topic for class discussion


Explain: Indicates that a topic may require further explanation


Flipchart: Identifies an activity for which it may be helpful to write information on a flipchart

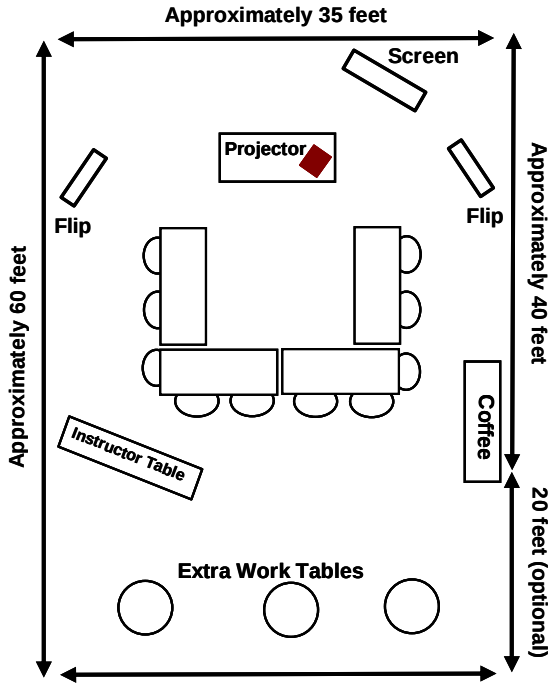

Note: Indicates an item to which special attention should be paid


Time: Indicates how much time to spend on a certain activity

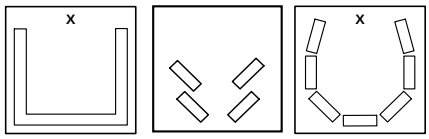

CPIM Study Tools: Indicates that these instructor materials (solution slides and performance check answers) are available to students online in the CPIM Study Tools.

Suggested Training Room Layout

The suggested training room layout shown below is conducive to learning as it promotes interaction among the learners as well as between the learners and the instructor. Ideally, the room should accommodate additional work tables for breakout exercises at the back. However, this is not necessary.



Or, use one of the layouts shown on the right to encourage participation by the class and to involve all learners.



Try to avoid the traditional layout shown to the right when instructing. You will see that it fills from the back as people try to avoid active participation in the class. The focus is on the instructor and not on the learner.

Move around the room during class sessions—especially if you are restricted to using a traditional room layout. This will encourage every participant to take a more active role in the learning environment. When a session ends, put the room back in proper order before leaving.

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Visual Aids (Slides)

Visual aids in the form of PowerPoint slides are included and designed to help explain information or to provide visual cues for recalling and understanding information. The course CD contains all the files you need to present the visuals.

If you do not have access to a full version of PowerPoint, a PowerPoint viewer file can be downloaded from Microsoft.

To Move through the Slides

- Click the mouse button to advance from slide to slide.
  - You can also use the arrow keys, spacebar, and the Page Up and Page Down keys to move through the slides.
  - To jump to a specific slide in the presentation, type the slide number, and then press <enter>.

To Draw Freehand on a Slide

- Click the Freeform tool on the bottom left or right corner of the slide (it resembles a pencil).
- Place the crosshair pointer where you want to begin drawing.
- Hold down the mouse button while drawing. A drawing pencil will appear.
- Move the mouse to draw shapes on the slides.
- To end drawing, press the Escape key on the keyboard.
- Alternatives to the Freeform tool on slides that the instructor must fill in include the following:
  - Use traditional overhead transparencies and a second projector for visuals where spaces must be filled in
  - Some projectors allow the user to place a blank transparency over the LCD panel. The instructor can then write on the blank transparency

To End the PowerPoint Slide Show

- Press the Escape key

Equipment

Arrive at least 45 minutes to one hour early for each session to set up and test the equipment—projector, flipchart, whiteboard, etc. Test the equipment; walk to the back of the room to test for focus, clarity, and sight lines. Learn how to dim the lights if necessary.

Blackboards and Whiteboards

Blackboards are one of the oldest visual aids and can be very effective. Whiteboards can be used in much the same way. Use them to work through class problems and for illustration. Be brave! Draw stick people and trucks, etc., to make your point. This can give good memory clues to learners, pace the presentation, and enliven the class at your artistic expense.

Flipcharts

Flipcharts can be used for working problems and will be used in the final review activity. You can also post questions to a flip chart to come back to later. The information on flipcharts is permanent and can be retrieved for later use. They are also great to post around the room during the workshop. Flipcharts require special markers. Whiteboard markers will work, but tend to dry out quickly.

Performance Checks

There is much material to be covered in each session. The performance checks were created to give you an opportunity to assess the participants' learning. The performance checks may be used as evaluation tools or homework assignments. An option is to send them to the participants as a pre-course assignment to assess their knowledge before the course starts. If you are using the performance checks for evaluation or homework assignments, make sure you have a policy and that the participants understand it. The participants are adults with other responsibilities, so you should try to have a flexible policy.

Please note that a progress check answer sheet for the participants' use in recording the correct answers to the performance check questions can be found in the Appendix.

Class Participation

Tell the participants that everyone has a contribution to make, and everyone should participate in class discussions and problem solving.

Icebreaker

Before the first session, have the participants introduce themselves, identify their employer, state their job title/functions, and what they hope to get out of the class.

APICS CPIM Study Tools

In addition to your printed APICS CPIM instructor guide, APICS has developed the APICS CPIM Study Tools—an online learning environment to help your students master the core concepts within the APICS CPIM module and to help you manage your students' progress. This online tool contains presentation slides and assessments to complement your students' APICS CPIM learning experience.

To access APICS CPIM Study Tools, you will need an APICS ID.

- If you currently do not have an APICS ID, simply go to apics.org/newuser to create one.
- If you are a member of the APICS Instructor Development Program (IDP), simply log in to apics.org using your APICS ID.
- If you are not already a member of the APICS IDP, email idpapps@apics.org and inform them that you are an instructor who has purchased an APICS CPIM instructor guide with the intention of teaching an APICS CPIM course. The APICS Professional Development team will help get you set up so that you can access the APICS CPIM Study Tools.

Full instructions on accessing APICS CPIM Study Tools are available online at apics.org/cpimstudytools.

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Manufacturing Planning Hierarchy

It is important at this point to review the manufacturing planning hierarchy of which MPR is a major component. The hierarchical relationship of the business processes involved in manufacturing planning is shown in the visual.

Strategic and Business Planning: Direction Setting

These two processes overlap and are closely linked in direction setting for an organization. A formal distinction between the two is not always observable.

- Strategic planning—This strategic portion of direction setting addresses long-term objectives relating to products, customers, and markets.
- Business planning—This planning activity also is long-term in focus and much of it is denominated in monetary terms. It is the bridge from strategic planning to tactical or cross-functional planning at the MPR level discussed below.

Manufacturing Planning and Control: Tactical and Operations Planning

MPC processes operate within the direction-setting framework of strategic and business planning. MPC consists of short-, intermediate-, and long-term planning activities.

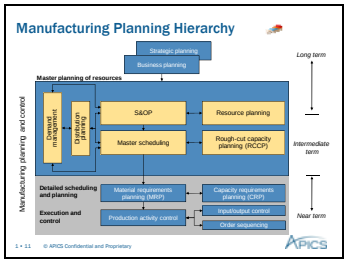
Master planning of resources (intermediate to long-term)

MPR consists of cross-functional tactical plans that are implemented by operational planning activities discussed below under detailed scheduling and planning (DSP) and execution and control of operations (ECO).

- S&OP and resource planning—S&OP is responsible for
  - processing inputs from the business plan, demand forecasts, production resource planning, and logistics resource requirements planning, which is part of distribution planning
  - translating these inputs into intermediate- to long-term sales, production, and distribution plans at the aggregate volume or product family level
  - validating plans against required production and distribution resources.
- Master scheduling and rough-cut capacity planning (RCCP)—This process is responsible, in the intermediate term, for
  - processing inputs on product volumes from production plans at the family level, forecasts and customer orders on hand, RCCP, and logistics requirements planning that is part of distribution planning
  - disaggregating product family volume data from the production plan into a master production schedule (MPS) for individual end items
  - validating the MPS against required production and distribution resources.
- Demand management—In MPC, this process
  - recognizes demand for products and services through forecasts, customer order management or order servicing by sales, marketing, and customer service, and CRM
  - provides inputs on demand for goods at the product family level to S&OP and at the end-item level for master scheduling.

Note: "Logistics resource requirements planning" is referenced in Ross, *Distribution Planning and Control*, 2nd ed., chap. 5.

Master planning of resources (cont.)



Visual 1-11

Continue to display Visual 1-11.

Further discuss MPR in the MPC hierarchy.

One point to keep in mind, continued from the previous instructor guide page:

- Distribution planning provides inventory and logistics planning input to both S&OP and master scheduling in manufacturing environments that fulfill orders from finished goods inventory.

DSP and ECO (near-term)

- DSP includes material and capacity requirements planning (CRP).
- ECO includes production activity control and reporting activities.

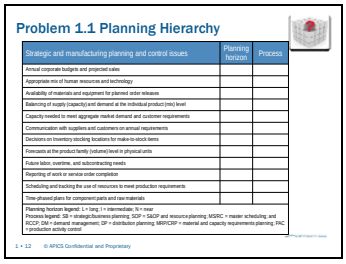
Master planning of resources (cont.)

- Distribution planning—This process provides two types of support to S&OP and master scheduling in the long and intermediate terms:
  - planning of inventory levels at distributed stocking points at the product family and end item levels based on local demand forecasts, customer orders, and disaggregated demand data from the central supply point
  - providing inputs on distribution resources necessary to support the S&OP and MPS through a subprocess called logistics resource requirements planning

DSP and ECO (near-term)

- Material requirements planning (MRP) and capacity requirements planning (CRP)—These processes with a near-term planning horizon also are known as *DSP*.
  - Their objective is to determine the material, labor, and equipment capacity required to support the MPS for individual end items.
  - They determine the following:
    - end item and component quantities needed to make or buy to fulfill the MPS
    - when these items and quantities will be needed
    - how many now are in stock
    - which are on order
    - the sufficiency of workers and equipment
- Production activity control—Also known as *ECO*, this process has the following objectives:
  - prioritizing and sequencing work to be performed
  - executing plans, implementing factory floor controls, and reporting activity results
  - performance reporting and feedback so that preceding MPC processes can make necessary adjustments for shortages or overages in the production process

Class Problem 1.1: MPC Business Processes and Planning Horizons


Problem 1.1 Planning Hierarchy

Strategic and manufacturing planning and control issues	Planning horizon	Process
Annual corporate budgets and projected sales		
Appropriate mix of human resources and technology		
Availability of materials and equipment for planned order releases		
Balancing of supply (capacity) and demand at the individual product (mix) level		
Capacity needed to meet aggregate market demand and customer requirements		
Communication with suppliers and customers on annual requirements		
Decisions on Inventory stocking locations for make-to-stock items		
Forecasts at the product family (volume) level in physical units		
Future labor, overtime, and subcontracting needs		
Reporting of work or service order completion		
Scheduling and tracking the use of resources to meet production requirements		
Time-phased plans for component parts and raw materials		

Planning horizon legend: L = long; I = intermediate; N = near
Process legend: SB = strategic/business planning; SOP = S&OP and resource planning; MS/RC = master scheduling; and RCCP; DM = demand management; DP = distribution planning; MRP/CRP = material and capacity requirements planning; PAC = production activity control

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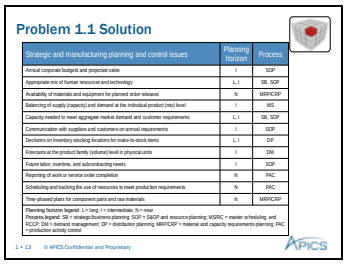
Visual 1-12

Ask participant groups to review the list of 12 issues in Visual 1-12. Suggest that they determine the planning horizon first and then select the appropriate process. Ask each group to present their solutions to the class for a short discussion.

Solution:

Note: Some issues might be difficult to categorize into one planning horizon, especially the two issues that can be categorized as either business planning or S&OP. The issue of where to locate stocking locations is a function of distribution planning but either can be long-term (part of business planning) or intermediate-term (concurrent with S&OP).


Problem 1.1 Solution

Strategic and manufacturing planning and control issues	Planning horizon	Process
Annual corporate budgets and projected sales	I	SOP
Appropriate mix of human resources and technology	L, I	SB, SOP
Availability of materials and equipment for planned order releases	N	MRP/CRP
Balancing of supply (capacity) and demand at the individual product (mix) level	I	MS
Capacity needed to meet aggregate market demand and customer requirements	L, I	SB, SOP
Communication with suppliers and customers on annual requirements	I	SOP
Decisions on Inventory stocking locations for make-to-stock items	L, I	DP
Forecasts at the product family (volume) level in physical units	I	DM
Future labor, overtime, and subcontracting needs	I	SOP
Reporting of work or service order completion	N	PAC
Scheduling and tracking the use of resources to meet production requirements	N	PAC
Time-phased plans for component parts and raw materials	N	MRP/CRP

Planning horizon legend: L = long; I = intermediate; N = near
Process legend: SB = strategic/business planning; SOP = S&OP and resource planning; MS/RC = master scheduling; and RCCP; DM = demand management; DP = distribution planning; MRP/CRP = material and capacity requirements planning; PAC = production activity control

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Visual 1-13 *

Strategic and manufacturing planning and control issues	Planning horizon	Process
Annual corporate budgets and projected sales	I	SOP
Appropriate mix of human resources and technology	L, I	SB, SOP
Availability of materials and equipment for planned order releases	N	MRP/CRP
Balancing of supply (capacity) and demand at the individual product (mix) level	I	MS
Capacity needed to meet aggregate market demand and customer requirements	L, I	SB, SOP
Communication with suppliers and customers on annual requirements	I	SOP
Decisions on Inventory stocking locations for make-to-stock items	L, I	DP
Forecasts at the product family (volume) level in physical units	I	DM
Future labor, overtime, and subcontracting needs	I	SOP
Reporting of work or service order completion	N	PAC
Scheduling and tracking the use of resources to meet production requirements	N	PAC
Time-phased plans for component parts and raw materials	N	MRP/CRP

Planning horizon legend: L = long; I = intermediate; N = near
Process legend: SB = strategic/business planning; SOP = S&OP and resource planning; MS/RC = master scheduling; and RCCP; DM = demand management; DP = distribution planning; MRP/CRP = material and capacity requirements planning; PAC = production activity control

Class Problem 1.1: MPC Business Processes and Planning Horizons

Visual 1-12 summarizes the key issues addressed by the MPC processes mentioned above. The purpose of this instructor-led problem is to

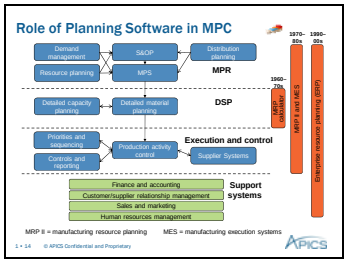
- sort the issues into long-term, intermediate-term, and near-term planning horizon categories
- identify the MPC system process that addresses each issue.

Work in groups. Categorize each issue by planning horizon—long (L), intermediate (I), or near (N)—and by MPC process using the worksheet.

Hint: When sorting the issues, first determine as best you can whether the lead-time implications fall into the long-, intermediate-, or near-term.

Strategic and manufacturing planning and control issues	Planning horizon	Process
Annual corporate budgets and projected sales		
Appropriate mix of human resources and technology		
Availability of materials and equipment for planned order releases		
Balancing of supply (capacity) and demand at the individual product (mix) level		
Capacity needed to meet aggregate market demand and customer requirements		
Communication with suppliers and customers on annual requirements		
Decisions on Inventory stocking locations for make-to-stock items		
Forecasts at the product family (volume) level in physical units		
Future labor, overtime, and subcontracting needs		
Reporting of work or service order completion		
Scheduling and tracking the use of resources to meet production requirements		
Time-phased plans for component parts and raw materials		
Planning horizon legend: L = long; I = intermediate; N = near Process legend: SB = strategic/business planning; SOP = S&OP and resource planning; MS/RC = master scheduling; and RCCP; DM = demand management; DP = distribution planning; MRP/CRP = material and capacity requirements planning; PAC = production activity control		

Role of Planning Software in MPC



Visual 1-14

Briefly explain the evolution of software applications that support MPC. It is important to draw the distinction between MPC, the set of business processes for planning and controlling operations, ERP, and other predecessor applications that magnify the performance or productivity of the planning and control process.

Sales and Operations Planning

S&OP is a key MPC business process. Its main attributes are shown in Visual 1-28, as described by Thomas Wallace and Robert Stahl in *Sales and Operations Planning: The How-To Handbook*, 3rd ed. (T. F. Wallace & Co., 2008).

An overview of S&OP relationships will be presented in the next visual, but keep in mind the following points about S&OP:

- It is a formal business process used by the leadership team to connect business planning with tactical planning at the MPR level, which includes S&OP, master scheduling, demand planning, and distribution planning.
- It balances supply and demand at the product family level.
- It is concerned with product family volume, not the mix of individual products in the family.
- It is most effective when on a formal monthly review and management decision-making cycle.
- It requires the participation of many departments or functions, such as sales and marketing, manufacturing, materials and supply chain management, logistics, finance, human resources, engineering, and research and development.

One method used to define product families is by similar manufacturing requirements. Why could similar manufacturing requirements be a significant criterion for determining product families?

_____

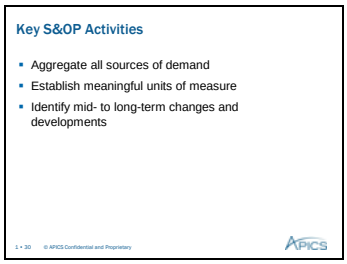
_____

S&OP Relationships

Visual 1-29 shows the nature of the relationships among S&OP and other strategic level and MPC processes. To summarize:

- Strategic and business planning provide direction setting.
- Demand management provides forecast and customer order information.
- Resource planning serves as a check on capacity and resource availability required by the production plan in the S&OP planning horizon.
- Distribution planning
  - can serve as a source of demand forecasts and actual orders generated by stocking locations and organizations in the supply chain
  - uses demand data from S&OP systems for logistics planning at the product family level
  - validates the adequacy of distribution resources to carry out the production plan.
- The only plan that has direct input into master scheduling is the production plan.

Key S&OP Activities



Visual 1-30

Explain the importance of recognizing and aggregating all types of demand as shown in Visual 1-30.

Explain that unit of measure will differ depending on the manufacturing environment.

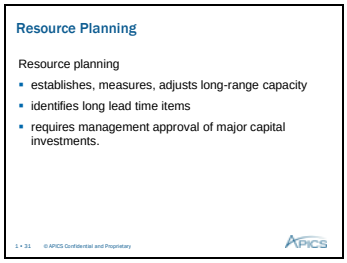
For MTO, ask why the unit of measure should be machine and labor hours.

Answer:

MTO usually involves job shop or batch processes in which production managers need to manage machine and labor capacity to make a variety of different products. Capacity is a key constraint. MTO usually is managed by order backlog, which is why S&OP requires the planning of available capacity.

Explain that one of the important functions of S&OP is to be responsive to mid- and long-term unexpected changes and developments, such as changes in order quantities from large customers or changes in distribution inventory policies such as delivery lead times, safety stock, and lot sizes.

Resource Planning



Visual 1-31

Discuss the three principal functions of resource planning:

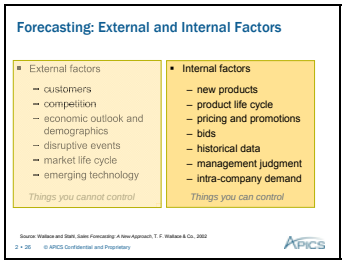
- adjusts limits of key resources required by product families in the long term
- supports business and strategic planning: identifies resources with long acquisition and installation lead times
- requires management approval of major capital investments

Internal Factors

As mentioned earlier, internal factors affecting forecasts are essentially those that the organization can control. The table below summarizes seven major factors.

Factors	Typical issues that affect the forecast
New products	Difficulty of forecasting when new products will be introduced Cannibalizing effect of new products on sales of existing products Need for an initial forecast estimate and also the ability to manage capacity or flex production to meet demand (See Product Life Cycle.)
Product life cycle	Use of early product life cycle stage sales growth of similar existing products as an analog for new products Need to account for rising, level, and then falling sales as products progress through growth, maturity, and decline stages of the product life cycle Managing product lines so that new products continuously replace phased-out ones
Pricing and promotion	The effect of price changes on the dampening and stimulating of demand The effect of promotions on stimulating and changing the time of demand Use of historical data to predict the effect of new promotions and price reductions
Competitive bids	Dependence on awards earned in competitive bidding Need to estimate probabilities of submitting successful bids
Historical (intrinsic) data	Adequacy and accuracy of historical demand, or time series, data Could be useful in estimating the effects of promotions on product demand Needs supplementing with management adjustments based on judgment and experience; for example, exponential smoothing Needs to be based on booked orders to recognize “true” customer demand and not actual sales, or shipments and billings
Management judgment	Input on long-range business activity levels based on executive management insight Adjustment of planned available capacity for lack of resources or competing needs for resources Setting revenue growth goals that are more aggressive than historical demand would normally indicate, and approving product, pricing, and promotion activities to boost sales
Intra-company demand	Need to recognize orders from other plants within the same division or in a sister division (interplant transfers) Demand for promotional purposes and testing

Internal Factors (cont.)



Visual 2-26

Continue to discuss internal factors.

Ask what forecasting technique would be most effective in analyzing the effects of pricing and promotions on demand and why.

Answer:

Causal models are best suited to analyzing the effects of pricing and promotion. Historical data on past promotions provide highly useful data, but regression analysis techniques can correlate the independent variables behind the promotion (magnitude of the price reduction, type of product, customer segment, and others) with demand data. This will produce a more detailed picture of the potential effects of a promotion on product demand.

Note: Some participants will not yet have been exposed to regression analysis. Explain the concept briefly and note that we will cover it in more detail later.

In preparing forecasts, ask what types of historical data provide the best view of real customer demand—booked orders, shipments, or billing—and why.

Answer

Booked orders are the most reliable indicator of true demand. Booked orders are not distorted by backorders, late shipments, partial shipments, and cancellations.

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Internal Factors (cont.)

What forecasting technique would be most effective in analyzing the effects of pricing and promotions on demand? Why?

_____

_____

_____

_____

In preparing forecasts, what type of historical data provides the best view of real customer demand: booked orders, shipments, or billing? Why?

_____

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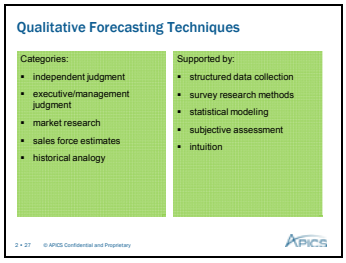
Qualitative Forecasting Techniques

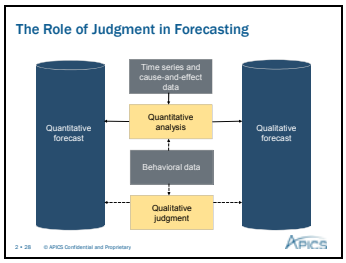


Visual 2-27

Briefly introduce the five categories of qualitative forecasting techniques.

- Qualitative techniques are subjective and judgmental in nature but often employ proven social science research methods relating to data collection, surveys, and statistical analysis.
- Use as an example a survey of the probability that a respondent is going to buy a car in the next year. The survey uses a Likert response scale of 1 to 5, with 5 being "almost certain" to buy. Other questions might cross-validate the customer's stated intent by asking for annual income information and model year of the respondent's current car.
- When interpreting the results, analysts deal with real quantifiable data that have most likely been tabulated and manipulated by mathematical and statistical software. They are not time series, or historical, data used in quantitative intrinsic forecasting but are important point-in-time customer attributes based on the probabilities of buying a car.
- In other words, a qualitative forecast technique using market research or surveys has used quantitative analysis techniques based on standard survey research and statistical methods. The line between quantitative and qualitative forecasting is not as clear it might seem at first.

The Role of Judgment in Forecasting



Visual 2-28

Explain that a "quantitative forecast" could be based primarily on time series analysis (of car sales) and causal analysis (effect on car sales of demographic and income data) but be influenced as well by qualitative judgments (opinion of car experts) and quantitative analysis of behavioral data (consumer spending surveys).

Qualitative forecasts for launches of a new car model with no demand history can use regression analysis for sales of a similar competitor's model that management believes are historically analogous, as well as on behavioral data from consumer preference surveys.

Time Series Decomposition

The decomposition of time series data seeks to understand the patterns of demand in a given sequence of historical data. Time series data can be divided into four components:

- trend
- seasonal
- cyclical
- random (a component without a pattern)

In the Basics of Supply Chain Management CPIM module, we demonstrated the calculation of a forecast based on a seasonal index.

As shown in Visual 2-41, however, time series data can be influenced by more than one demand component. Our goal here is to demonstrate how decomposition can be used to create a forecast when there are both trend and seasonal components in a time series. Our example uses a two-year time series for simplicity.

Step 1: Plot the seasonal data and calculate the trend line

The data have already been plotted for 2007 and 2008.

- To calculate the trend line, you can use a spreadsheet graph application, as we have done here.
- It is important to note the left intercept at 161. The equation for the trend line shown below simply means that the trend line starts at 161 and rises by 50 units every quarter (*t)* to 561 in quarter 2008. (See "Trend" column.)
- This is a rise of 400 units over eight quarters, which is a rise of 50 units per quarter.

$$\text{Trend} = 161 + 50(t)$$

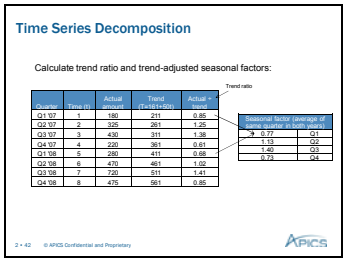
$$\text{Trend}_1 = 161 + 50(1) = 211$$

So the trend for quarter 1 of 2007 is 211, as shown in the table below along with the actual and trend figures for all eight quarters of 2007 and 2008.

Quarter	Time (t)	Actual amount	Trend (T=161+50t)
Q1 '07	1	180	211
Q2 '07	2	325	261
Q3 '07	3	430	311
Q4 '07	4	220	361
Q1 '08	5	280	411
Q2 '08	6	470	461
Q3 '08	7	720	511
Q4 '08	8	475	561

Time Series Decomposition (cont.)

Step 2: Calculate the trend-adjusted seasonal factor



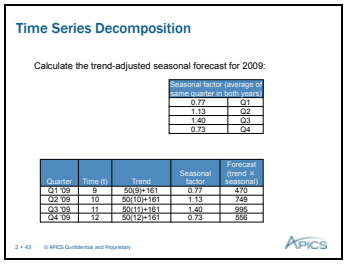
Visual 2-42

Explain the calculations shown in the visual for

- the actual-to-trend ratio (actual ÷ trend) for each quarter of 2007 and 2008
- trend-adjusted seasonal factors for each quarter obtained by averaging same-quarter ratios for quarters 1 through 4 of these two years.

Explain that the trend-adjusted seasonal factor now can be used to calculate the trend-adjusted seasonal forecast for 2009.

Step 3: Calculate the trend-adjusted seasonal forecast



Visual 2-43

Explain that the trend-adjusted seasonal factor for each quarter now can be applied to the trend value for each quarter in 2009 to calculate the 2009 forecast. Point out that the aggregate forecast of 2,763 in 2009 is 818 units higher than in 2008 and illustrates the effect of trend on the aggregate forecast.

Time Series Decomposition (cont.)

Step 2: Calculate the trend-adjusted seasonal factor

This step is fairly straightforward and requires two calculations:

- the actual to trend ratio (actual ÷ trend) for each quarter of 2007 and 2008
- the trend-adjusted seasonal factors based on averaging same-quarter ratios for quarters 1 through 4 of these two years

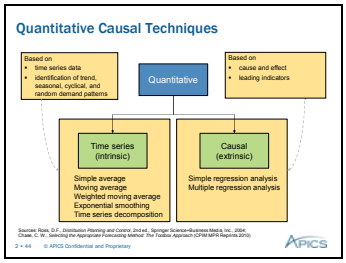
The trend-adjusted seasonal factors now can be used to generate the seasonal forecast for 2009.

Step 3: Calculate the trend-adjusted seasonal forecast

For each quarter of 2009 (the forecast year), multiply the trend value shown in the trend column by the quarter's trend-adjusted seasonal factor.

Note that the aggregate forecast for 2009 is 2,763, which is 818 units higher than the actual demand in 2008 of 1,945; this shows the effect of trend on the aggregate forecast.

Quantitative Causal Techniques



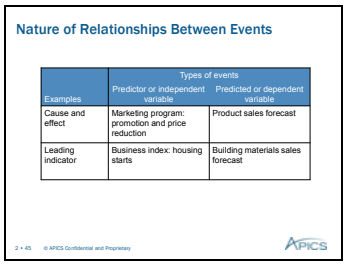
Visual 2-44

Discuss the differences between intrinsic and causal quantitative techniques. Point out the following:

- Intrinsic techniques seek to examine and explain the mathematical relationships in time series decomposition data in order to predict the future.
- Causal techniques attempt to explain the nature of relationships between related events or occurrences and the predictability of those relationships in the future.

Also explain that causal techniques are not used just because time series data are not available. Used in conjunction with time series data, they can explain and help interpret the effect of independent variables on demand.

Nature of Relationships Between Events



Visual 2-45

Explain the importance of understanding the dependent versus independent variable nature of relationships, as these are the focus of causal techniques. Also discuss what differentiates them from intrinsic techniques.

Review the examples of the three types of relationships. These include:

- Cause and effect—The independent variable tends to cause the dependent variable to change in a certain way.
- Leading indicator—The independent variable is correlated with the dependent value.

Quantitative Causal Techniques

Quantitative intrinsic techniques, which we have just reviewed, focus on

- analyzing time series data
- decomposition of demand patterns into trend, seasonal, cyclical, and random demand patterns
- determining the mathematical relationships within the data and demand patterns and extending them into the future.

The other category of quantitative forecasting techniques consists of causal techniques. When applied in forecasting, causal techniques

- analyze and predict based on relationships between events or occurrences, such as housing starts and sales of central air conditioning systems
- attempt to explain and quantify the relationships in order to predict demand in the future.

It would be misleading to think that quantitative causal techniques are used mainly when time series data are not available. Think of them as another tool that can be used to understand demand patterns. For example, by explaining the relationship between events such as housing starts and air conditioning system sales, causal techniques such as regression analysis enable vendors of these systems to better understand their intrinsic time series sales figures.

Nature of Relationships Between Events

Let's look further at the nature of relationships between events and at the analytical tools used to explain them.

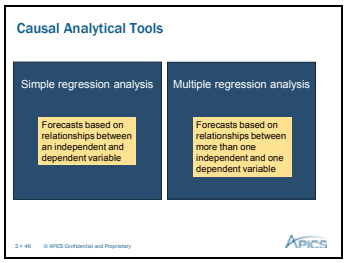
Simply put, causal techniques attempt to quantify the relationship between two types of events:

- The first event is the *predictor* or *independent variable*. You could call this the *cause of* or *influence on* the second event.
- The second event is the *predicted* or *dependent variable*. You could call this the *effect* or the *associated result*.

Some common examples of this relationship are based on cause and effect and leading indicators.

- A successful price reduction and promotion program to increase product demand is an example of a cause-and-effect relationship.
- A specific business activity index, such as housing starts, serves as a leading indicator for the demand for plywood and fasteners.

Causal Analytical Tools

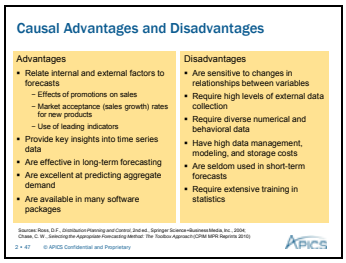


Visual 2-46

Briefly review two types of causal techniques involving regression analysis. Point out the following:

- Simple regression analysis explains the effect of a single independent variable on a dependent variable. An example would be an empirically determined correlation between demand for ice cream (the dependent variable) at a factory and the average temperature of the previous week (the independent variable).
- Multiple regression analysis explains the effect of multiple independent variables on a single dependent variable. This provides a more robust understanding of the dependent variable.

Advantages and Disadvantages of Causal Techniques



Visual 2-47

Briefly review the advantages and disadvantages, or the strengths and weaknesses, of causal techniques.

- Highlight especially that causal techniques play an important role in relating forecasts to some of the internal and external factors discussed earlier in this section such as promotions, leading indicators, and new product sales growth rates.
- Also note the additional data collection, management, and modeling costs incurred by causal compared to time series techniques.

Bias

In reviewing the use of MAD, the actual demand in the forecast examples we used had a cumulative period forecast error of zero. This condition—cumulative period forecast error of zero no matter what the value of the MAD—is known as *the absence of bias*, or zero bias. Actual demand did not deviate consistently from the mean in one direction.

The formula for calculating bias is shown in the visual.

- For products A and B, the bias is zero because the running sum of forecast error (RSFE) was zero.
- For product C, which we will discuss shortly, the bias was 27.5.

The Problem of Bias

A bias of zero is highly desirable. We'll demonstrate this by reviewing two different forecasts as shown in the visual. The objective is to show how a zero bias means that the forecast model is good and that over time, the difference between actual demand and the forecast is because of random error and not the forecast model.

Products B and C are different in the following respects:

- Product B has a high MAD of 300 as we demonstrated earlier, but it has no bias.
- Product C has a very low MAD of 27.5, but a large bias or RSFE of 275 because actual demand was consistently higher than the forecast.

Which forecast do you think is better, and why?

_____

_____

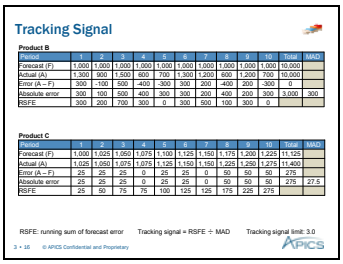
_____

The advantage lies with the forecast for product B, where random variation occurs around a stable average. Because the forecast approximates the average of the demand, it is easy to use the MAD or standard deviation to calculate safety stock to buffer against the random variation. In addition, process improvements such as lead-time reduction and more flexible production can reduce dependence on forecasts.

Forecasts that are too low, as in the case of product C, have essentially missed the average of an upward trend demand pattern. Worse yet, production and capacity will not be geared up to meet demand because the forecast was too low. The forecast for product C needs to be higher, and numerous statistical software applications can deal with trends in time series data as shown for product C.

The conclusion is that bias is the most important factor to deal with in evaluating and planning the forecast. Remove bias and it is much easier to manage random variation in demand through statistical safety stock.

Tracking Signal



Visual 3-16

Review the purpose of the tracking signal, which is to alert the forecaster that variation—as measured by RSFE—has exceeded a preset limit or multiple of inherent randomness as expressed in the MAD. If the tracking signal—a tracking signal of 3.0, for example—is exceeded, the forecast may have lost its ability to predict actual period demand based on random variation and the forecast model might need to be modified.

Ask whether the tracking signal trip value of 3.0 has been exceeded by actual demand for products B and C, and in what period. Also ask participants to calculate the signal's trip value.

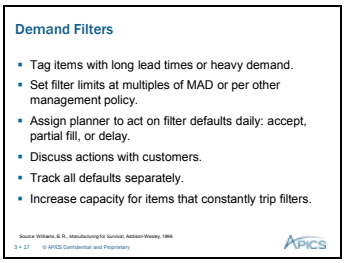
Answer:

The actual demand for B did not exceed the trip value in any period. The tracking signal trip value was exceeded by the RSFE of actual demand for product C in period 4. The calculation for product C in period 4 is as follows:

RSFE ÷ MAD = 75 ÷ 19 = 3.9

Click to reveal the MAD and tracking signal calculations *for each period* on Visual 3-16. If these calculations were made after each period, rather than waiting until after period 10, the tracking signal would be seen to reach >3 in period 4, at which time the forecast could have been corrected to account for the upward trend.

Demand Filters



Visual 3-17

Review the purpose of demand filters. Demand filters are important in identifying and controlling abnormal orders, such as orders of unusual size that could affect service to other customers.

Customer Relationship and Order Management

In this section, we address two key aspects of demand management: CRM and order management.

Customer Relationship Management (CRM)

Value Proposition

The value proposition is as follows:

- Differentiate the customers' experience with the organization from their experiences with rivals by superior anticipation and responsiveness.
- Increase lifetime customer retention and loyalty.
- Provide insight into the timing and quantity of impending customer orders.

In Session 1, we reviewed the role of CRM in demand management. We discussed the third value proposition relating to the use of information from field sales staff and analysis of data in CRM databases to

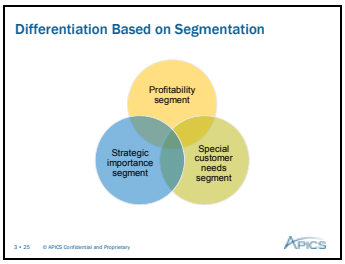
- understand customer needs and preferences
- anticipate customer demand in order to replace the forecast with knowledge of impending orders from specific customers.

Scope of CRM

As the value proposition implies, CRM has a much broader scope than we discussed in Session 1.

- Today's CRM applications extend beyond account management and are conjoined with marketing and sales strategy.
- As such, CRM marketing and fulfillment strategies recognize the importance of a number of factors such as
  - differentiation based on customer segments
  - use of data and analytics to improve sales performance.

Differentiation Based on Customer Segmentation



Visual 3-25

Introduce three examples of customer segments that require differentiated customer relationship management approaches. By "differentiated," we mean approaches that recognize the relative importance of customers in these segments compared to the general customer base, and the need to relate to customers in ways that are appropriate for a particular segment.

Profitability segmentation

Explain the use of Pareto analysis to stratify the customer base in terms of profitability and differentiated customer service.

Strategic importance segmentation

Explain the risk associated with customers of strategic importance, who have a high degree of leverage because they account for a significant portion of their suppliers' profitability and channel access to the customer base.

Also point out that a certain degree of overlap can exist between the profitability and strategically important customer segments. It is possible to have a profitable customer who does not account for a significant percentage of a supplier's revenues.

Note: You may find it useful to review the content on CRM in the APICS Certified Supply Chain Professional course.

Differentiation Based on Customer Segmentation

A key to successful CRM is the ability to provide the right kinds of differentiated services to important customer segments within the total customer base. As shown in the visual, some of the most important criteria for customer segmentation are based on the following:

- profitability
- strategic importance to the business
- special needs

Profitability segmentation

Pareto analysis is used to determine the most profitable customers. Based on Pareto's law, it is a statistical certainty that a small percentage of customers will account for a disproportionately large share of a supplier's profitability.

Profitable customers, as a result, can receive differentiated treatment in areas such as the following:

- volume discounts
- priority attention from sales and marketing staff and other functions such as product development

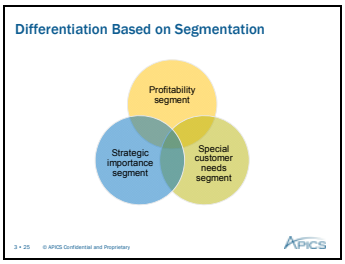
Strategic importance segmentation

There can be a certain degree of overlap between customers in the profitability and strategic importance segments, but there are significant differences between the two.

- Customers in the strategic importance segment have considerable leverage with respect to their suppliers' overall profitability and possibly their status as going concerns.
- Consider, for example, suppliers to the world's largest retailer. The world's largest retailer is the major customer for many suppliers, and imposes many terms and conditions when suppliers do business with that retailer.

Manufacturers and service providers are financially vulnerable to customers in the strategic importance segment and their CRM strategies need to take this into account. In the special customer needs segment, we point out that there is an overlap between customers with special needs and customers of strategic importance in terms of CRM requirements.

Differentiation Based on Customer Segmentation (cont.)



Visual 3-25

Special customer needs segmentation

Explain that many customers require special services of the type shown in the table on the participant workbook page.

Explain that the special-customer-needs segmentation overlaps with the profitability and strategically important customer segmentation. The kinds of services needed in this segment often are those required to care properly for the two other customer segments just mentioned.

Reliability and responsiveness metrics

In the following pages, we will review the five performance attribute categories of order delivery metrics. We also will highlight some concepts relating to the level 1 metrics and present examples of level 2 metrics and their related performance measures. Level 2 metrics are subsets of level 1. The level 2 metrics shown in the visuals are examples and are not an exhaustive list. We will provide, as appropriate, some examples of how they

- play an important role in diagnosing problems and improving performance
- can be used independently as metrics, an example being the widespread use of order fill under the perfect order fulfillment metric (delivered in full) in the reliability category.

Reliability

This attribute category focuses on quality of product and service. It is known as the *perfect order* category.

- Perfect order fulfillment at level 1 is defined as the percentage of orders complying with all level 2 metrics, which encompass the following "corrects": correct product, place, time, product condition and packaging, quantity, documentation, and customer.
- Separate measurements of level 2 metrics help diagnose root causes of imperfect orders.
- Quality is subsumed under reliability as a level 2 metric.
- Line fill rate (delivered in full) also is a level 2 metric and often is used independently.
- Perfect order fulfillment is calculated as follows:

Number of perfect orders ÷ total number of orders

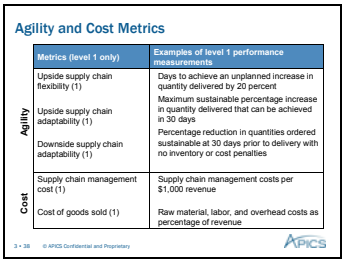
Responsiveness

Responsiveness focuses on the average cycle time that a manufacturer requires to respond to and deliver customer orders.

- Order fulfillment cycle time is the sole level 1 responsiveness metric. It is based on the time from acceptance of a sales order to customer receipt of the product. It consists of
  - order fulfillment process time
  - dwell time, or the time an order spends waiting to move between process stages.
- It has several level 2 metrics. Its important level 2 metrics include order entry time; dwell time; and make, distribute, and transport time.
- The performance measurement for the level 1 metric is based on the average speed at which the supply chain delivers products to customers.
- Separate measurements for each of the three level 2 metrics help diagnose the root causes of longer-than-committed cycle times.
- While order fulfillment cycle times will differ among individual orders, the level 1 metric at the aggregate level is calculated as follows:

Sum of actual cycle times for all orders delivered ÷ total number of orders delivered

Agility and cost metrics



Visual 3-38

Explain that the agility metric evaluates the ability of a manufacturer to reliably deal with demand variation in the near and long term. It addresses both the flexibility and adaptability of the manufacturer's supply chain to changes in the marketplace.

- Upside supply chain flexibility is measured by the number of days required to meet an unplanned and sustainable increase of 20 percent in delivery quantities to meet market demand. The number of days required to achieve the 20 percent increase depends on the increase in the speed of the make, source, deliver, and return capabilities of the organization. Note that the upside flexibility of a supply chain can be constrained by the least flexible firm in the supply chain.
- Upside supply chain adaptability refers to the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days. Again, the percentage increase will depend on improvements in the make, source, deliver, and return capabilities of the organization.
- Downside supply chain adaptability is the ability to handle a reduction in orders. It is based on the minimum percentage reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties.

Explain that the supply chain cost attribute category is divided into supply chain management costs and cost of goods sold.

- Supply chain management costs include the fixed and operational costs of the plan, source, and deliver and return processes. It is measured per $1,000 in revenue.
- Note that "costs to make" is included in another level 1 metric, cost of goods sold, which is measured as a percentage of revenue.
- Supply chain management costs at level 2 can be compared with the costs of similar companies to obtain a percentile ranking. These would include costs to plan, source, and deliver.
- Note that the organization's performance measurements and percentile rankings at level 2 are important because they provide useful diagnostic data for performance improvement.

Agility and cost metrics

Agility

Agility category level 1 metrics evaluate the ability of a supply chain to deal reliably with demand variation in the near and long terms.

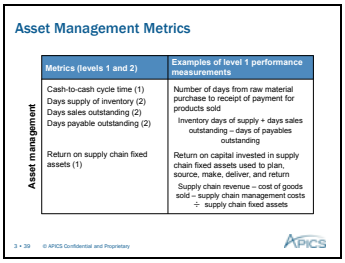
- Upside supply chain flexibility is measured by the number of days required to meet an unplanned and sustainable increase of 20 percent in delivery quantities to meet market demand. The number of days required to achieve the 20 percent increase depends on the increase in the speed of the make, source, deliver, and return capabilities of the organization.
- Upside supply chain adaptability refers to the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days.
- Downside supply chain adaptability is the ability to handle a reduction in orders. It is based on the minimum percentage reduction in quantities ordered that is sustainable 30 days prior to delivery with no inventory or cost penalties.

Cost

The supply chain cost attribute category includes supply chain management cost and cost of goods sold.

- Supply chain management cost is defined as the fixed and operational costs of the plan, source, and deliver and return processes. It is measured per $1,000 in revenue.
- It does not include cost to make which is included in another level 1 metric, cost of goods sold, which is measured as cost of goods sold as a percentage of revenue.
- Supply chain management costs at level 2 can be compared with the costs of similar companies to obtain a percentile ranking. These would include costs to plan, source, and deliver.

Asset management



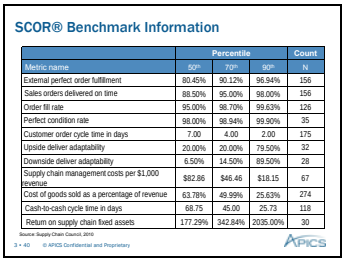
Visual 3-39

Explain that cash-to-cash cycle time measures the efficiency of the use of assets—fixed and working capital—on a cross-functional basis by supply chain processes.

- The calculation of cash-to-cash cycle time determines the number of days it takes the supply chain to turn cash used to purchase materials into cash from a customer.
- At both level 1 and 2, the performance measurement value can be compared with the values of similar companies to obtain a percentile ranking.

Explain that return on supply chain fixed assets measures the effectiveness of the manufacturer in generating revenues from its capital investment in fixed assets.

Benchmark information



Visual 3-40

Explain that the Supply Chain Council is a membership organization of hundreds of companies that report performance data for metrics at levels 1 to 4 in the five performance attribute categories. They have permitted us to share some data for educational purposes only.

That being said, explain the reasons for the limited perspective that these numbers provide as explained in the participant page. On a more positive note, the data show the value of a metrics system that is based on

- an integrated view of supply chain processes
- cross-functional supply chain management within and between manufacturers.

Explain the table in the Visual 3-40 and ask participants to group the metrics by category and separate level 1 from level 2 metrics as discussed earlier. Make sure they understand the percentile concept. The 90th percentile indicates the lowest reported value in the top 10 percent of values reported.

Role of Standard Deviation

Now let's refer to Visual 3-45 for the calculation we made earlier of standard deviation in *physical units*, 211. The standard deviation (211) indicates the relative tightness of the actual period demand variances around the average period forecast of 1,000 units. If you look again at the next visual, you will see the assignment of a value of +211 to 1.0 standard deviation to the right of the mean.

Statistically, this means that 84.13 percent of period demands will fall within 1,211 units—or a mean forecast of 1000 + 1.0 standard deviation of 211 units—for a service level of 84.13 percent. The logic behind this is as follows:

- Fifty percent of actual period demand falls to the left of the mean forecast in a normal distribution, so the service level of the mean forecast is 50 percent without safety stock.
- 34.13 percent falls between the mean and the standard deviation of +1.
- 84.13 percent falls between the left-hand limit of the distribution and the standard deviation of +1.0 for a service level of 84.13 percent and a safety stock of 211.

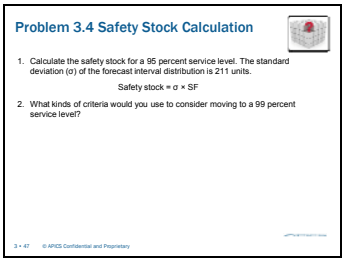
Calculating the Safety Stock

However, our goal is a service level of 95 percent, not 84 percent. The question is: Where to the right of the +1.0 standard deviation of 211 will you need to establish the safety stock level for a 95 percent service level?

The simplest solution is to use a Z value safety factor from a safety factor table.

You will have the opportunity to calculate the safety stock for a 95 percent service level in Class Problem 3.4.

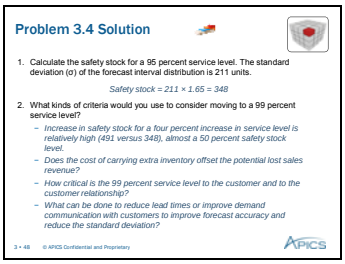
Class Problem 3.4: Safety Stock Calculation



Visual 3-47

Ask participants to work in pairs or groups. If time permits, use the answers to the second question to reinforce thinking (1) about tradeoffs between different levels of safety stock, and (2) that improving the forecast may only be part of the answer, as illustrated in the last of the criteria listed in the solution slide.

Solution:



Visual 3-48 *

1. Safety stock = 211 × 1.65 = 348
2. Increase in safety stock for a four percent increase in service level is relatively high, at 491 versus 348, which is almost a 50 percent safety stock level.

   Does the cost of carrying extra inventory offset the potential lost sales revenue?

   How critical is the 99 percent service level to the customer and to the customer relationship?

   What can be done to reduce lead times or improve demand communication with customers to improve forecast accuracy and reduce the standard deviation?

Class Problem 3.4: Safety Stock Calculation

Work in pairs or small groups.

1. Calculate the safety stock for a 95 percent service level. The standard deviation of the distribution during the forecast horizon is 211 units. Refer to the safety factor table and formula below. (Note that we have used the Greek letter **σ** for standard deviation.)

Standard deviation (σ) safety factors		
Service level percent	Stockout probability percent	σ safety factors (Z value)
50	50	0.00
84.13	15.87	1.00
85	15	1.04
90	10	1.28
95	5	1.65
96	4	1.75
97	3	1.88
98	2	2.05
99	1	2.33
99.86	.14	3.0
99.99	.01	4.0

Formula for safety stock based on a Z value:

$$SS = \sigma \times SF$$

2. What criteria would you use to consider moving to a 99 percent service level?

_____

_____

_____

_____

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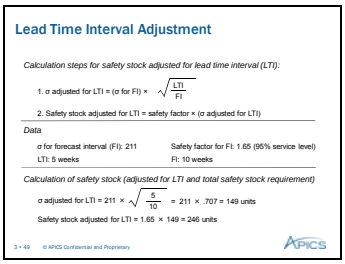
Accounting for Lead Time Interval



Visual 3-49

Explain that up to this point we have been discussing the need for a quantity of safety stock to buffer against the actual customer demand deviation (uncertainty) from the forecasted demand we calculated using a selected set of 10 periods. Note that this problem uses Arnold et al.'s interpretation of these 10 periods as the forecast interval (FI). The assumption so far has been that there is no uncertainty in the replenishment lead time interval (LTI). But LTIs are subject to uncertainty, and the longer the LTI is relative to the FI, the more uncertainty there will be regarding the on-time arrival of the inventory necessary to fulfill customer orders. We will apply this LTI to the previously-calculated safety stock.

Visual 3-49 summarizes the calculation of safety stock adjusted for LTI. Explain the calculation using formulas and data shown in the visual. Note that we are using the standard deviation (σ, which is 211) and FI (10 weeks, rather than periods) assumed in the safety stock calculation. In that calculation, we used a safety factor (95 percent service level). We are adding the assumption of a five-week LTI.

Review the following principles with the class:

- If the LTI is five weeks and is less than an FI of 10 weeks, then the σ calculated for the FI will decrease, reducing the amount of safety stock required since the risk of a stockout during the shorter replenishment period (LTI) is reduced.
- If the LTI is 15 weeks and is more than an FI of 10 weeks, then the σ calculated for the FI will increase, enlarging the amount of safety stock required since the risk of a stockout during the replenishment period (LTI) is increased.

The underlying concept of the LTI-adjusted safety stock is that the longer the FI is relative to the LTI, the more the time available in the FI to buffer uncertainties in the LTI.

Note: You may find it useful to refer to Jacobs et al., *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification ed., chap. 16, and Arnold et al., *Introduction to Materials Management*, 7th ed., chap. 11, p. 247. The term "forecast interval" (FI) in this problem is taken from the latter; they interpret the FI to be equal to the *APICS Dictionary* term "forecast horizon," which is 10 periods in this problem.

Accounting for Lead Time Interval

So far, we have been discussing the need for safety stock to buffer against customer-associated demand uncertainty during the forecast horizon. The assumption has been that there is no uncertainty relating to replenishment of the inventory being held for sale to customers. There is, however, real uncertainty in the form of transportation delays, miscommunication, production shortages, and quality issues that affect replenishment of the inventory used to fulfill customer orders.

This requires the adjustment of the safety stock calculation to account for the difference between the lead time interval ("LTI" in Visual 3-49) and the forecast interval ("FI" in Visual 3-49). Note that The term "forecast interval" (FI) in this problem is taken from Arnold et al.; they interpret the FI to be equal to the *APICS Dictionary* term "forecast horizon," which is 10 periods in this problem.

The basic principle can be summarized as follows:

- If the replenishment lead time interval is five weeks, for example, and is less than a forecast interval of 10 weeks, then the σ calculated for the forecast interval will decrease, reducing the amount of safety stock required since the risk of a stockout during the shorter replenishment period (LTI) is reduced.
- If the replenishment lead time interval is 15 weeks, for example, and is more than a forecast interval of 10 weeks, then the σ calculated for the forecast interval will increase, enlarging the amount of safety stock required since the risk of a stockout during the replenishment period (LTI) is increased.

The following steps can be used to calculate the safety stock required for lead time uncertainty. We'll assume that the σ is 211, the same σ used earlier in the safety stock calculation for a 10 period forecast interval.

1. Calculate the σ as adjusted for the lead time interval:

$$\sigma \text{ adjusted for LTI} = (\sigma \text{ for FI}) \times \sqrt{\frac{\text{LTI}}{\text{FI}}}$$

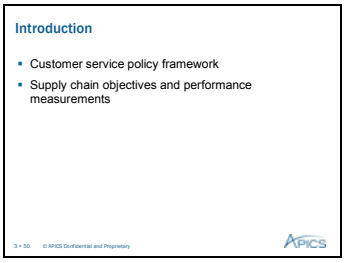
2. Multiply the σ adjusted for LTI by the relevant safety factor to calculate the LTI-adjusted safety stock:

$$\text{SS adjusted for LTI} = \text{safety factor} \times (\sigma \text{ adjusted for LTI})$$

The underlying concept of the LTI-adjusted safety stock is that the longer the FI is relative to the LTI, the more time available in the FI to buffer uncertainties in the LTI.

Note: The term "forecast interval" (FI) in this problem is taken from Arnold et al., *Introduction to Materials Management*, 7th ed., p. 247. ; they interpret the FI to be equal to the *APICS Dictionary* term "forecast horizon," which is 10 periods in this problem.

Customer Service Policy and Performance Targets



Visual 3-50

Explain that up to this point we have been discussing many individual elements of customer service as listed on the participant workbook page. What we can conclude is that customer service is the bridge between customers and the value-producing processes of manufacturing and service organizations.

- Customer service is implicit in sales and marketing activities that determine what products and services customers are willing to pay for.
- Customer service is within the mission of manufacturing and distribution in the delivery of goods and services to customers.

In this short section, we will

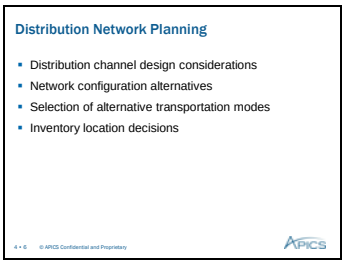
- briefly summarize the elements of a customer service policy framework
- review the relationship between supply chain management objectives and performance measurement, which is a key element in the customer service policy framework.

Learning Objectives

- *Distribution Network Planning*
  - Differentiate between functional and institutional distribution channels.
  - Identify the major influences on the design of institutional channels.
  - List at least four distribution network design factors.
  - Describe the strategic influences on network configuration.
  - Explain the role of distributors as intermediaries in distribution networks.
  - Explain the rationale for multilevel networks and the purpose of the bill of distribution (BOD).
  - Describe the factors affecting safety stock in distribution networks.
  - List the performance characteristics used to evaluate transportation modes.
  - Differentiate between the types of factors used to determine the location of distribution centers.
- *DRP*
  - Explain the role of product family and item forecasts in replenishing distribution inventory.
  - Differentiate between allocation and aggregation methods of forecasting.
  - List the significant differences between push and pull replenishment.
  - Calculate a distribution requirements plan from warehouse gross requirements.
  - Provide examples of special events that must be taken into account.
  - Explain the logic of allocating distribution system inventory shortages.
  - Summarize the linkages between DRP, S&OP, and master production scheduling.
- *Measuring Performance*
  - Describe the seven categories of logistics performance objectives.
  - Give at least two examples of measurements for customer service, warehouse operations, transportation, and inventory management.

Distribution Network Planning

References: Jacobs, et al., *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification ed., chap. 14; Ross, *Distribution Planning and Control,* 2nd ed., chap. 2, 5, 8, 11, 12; Wallace and Stahl, *Master Scheduling in the 21st Century*, 2003, chap. 12.

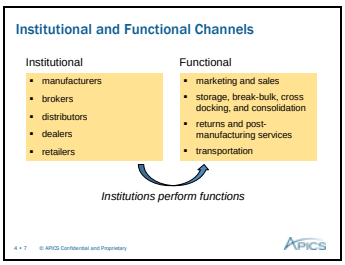


Visual 4-6

This section of the course on distribution network planning addresses four issues:

- channels of distribution design considerations
- network configuration alternatives
- selection of transportation modes
- inventory location decisions

Distribution Channel Design Considerations



Visual 4-7

Explain the two views of distribution channels and that the institutional view of channels is difficult to separate from the functional. Every channel function is the responsibility of a channel member, and the responsible member might differ from one distribution channel to another. For example, a manufacturer might choose to be the institutional channel for certain products and assume responsibility for the functional channels of marketing, regional warehousing, and sale and shipment to retailers—bypassing the use of distributors as institutional channels.

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Network Configuration

Distribution networks can be characterized as the playing field for the functional and institutional channels that move products from manufacturers to end users. As we discussed earlier, channel functions are distribution processes that add value to manufactured products sold to customers, such as

- marketing and sales
- storage, break-bulk, cross docking, and consolidation
- returns and post-manufacturing services
- transportation.

These processes are executed by institutional channels or channel members who perform channel functions that the manufacturer requires. A manufacturer, for example, may build a network by entering into relationships with distributors, retailers, and public warehouses.

- Some of the distributors might be large regional distributors served by the manufacturer's central supply source or regional distribution centers (DCs). These distributors might supply regional retailers or smaller third-party distributors that serve local retail stores.
- Other distributors that are supplied by the manufacturer's satellite DCs might have local operations only.
- Retailers might be national in scope and supplied through the manufacturer's regional DCs.
- Still other retailers might be supplied by the manufacturer through its own extensive set of satellite DCs or public warehouses.

The possibilities are endless.

Distribution Networks

The visual shows the physical components of distribution networks, typical design decisions, and representative design issues that need to be reflected in network configuration from a manufacturer perspective.

What are some other design decisions and issues that might be added to the list shown in the visual?

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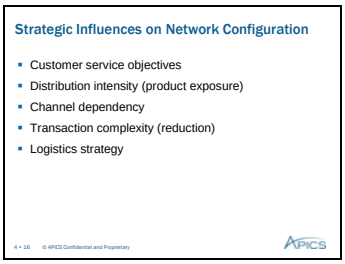
Strategic Influences on Network Configuration



Visual 4-16

Discuss the strategic influences on network configuration. Note that customer service, distribution intensity, and channel dependence have already been introduced as factors affecting institutional channel design. In brief, some key points are as follows:

- Customer service—Location, or place utility, of products must meet customer expectations for access; customer wait time must be commensurate with the product being produced, whether the item is a consumer packaged good or capital equipment. Both of these affect distribution intensity of customer contact points in the network.
- Distribution intensity—Distribution intensity relates to the need for product exposure in the market. Everyday consumer products require widespread distribution to low-level stocking locations. This implies multilevel networks and complex channel member relationships. Sales of MTO products through direct/internal channels to other manufacturers or distributors require less complex networks and channel relationships.
- Channel dependence—The goal of achieving high levels of supply chain efficiency means high levels of information technology (IT) infrastructure support for the network and substitution of cross docking and flow-through distribution to speed deliveries and reduce inventory levels.
- Transaction complexity reduction—As intermediaries between manufacturers and their customers, or other distributors and their customers, distributors reduce the number of transactions between channel members and therefore reduce network complexity. This will be described in more detail later.
- Logistics strategy—Networks need to accommodate the storage and movement of inventory to customers. The number, location, and capacity of production, storage, and service facilities, plus the transportation resource requirements, are of utmost importance to customer service. They also need to be balanced with inventory and operating costs.

Bill of Distribution

To close the discussion of multilevel distribution networks, we need to review the concept of BOD. The BOD also is called the *distribution network structure*.

Purpose and significance

The purpose of the BOD is to

- facilitate the transfer of demand for the product, from the point of customer demand at lowest-level satellite warehouses or regional DCs, upward through the distribution channel to the central supply source
- document the channels of inventory replenishment from one or more channel supply sources, such as manufacturers or major distributors, to distributed inventory stocking locations and on to customers.

The BOD is significant for two reasons:

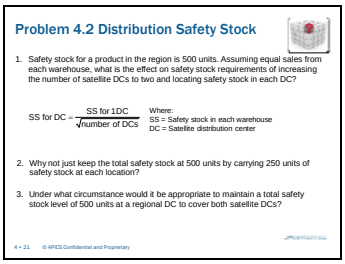
- It traces the inventory flow channels for every item sold.
- It provides the location and flow information that support the two main distribution planning functions:
  - logistics resource requirements planning (LRRP) in conjunction with S&OP, and logistics capacity planning in master scheduling
  - DRP in conjunction with master scheduling

Benefits summary

The BOD benefits are as follows:

- It provides inventory planners with visibility to supply and demand relationships in the distribution channel.
- It clearly establishes the relationship between inventory stocking locations at different levels, such as central supply, regional DCs, and satellite DCs.
- It clearly defines the resupply path for each item in each stocking location.
- It enables the DRP software application to begin low-level coding at the lowest stocking location in the distribution channel and progress up through each level to the appropriate sources of channel supply.

Class Problem 4.2: Distribution Safety Stock

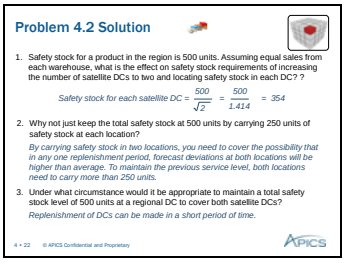


Visual 4-21

Ask the participants to work in pairs or groups to answer the three questions in Class Problem 4.2. Calculators will be useful.

Note: Remind the class that the introduction to this problem on safety stock in a distribution channel was included in a discussion of the advantages of holding safety stock in multilevel distribution networks at the regional DC level. This class problem starts by asking the participants to calculate new safety stock requirements for a product as a result of establishing another satellite DC in a region and holding safety stock at both locations. It then follows with questions that lead back to the option of holding all safety stock at the regional DC that replenishes both satellite DCs.

Solution:



Visual 4-22 *

1. Safety stock for each satellite DC = 500 ÷ √2 = 500 ÷ 1.414 = 354.
2. When carrying safety stock in two locations, you need to cover the possibility that in any one replenishment period, forecast deviations at both locations could be higher than the forecast. To maintain the previous service level, both locations need to carry more than 250 units.
3. Replenishment of DCs can be made in a short period of time.

Replenishment Planning Approaches

Objectives and Planning Parameters

From the standpoint of a distribution inventory planner, the operations of a warehouse have the following objectives:

- Provide high levels of customer service.
- Minimize operating costs.
- Minimize inventory investment.

The parameters of replenishment planning are as follows:

- balance between ordering and carrying costs, or economic order quantity (EOQ)
- accuracy of forecasts
- adequacy of stock levels between order replenishments (safety stock, safety lead time, and delivery lead time)

These objectives and parameters underlie replenishment planning approaches, which we will address presently.

What do we mean by "parameters"?

_____

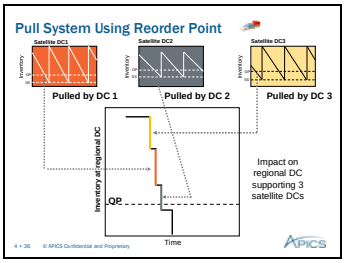
_____

Push Versus Pull Approaches

There are two basic approaches to replenishment planning: push and pull, as summarized in the table.

Key attributes	Pull systems	Push systems
Authority to initiate replenishment order	Decentralized (warehouse)	Centralized (central supply)
Planning	Simple: plan only for the warehouse's channel	Single inventory plan for total system inventory
Customer service	Measured at the warehouse level	Measured on a systemwide basis
Reorder point	Standard order point, min/max, and periodic review	When projected available inventory balance for a given future period is negative or below the safety stock level
Systemwide safety stock	High: safety stock carried at each location and level in the distribution network	Lower: consolidated at one location
Organizational implications	Downstream inventory requirements not visible to regional and national supply points	Assumption of planning responsibility by central planners Training in forecasting techniques needed Constant communication of accurate demand and supply information between central supply and warehouses

Use of Order Point in Pull Systems



Visual 4-36

Explain the pull system example, in which three local DCs release orders to a regional DC when inventory falls to the order-point level. Not shown but implied is that the regional DC also will release a replenishment order to central supply when its order point is reached upon the shipment of a replenishment order from DC 2.

Point out the disadvantages of the pull system—especially the challenge they present to central supply because visibility to downstream demand is very limited at best and demand at the factory is lumpy.

Note: The gold, orange, and brown vertical bars in the regional DC inventory schedule represent the order quantities requested by DCs 1, 2 and 3. The order from DC 2 causes the regional DC to reach its order point.

Use of Order Point in Pull Systems

The purpose of the visual is to demonstrate the impact of a pull system using the order point on a regional DC. Here are some of the key points that it illustrates and implies:

- Pull systems are decentralized. The lowest level stocking locations—DCs 1, 2, and 3—manage their own inventory to serve customers and release replenishment orders.
- DCs 1, 2 and 3 set order, or reorder, points for each SKU. The order points are based on the forecast demand through the replenishment lead time, or the time required for re-supply from the regional DC, plus safety stock.
- The regional DC also employs reorder point, safety stock, and order quantity factors in releasing its own replenishment orders to the central factory warehouse (not shown). Note that the replenishment order from DC 2 drops its inventory to below the regional DC's order point for an order release to central supply.

There are a few advantages but more disadvantages to the order-point pull system.

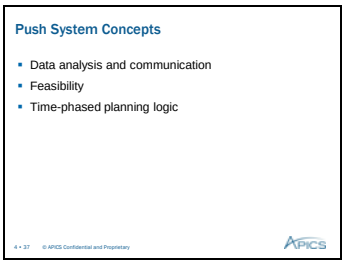
Advantages include the following:

- Demand data used to determine replenishment may be more timely and accurate.
- Local DCs are closer to the source of demand.

Disadvantages include the following:

- Upstream stocking locations, or the regional DCs and central supply, do not have access to the forecasts made by the local DCs.
- Demand arrives unpredictably and in a lumpy pattern.
- Orders are released without being coordinated with the needs of other DCs.
- Orders released are not coordinated with regional DC replenishment schedules or factory production schedules.
- Overall, upstream visibility to downstream forecasts and inventory levels is very poor.

Push Systems for Distribution Inventory



Visual 4-37

Introduce three push system concepts we need to know about push replenishment systems.

Data analysis and communication

Explain that a centralized push system requires a high degree of data sharing and communication.

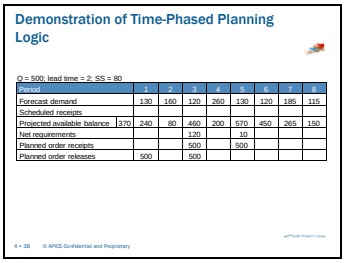
- Timely forecasts, sales, inventory status, and stock adjustment data need to be available.
- Lowest-level DCs need to communicate demand information relating to special marketing events that might cause a short-term spike or drop in demand.

Feasibility of centralized push systems

Explain that centralized push systems are most effective when

- all facilities are controlled by a single organization
- they involve partnerships with non-company-owned channels
- they are implemented as far into the distribution channel as practical.

Time-phased planning logic demonstration



Visual 4-38

Using the build feature of this visual, demonstrate the time-phased planning logic used in DRP.

Note: Point out the dynamic aspect of the forecast demand, which makes the use of time-phased planning logic beneficial.

Distribution Requirements Planning

DRP is a framework for implementing pull systems in distribution inventory management.

Time-phased planning logic

As mentioned earlier, DRP's time-phased planning logic is the logic used by material requirements planning (MRP). Standard time-phased planning logic grid displays are employed for each item.

Bill of distribution

In DRP, the dependencies between stocking locations at multiple levels are shown by a BOD, just as item records in MRP are linked through a bill of material.

Imploding to master scheduling

The planned order releases at the lowest-level stocking locations in the system, determined using time-phased planning logic, are then imploded, or rolled up, to contribute to the gross requirements of the next higher-level DC for that item. When the factory supply level is reached, those gross requirements are inputs to the master production schedule (MPS).

The planning horizon

The number of periods into the future for time-phased records in DRP systems must be planned when the system is designed.

- In general, the planning horizon should extend far enough into the future to cover the sum of all lead times from the beginning to the end of the manufacturing process through delivery to the final distribution point.
- Only with a sufficiently long planning horizon can organizations take actions, including production, in time to satisfy the demands of end users.

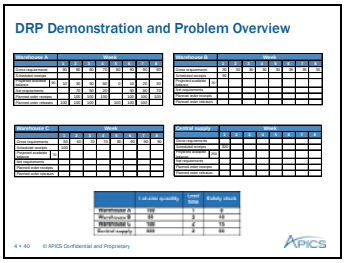
Frequency of replanning

Replanning can be performed either periodically or continually using system net-change regeneration.

- With periodic replanning, the time-phased planning logic records are regenerated on a regular cycle, usually corresponding to the length of each period in the display. Daily replanning is a common time interval. At the time of replanning, the current period's plan disappears—period two becomes period one, three becomes two, and so forth, with a new forecast added to the last period in the horizon.
- With continual planning, all data are maintained on a perpetual basis with updating of inventory, forecast, and order data based on transactions as they occur, usually in real time. This creates a much more dynamic system that can react quickly to changes as they occur.
- With net change, only those products that have had unplanned activities posted against them since the last run will be processed and calculated.

DRP Demonstration and Problems

Overview



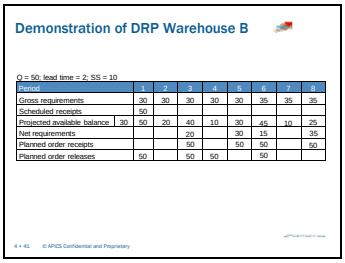
Visual 4-40

Explain that we will be studying an example that has three warehouses and a central supply source in order to understand DRP calculations. Warehouse A data have been filled in. Participants will do the following:

- Participate in a demonstration with the instructor to balance the DRP grid for warehouse B.
- Balance the DRP grid for warehouse C.
- Participate in a demonstration to learn how the planned order releases for warehouses A, B, and C are recorded in the central supply gross requirements grid.
- Balance the central supply grid.

Now move into a demonstration of how DRP grids are filled out, using warehouse B as an example.

Warehouse B demonstration



Visual 4-41

Using the build feature of this visual, walk through the process for balancing the DRP grid. Explain to participants that they will next fill in the warehouse C and central supply grids in Class Problems 4.5 and 4.6, respectively.

Measuring Performance

In *Distribution Planning and Control* (Ross, chap. 1, 2nd ed.), the author divides the performance measurement of the distribution network and planning process into seven performance objective categories, as shown in the visual and summarized in the table below.

The structure of these categories corresponds closely to the five attribute categories of the Supply Chain Council's Supply Chain Operating Reference (SCOR®) framework for performance. They share a similar philosophy:

- Performance of a system reflects the quality of performance in more than one category.
- Performance objectives in different categories may be in conflict.
- The priority of different performance objectives among organizations will differ because the organizations' products, markets, and competitive strategies are different.
- Within an organization, supply chain managers need to resolve conflicts between different performance objectives. Higher transportation costs might be tolerated, for example, in order to meet customer service objectives for a strategic customer.

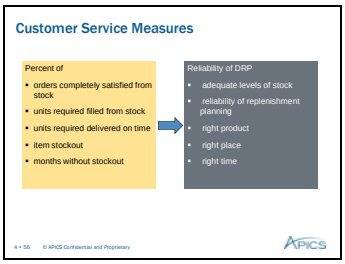
Performance objective category	Description	Corresponding SCOR attribute	Relevant SCOR level 1 metric
Service	Create customer value through agile and flexible operations to configure mix of products and services. Meet unique customer needs.	Responsiveness	Order fulfillment cycle time
Fast flow response	Fulfill the delivery requirements of each customer in a timely manner by having agile and flexible channels, driving waste out of processing time, responding to orders rather than forecasts through lean operations.	Responsiveness	Order fulfillment cycle time
Reduction of operating variance	In a manufacturing and distribution environment, eliminate variance in any sphere as it affects productivity.	Reliability	Perfect order
Minimum inventories	Maintain levels of inventory necessary to achieve sales and revenue objectives and the supply chain's commitment to customer service. Continually reduce inventory to achieve the lowest cost of logistics. Increase inventory-turn velocity.	Asset management	Cash-to-cash cycle time
Transportation reduction	Use closer interchannel inventory planning and replenishment, larger shipments over longer distances for economies of scale, and third-party service providers.	Cost	Reduce supply chain management cost
Quality management	Prevent defects such as incorrect inventories, invalid orders, and late shipments, which require lengthy and costly processes to reverse.	Cost Reliability	Reduce supply chain management cost Perfect order
Product life cycle support	Meet regulatory requirements and consumer expectations for handling, or reverse logistics, of the challenges posed by product recalls and returns, as well as recycling and refurbishment.	Agility	Upside supply chain flexibility Upside supply chain adaptability

Distribution System Performance Measures

Explain that performance measurements can be divided into the three areas associated with the overall objectives of distribution:

- customer service
- distribution efficiency
- inventory management

Customer Service



Visual 4-56

Explain that at first, these measures seem to be focused on order fulfillment rates and customer satisfaction, but they go deeper. They assess the quality of DRP, and they help to measure

- how reliably the replenishment planning process is maintaining adequate levels of distribution inventory
- how often the right products are in the right place at the right time in the distribution environment
- the level of variances in fulfilling customer orders

Ask what other performance measures are needed to validate the effectiveness of DRP.

Answer:

Inventory turns and cash-to-cash cycle time will indicate if too much inventory is being held in stock.

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Wrap-Up and Homework

Vocabulary Check

Match the vocabulary words to the correct definition:

1. _____ The function of determining the need to replenish inventory at branch warehouses
2. _____ The process of equitably allocating available stock among field distribution centers
3. _____ In distribution, a system for replenishing field warehouse inventories where replenishment decision making is centralized, usually at the manufacturing site or central supply facility
4. _____ Synonym for BOD
5. _____ In distribution, a system for replenishing field warehouse inventories where replenishment decisions are made at the field warehouse itself, not at the central warehouse or plant
6. _____ The time from the receipt of a customer order to the delivery of the product
7. _____ Any series of firms or individuals that participates in the flow of goods and services from the raw material supplier and producer to the final user or consumer
8. _____ An estimate of sales, often time-phased, for a grouping of products or product families produced by a facility or firm
9. _____ A warehouse with finished goods or service items
10. _____ The planned channels of inventory disbursement from one or more sources to field warehouses and ultimately to the customer; there may be one or more levels in the disbursement system

Word Bank:

a. aggregate forecast
b. BOD
c. channels of distribution
d. delivery lead time
e. distribution center
f. distribution requirements planning
g. distribution network structure
h. fair-share quantity logic
i. pull system
j. push system

Performance Check 

Remind the class that the main purpose of the performance check is to provide feedback. The questions all are multiple choice and are of the same type as on the APICS Master Planning of Resources examination.

If you will be assigning grades, **ask** the class to write their answers on a separate answer sheet.

Give the class the answers and let them mark their own papers. This is a good opportunity to reinforce material from this session. Discussion of answers is encouraged.

When the discussion is completed, **collect** the papers. If you are assigning grades, you can record from the papers.

Answers:

1. **b**—The definition of planning horizon is that it should extend far enough into the future to cover the sum of all lead times from the beginning to the end of the manufacturing process through delivery to the final distribution point. Answers *a*, *c*, and *d* are incorrect because planning horizon should extend far enough into the future to cover all lead times through delivery to the final distribution point.
2. **a**—With a pull system, a distribution center replenishes inventory based upon its own demand and supply parameters. Answer *b* is incorrect because centralized inventory management pushes inventory out to the distribution centers. Answer *c* is incorrect because pull systems are based on demand closest to the customer, not closest to production. Answer *d* is incorrect because there is no centralization of inventory management in a pull system of planning and control.
3. **d**—This is the overall goal of a distribution system. Answer *a* is incorrect because customer service is an important goal, but not the complete goal. Answer *b* is incorrect because customer service must be a factor. Answer *c* is incorrect because investment and cost are not the only factors; customer service must also be a factor.
4. **c**—"Percent of orders completely satisfied" is the correct answer. Answers *a* and *b* are incorrect because they are warehouse operations measurements. Answer *d* is incorrect because inventory turns is an inventory management measurement.

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