Note to site coordinators about distributing copies of this PowerPoint PDF to webinar participants

All slides are designed to be easily read when printed at the established three slides per page.

Appendices will not be included in the presentation. Accordingly, they use smaller font sizes but can still be easily read, assuming the PDF is printed at three slides per page.

Please distribute hard copies at the webinar just before it begins.

Note to webinar participants about this PowerPoint PDF

The handout is intended to supplement the webinar in three ways:

- Provide brief text and visuals that reinforce or illustrate the webinar leader's presentation.
- Provide a basis/place for taking notes during the webinar.
- Provide additional material (e.g., the appendices) for self or group study after the webinar.

This handout is not intended to be a self-standing document, that is, the handout has minimal value to a non-participant.

CRITICAL PATH METHOD: INTRODUCTION TO THE METHOD AND SOFTWARE

A Seminar Sponsored
by the
ASCE Continuing Education Program
In cooperation with
ASCE Leadership Development

Presented by
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APPENDICES

A: RESOURCES FOR FURTHER STUDY

B: PRESENTER

C: CPM HISTORY

TOPICS

INTRODUCTION

NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

TIPS FOR IDENTIFYING TASKS

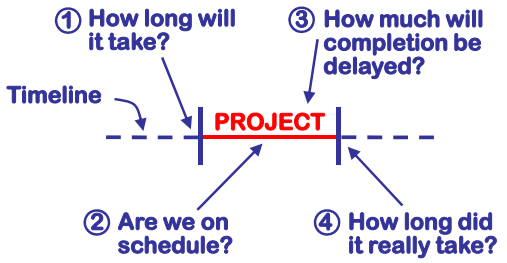
SOFTWARE

RECAP

As a result of this workshop, you should *be able to:*

- *Understand and apply* the basic steps in the CPM
- Appreciate the "think through – then do" *benefits* of the CPM

Schedule questions



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Chronological listing

Design of a small dam

Task	Elapsed time (weeks)
A. Perform site reconnaissance and survey	2.0
B. Draw site map	2.0
C. Specify soil borings	0.5
D. Arrange for and do soil borings	1.5
E. Submit application for preliminary permit	2.0
Etc.	---

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Gantt (bar) chart

Design of a small dam

Task	Time (weeks)					
	1	2	3	4	Etc.	
A						
B						
C						
D						
E						
Etc.						

TOPICS

INTRODUCTION

NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

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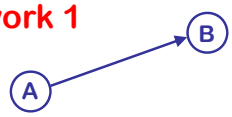
SOFTWARE

RECAP

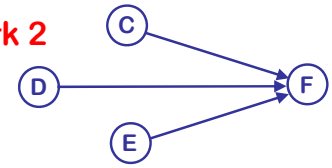
Network fundamentals

Network: Two or more ***nodes*** representing interdependent tasks connected by directional ***branches***

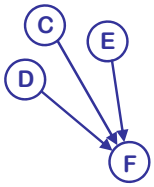
Network 1



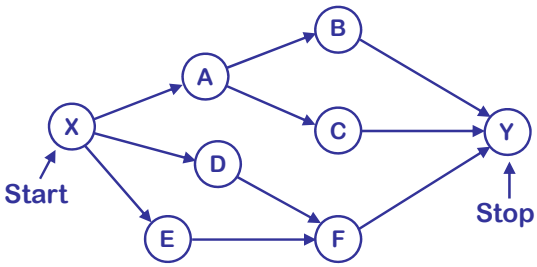
Network 2



Network 2



Network 3



TOPICS

INTRODUCTION

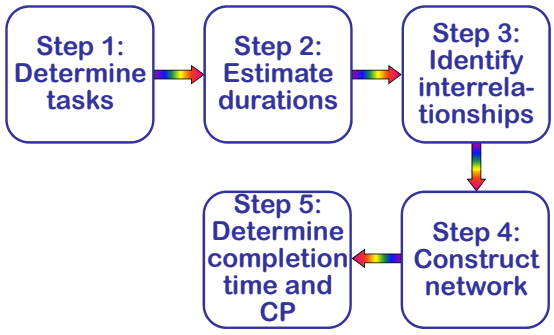
NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

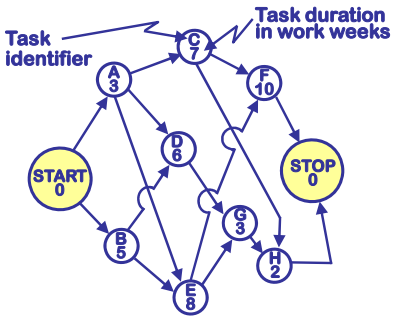
TIPS FOR IDENTIFYING TASKS

SOFTWARE

RECAP



Assume Steps 1 through 4 are complete



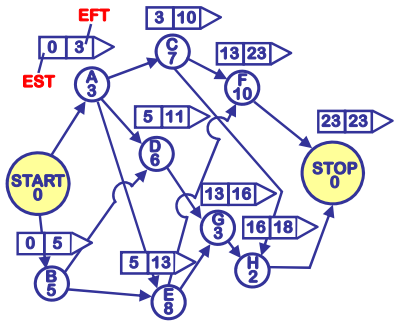
CPM *purpose*

- Determine *minimum time period* in which this project can be completed
- Identify *critical path*

Define EST and EFT for each task

- EST—Earliest Start Time. The earliest elapsed time, measured from the start of a project, when a particular task can possibly begin.
- EFT—Earliest Finish Time. The earliest elapsed time, measured from the start of a project, when a particular task can possibly be finished.
- EFT = EST + Duration

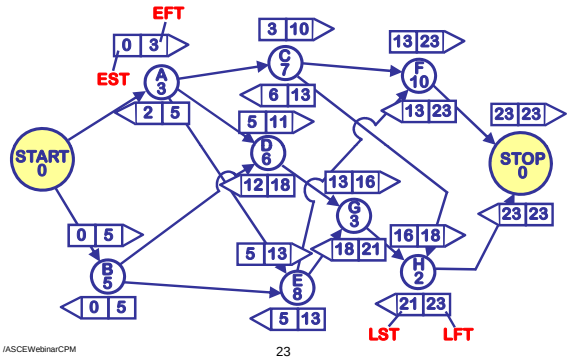
ESTs and EFTs



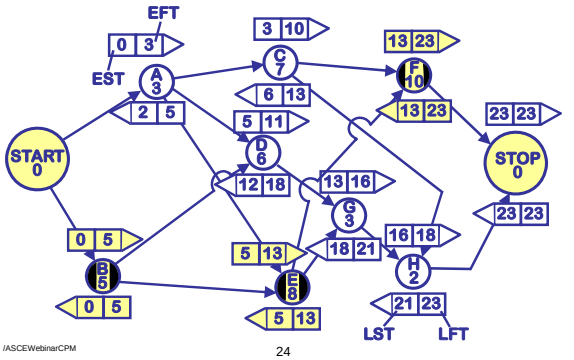
LST and LFT

- LFT—Latest Finish Time. The latest elapsed time, measured from the start of a project, when a particular task can be finished without delaying the overall completion of the project.
- LST—Latest Start Time. The latest elapsed time, measured from the start of a project, when a particular task can be started without delaying the overall completion of the project.
- LST = LFT - Duration

LSTs and LFTs



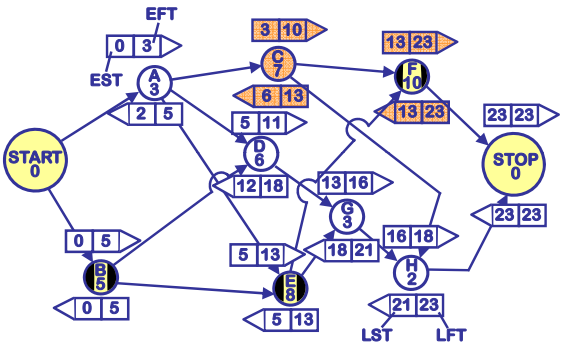
Critical path



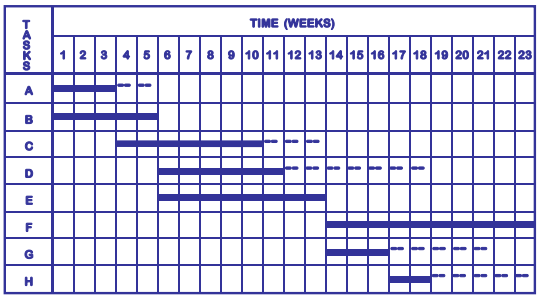
Float: **Amount of time that the start of a task can be delayed without delaying completion of the project**

Float = LST - EST
= LFT - EFT

Determine *floats*



Gantt (bar) chart



CPM analyses are routinely *updated*

Flawed logic

Missing tasks

Personnel shortages

Material delays

Faulty duration estimates

Weather

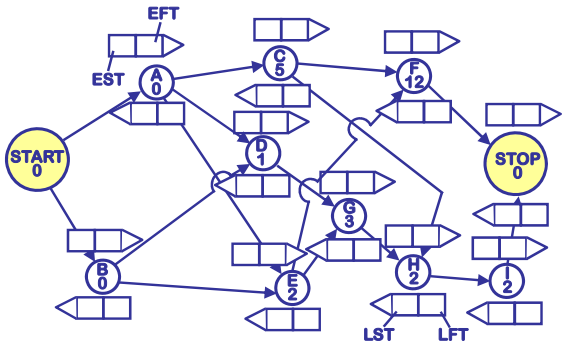
?

The following conditions exist at the end of the 10th week of the example project:

Task	Status
A	Done
B	Done
C	Underway with 5 weeks of work to be completed
D	Underway with 1 week of work to be completed

Task	Status
E	Underway with 2 weeks of work to be completed
F	Not started and duration estimate is increased from 10 to 12 weeks
G	Not started and no change in estimated duration
H	Not started and no change in estimated duration
I	A new task that depends only on H and has a 2 week duration

Updated network diagram



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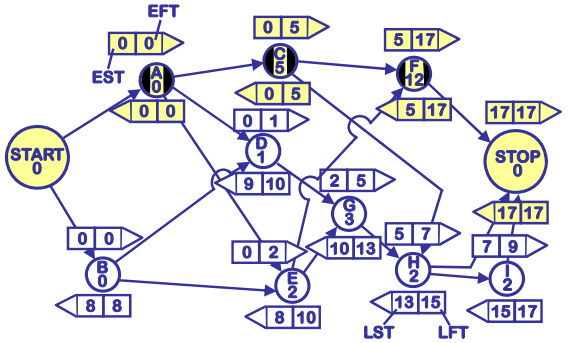
New critical path



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Negative Float

A task has a
negative float
if it must start
before
its predecessor is finished

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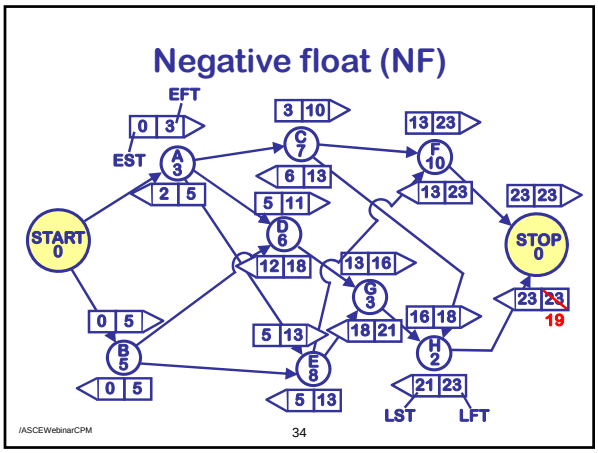
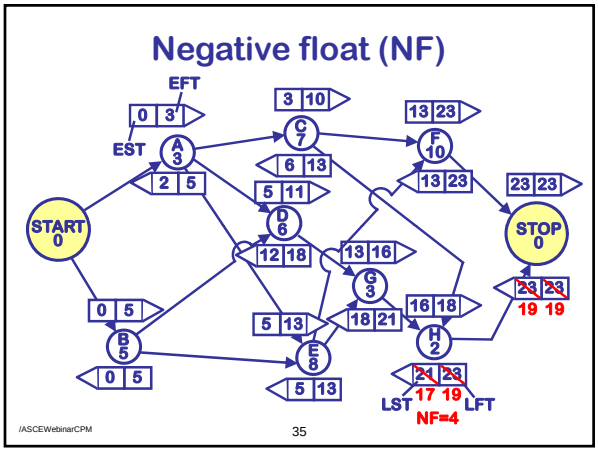
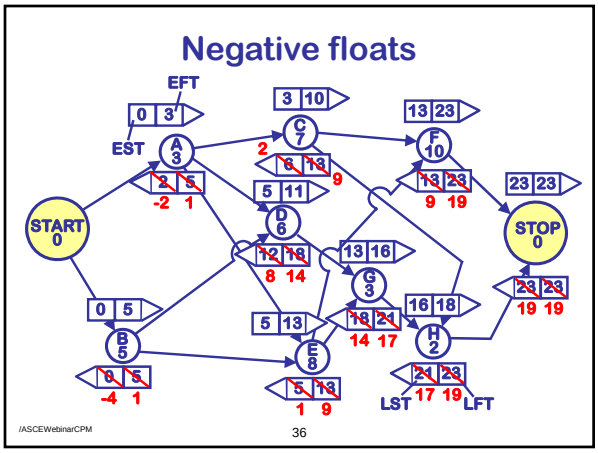
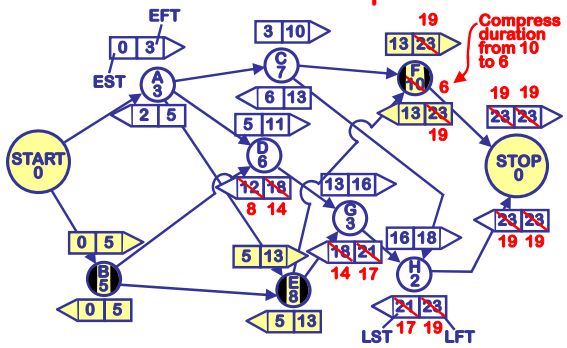

Negative float (NF)
EFT
EST
START 0
A 3
B 5
C 7
D 6
E 8
F 10
G 3
H 2
STOP 0
LST
LFT
/ASCEWebinarCPM
34


Negative float (NF)
EFT
EST
START 0
A 3
B 5
C 7
D 6
E 8
F 10
G 3
H 2
STOP 0
LST
17 19
LFT
NF=4
/ASCEWebinarCPM
35


Negative floats
EFT
EST
START 0
A 3
B 5
C 7
D 6
E 8
F 10
G 3
H 2
STOP 0
LST
17 19
LFT
/ASCEWebinarCPM
36

Revised critical path



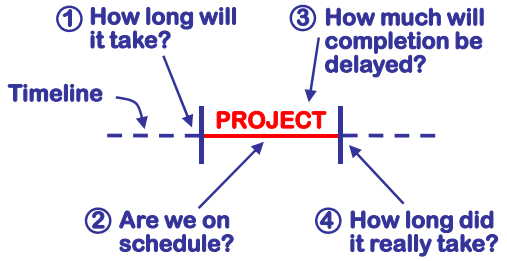
Observations

- *Horizontal,* left-to-right format is most common
- Can be two or more *"parallel"* CPs
- *Manual analysis* not practical for actual projects

High-value uses of the CPM

- Projects being undertaken for the *first time*
- *Multi*-discipline-department-office projects

CPM helps answer the *"four questions"*



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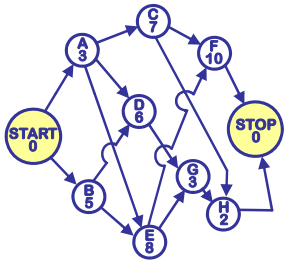
Principal value of the CPM



Network!

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TOPICS

INTRODUCTION

NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

TIPS FOR IDENTIFYING TASKS

SOFTWARE

RECAP

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Consider *physical location* of tasks

Task: Survey structure, streambed, and approach roads

Tasks:

- Survey structure
- Survey streambed
- Survey left approach road
- Survey right approach road

Phase long tasks

~~Public information program (PIP)~~

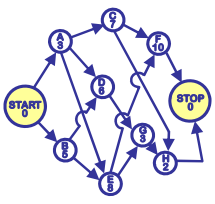
Many months

PIP Phase 1 | PIP Phase 2 | PIP Phase 3

Assign *responsibility* for tasks

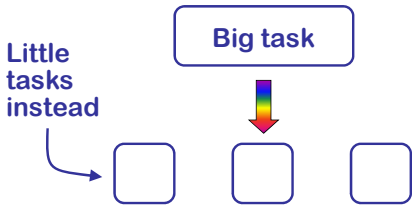
Task	Responsible person		
	Priscilla	Bob	Jose
Prepare project plan	X		
Conduct kick-off meeting with client			X
Survey left approach road		X	

Cross-check tasks against deliverables



Deliverables

Keep tasks *"small"*



Detailed *examples:*

Warehouse construction project (Naylor 1995)

Construction of a university building and a hydroelectric facility (Fisk 2000)

Gas station construction project (Halpin 2006)

Tasks Needed for Construction of a Gas Station

Task	Title	Duration (Days)
1	Mobilize	10
2	Obtain permits	15
3	Site work	8
4	Exterior utilities	12
5	Excavate catch basin	2
6	Excavate footers	5
7	Excavate foundation piers	6
8	Pour footers, etc.	8
9	Erect building frame	10
10	Exterior brick facade	14

Task	Title	Duration (Days)
11	Exterior fascia panels	4
12	Roof construction	15
13	Landscaping	12
14	Pour interior slabs	10
15	Glazing and doors	6
16	Interior walls	10
17	Electrical & mechanical systems	25
18	Shelves	3
19	Floor coverings	6
20	Interior finishes	8
21	Final inspection	1
22	Demobilization	3

Source: Halpin, 2006

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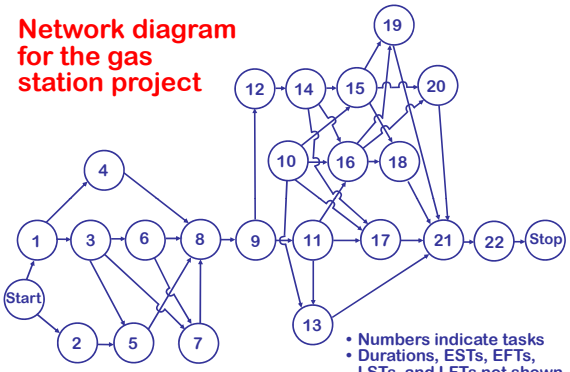
52

Network diagram for the gas station project



- Numbers indicate tasks
- Durations, ESTs, EFTs, LSTs, and LFTs not shown

Source: Halpin, 2006

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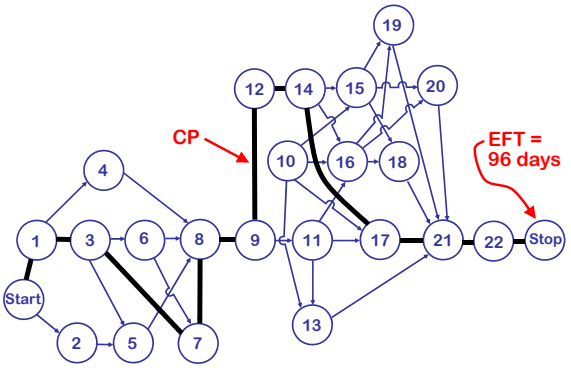
53



Source: Halpin, 2006

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54

Two points illustrated by applying the CPM to the gas station project:

- Must think through before we do
- Manual application not practical

TOPICS

INTRODUCTION

NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

TIPS FOR IDENTIFYING TASKS

SOFTWARE

RECAP

Available[1] software packages with CPM capability include:

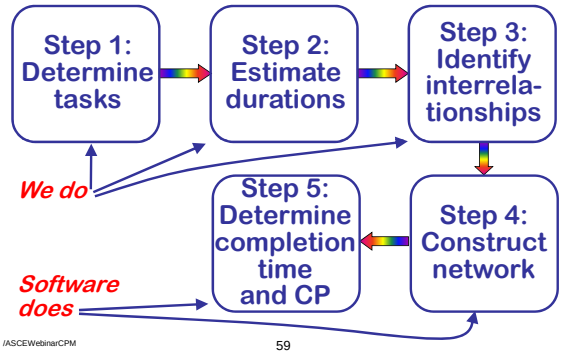
Microsoft Project[2]

Primavera/Oracle[2]

Open Workbench[2]

1) These are examples, the list is not all-inclusive.
2) For information, see the Website section of Appendix A.

Software is great!



Software with CPM capability enables us to consider *real project features* such as:

- Many tasks
- Complex interdependencies
- Frequent updates
- Weekends and holidays
- Personnel and other resource availability

Open Workbench is *freeware*

- *Company:* Softonic (formerly Computer Associate's Clarity Division, formerly Niku Corporation)
- *Computer OS:* Microsoft Win2000/XP/2003
- *Download:* http://open-workbench.en.softonic.com/

TOPICS

INTRODUCTION

NETWORK FUNDAMENTALS

CPM PROCESS AND EXAMPLE

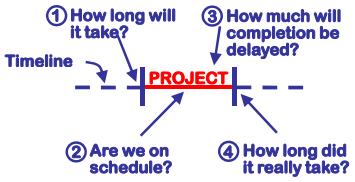
TIPS FOR IDENTIFYING TASKS

SOFTWARE

RECAP

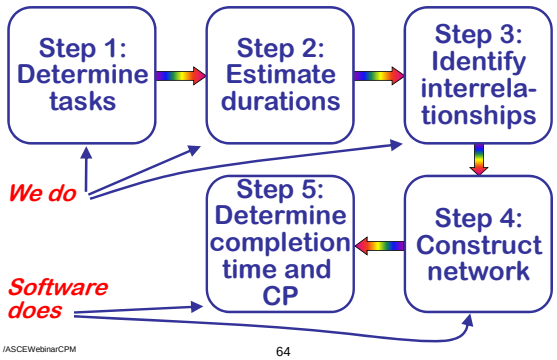
Recap

Questions:



CPM provides *answers*

The CPM:



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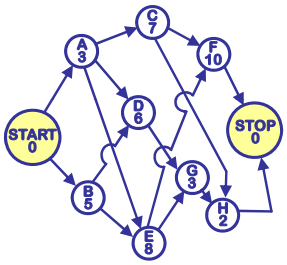
64

Principal value of the CPM



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65

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Questions
Comments
Critiques
Tips
Suggestions

stuwalesh@comcast.net

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66

Note: Listed here are sources cited earlier plus additional materials for individual and group study. If you know of a useful resource that should be included, please let me know.

Some images in this handout are used through a licensing agreement with iStockPhoto.com.

Thank you,
Stu Walesh
stuwalesh@comcast.net

Books and Articles

American Consulting Engineers Council. 1999. "Where Are You In The IT Pack?," *American Consulting Engineer,* November/December: 14-15. (Concluded that "Microsoft Project is by far the most frequently used project management tool." However, please note that this article was published in 1999.)

Collier, K. 1994. *Managing Construction: The Contractual Viewpoint,* Delmar Publishers, Albany, NY. (Negative float can arise when a project must be completed earlier than originally planned. States that "a [task] with negative float has a required start date earlier than the activity's scheduled start date." Tasks with negative float are identified by imposing the desired sooner completion date and working backwards.)

Construction Industry Institute. 1988. *Concepts and Methods of Schedule Compression,* Publication G-7, November.

Essex, D. E. 2005. "Master the Clock," *PM Network,* June, pp. 59-60. (Identifies project management software providers. Notes that PMI is developing a *Practice Standard for Scheduling* for release in early 2006.)

Essex, D. E. 2005. "Open-Workbench: Microsoft Project Killer?," *PM Network,* June, pp. 68-69. (Describes a free, open-source scheduling software package and how to obtain it. Features include CPM, Gantt charts, earned value, and time-to-complete. See the later Websites section of this appendix.)

Fisk, E. A. 2000. *Construction Project Administration – Sixth Edition,* Prentice Hall, Upper Saddle River, NJ. (Includes two construction CPM examples in Chapter 13, a university building and a hydroelectric project.)

Halpin, D. W. 2006. *Construction Management – Third Edition,* John Wiley & Sons, Hoboken, NJ.

Loulakis, M. G., and L. P. McLaughlin. 2005. "The Law: Court Requires CPM Analysis to Prove Shop Drawing Approval Delays," *Civil Engineering - ASCE*, June, p. 88. (The General Service Administration (GSA) Board of Contract Appeals "held that a contractor would have to use CPM schedule analysis to establish merits of its delay claim concerning the GSA's alleged late return of contractor submittals." The contract between the contractor and the GSA required that the contractor "maintain a CPM schedule.")

Mussivand, T. V. 1973. "Application of Critical Path Method to Water Resources Planning," *Journal of the American Water Resources Association,* Volume 8, Issue 4, pp. 685-696, June 8. (The paper's purpose is to "illustrate the effectiveness of the Critical Path Method by discussing its application to actual water resources projects.")

Naylor, H. F. W. 1995. *Construction Project Management: Planning and Scheduling.* Delmar Publishers, New York, NY. (Uses a 36 task warehouse construction project to illustrate various aspects of the CPM. Defines **total float** for a task as the difference between its LST and EST. **Free float** is defined as the amount of time a task's completion can be delayed without affecting the start time of any task following it.)

Spinner, M. P. 1992. *Elements of Project Management: Plan, Schedule, and Control,* Prentice Hall, Englewood Cliffs, NJ.

Walesh, S. G. 2000. *Engineering Your Future: The Non-Technical Side of Professional Practice in Engineering and Other Technical Fields,* Second Edition, Chapter 5, "Project Management," ASCE Press, Reston, VA.

Websites

"Critical Path Method," Wikipedia, (http://en.wikipedia.org/wiki/critical_path_method). Includes, in the External Links section, a slide presentation that describes and illustrates the CPM. (2/11)

"Critical Path Method," (http://hadm.sph.sc.edu/COURSES/J716/CPM/CPM.html). Introduces the CPM and describes, with an example, performing a CPM analysis with Excel and a program called Pathfind. (2/11)

"Helping You Engineer Your Future" (http://www.HelpingYouEngineerYourFuture.com) offers, for purchase, self-study aids to help individuals improve their project management knowledge and skills. (2/11)

"Microsoft Project ," (http://www.officemicrosoft.com/en-us/project-help/). Describes Project 2010. (2/11)

"MIND TOOLS – Critical Path Analysis and PERT Charts," (http://www.mindtools.com/critpath.html). Introduces the CPM and provides an example. This example differs from that used in the webinar in that the MIND TOOLS example uses the tasks on the arrows approach rather than the tasks on nodes. PERT (Program Evaluation and Review Technique) is introduced. (2/11)

"Open Workbench," (http://open-workbench.en.softonic.com). Source of freeware version of Softonic's Open Workbench for the desktop computer. The current version is 1.1.6.GA. Also includes useful FAQs. (2/11)

"Primavera," (http://www.oracle.com/us/corporate/acquisitions/primavera/index.html). Oracle acquired Primavera Software, Inc. in 2008. (2/11)

"Wideman Comparative Glossary of Project Management Terms," (http://www.maxwideman.com/pmglossary/PMG_A00.htm). As explained in the Introduction, the objective of the glossary "is to bring more order and better understanding to our world of project management. Accordingly, in many cases we provide not just one meaning, but several from many authoritative sources." (2/11)

APPENDIX B: PRESENTER

Dr. Stuart G. Walesh, PE provides management, engineering, education/training, and marketing services. He draws on more than 40 years of engineering, education, and management experience in the government and private sectors to help individuals and organizations engineer their futures. Walesh has functioned as a project manager, department head, discipline manager, marketer, professor, and dean of an engineering college.

Representative clients: include ASCE; Boston Society of Civil Engineers; BSA Life Structures; Castilla La Mancha University; CDM; Clark Dietz; Daimler Chrysler; DLZ; Earth Tech; Harris County (TX) Flood Control District; Hinshaw & Culbertson; Indiana Department of Natural Resources; Indiana Department of Transportation/Purdue University; J. F. New; Leggette, Brashears & Graham; Midwest Geosciences Group; MSA Professional Services; PBS&J; Town of Pendleton, IN; Pennoni Associates; Taylor Associates; City of Valparaiso, IN; University of Wisconsin Engineering Professional Development; and Wright Water Engineers.

Walesh authored *Urban Surface Water Management* (Wiley, 1989), *Engineering Your Future* (ASCE, 2000), *Flying Solo: How to Start an Individual Practitioner Consulting Business* (Hannah Publishing, 2000), *Managing and Leading: 52 Lessons Learned for Engineers* (ASCE, 2004), and *Managing and Leading: 44 Lessons Learned for Pharmacists* (ASHP, 2008, co-authored with Paul Bush, Pharm.D). Walesh is author or co-author

of over 200 publications and presentations and has facilitated or presented over 200 workshops, seminars, webinars, and meetings throughout the U.S.

Walesh is a member of ASCE's Committee on Academic Prerequisites for Professional Practice, was Special Issues Editor for ASCE's Committee on Publications, and chaired several national committees. In 1995, he received the Public Service Award from the Consulting Engineers of Indiana; in 1998, the Distinguished Service Citation from the College of Engineering at the University of Wisconsin; in 2003, the Excellence in Civil Engineering Education Leadership Award presented by ASCE; in 2004, he was elected an Honorary Member of ASCE; in 2005, he was elected a Diplomate of the American Academy of Water Resource Engineers; in 2007, he was named Engineer of the Year by the Indiana Society of Professional Engineers and received a Distinguished Service Award from the National Society of Professional Engineers; in 2008, he received the William H. Wisely American Civil Engineer Award from ASCE for leadership in promoting engineering as a profession; in 2009, he received the George K. Wadlin Distinguished Service Award from the Civil Engineering Division of the American Society for Engineering Education; and, in 2010, he was named a Fellow Member of the National Society of Professional Engineers.

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APPENDIX C: CPM HISTORY

The Critical Path Method was developed in 1956 by the Engineering Control Group, a design and construction unit of E.I. du Pont de Nemours and Company. The method was programmed by the Remington Rand Corporation to run on the UNIVAC computer. The first application of CPM was construction of a $10,000,000 chemical plant in Louisville, KY, in 1957. There were 800 tasks in this project. CPM is now widely used in planning and managing construction projects. However, CPM can be used for any project including, studies, planning, and design projects.

A related and somewhat more sophisticated method is the Program Evaluation and Review Technique (PERT). PERT and similar methods explicitly accommodate uncertainties associated with completion times of tasks. They are not addressed in this seminar.

Source: Walesh, 2000, Chapter 5