Electronics and
Computer Science

UNIVERSITY OF
Southampton

Planning Projects – Schedule and Cost Management

COMP6204: Software Project Management and Secure Development

Dr A. Rezazadeh (Reza)
Email: ra3@ecs.soton.ac.uk or ar4k06@soton.ac.uk
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Learning Objectives

- List several planning processes and outputs for project schedule and cost management when using a predictive approach to project management
- Describe the project schedule management planning processes and understand contents of a schedule management plan, activity list, activity attributes, milestone list, project schedule network diagram, duration estimates, basis of estimates, schedule baseline, project schedule, schedule data, and project calendars

Learning Objectives

- Understand how to find the critical path and its implications on timely project completion and explain the concept of critical chain scheduling and how it can be used in organizations
- Discuss the project cost management planning processes
- Create a cost management plan, cost estimate, basis of estimates, cost baseline, and project funding requirements
- Summarise planning project schedule and cost management for agile/hybrid projects including the concepts of timeboxing, the Kanban method, and relative sizing

Planning Processes and Outputs for Project Schedule and Cost Management

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Project schedule management	Plan schedule management	Schedule management plan
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Project Schedule Management (Predictive Approach)

- Project schedule management involves the processes required to ensure timely completion of a project
- The main planning tasks performed include *planning schedule* management, defining *activities*, sequencing activities, estimating activity durations, and developing the project schedule
- The main documents produced are a schedule management plan, an activity list and attributes, a milestone list, a project schedule network diagram, activity duration estimates, a schedule baseline, a project schedule, and project calendars

Contents of a Schedule Management Plan

- Scheduling methodology and tools used to create a schedule model, if required
- Release and iteration length, or time-boxed periods
- Level of accuracy required for activity duration estimates
- Units of measure, such as staff hours, days, or weeks
- Organizational procedure links

Contents of a Schedule Management Plan

- Project schedule model maintenance
- Control thresholds for monitoring schedule performance, such as a percentage deviation from the baseline plan
- Rules of performance measurement, especially if earned value management is used
- Formats and frequency for schedule reports

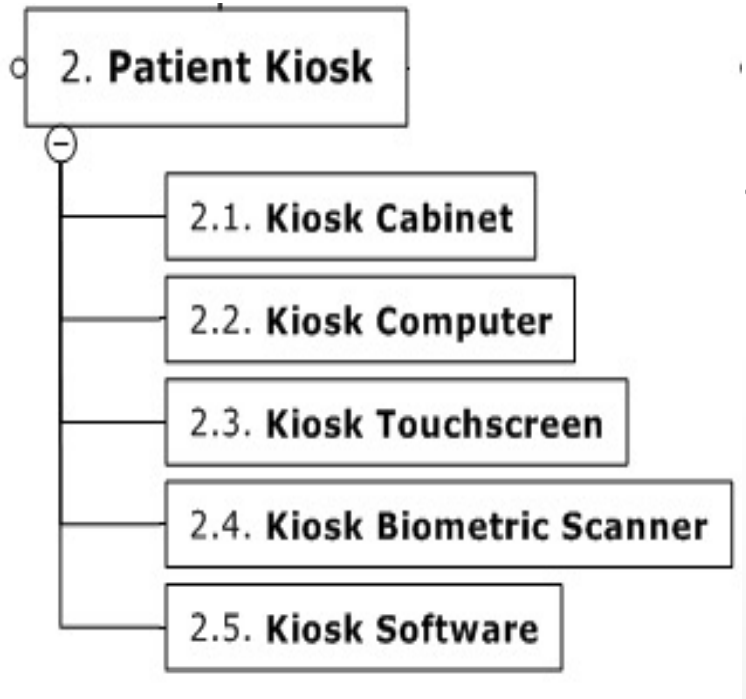
Defining Activities

- An *activity* is a distinct, scheduled portion of work performed during the course of a project.
- The goal of the defining activities process is to ensure that project team members have a complete understanding of all the work they must do as part of the project scope so that they can start scheduling the work.
- For example, how can you estimate how long it will take or what resources you need to prepare a report if you don't have more detailed information on the report?

Creating the Activity List and Attributes

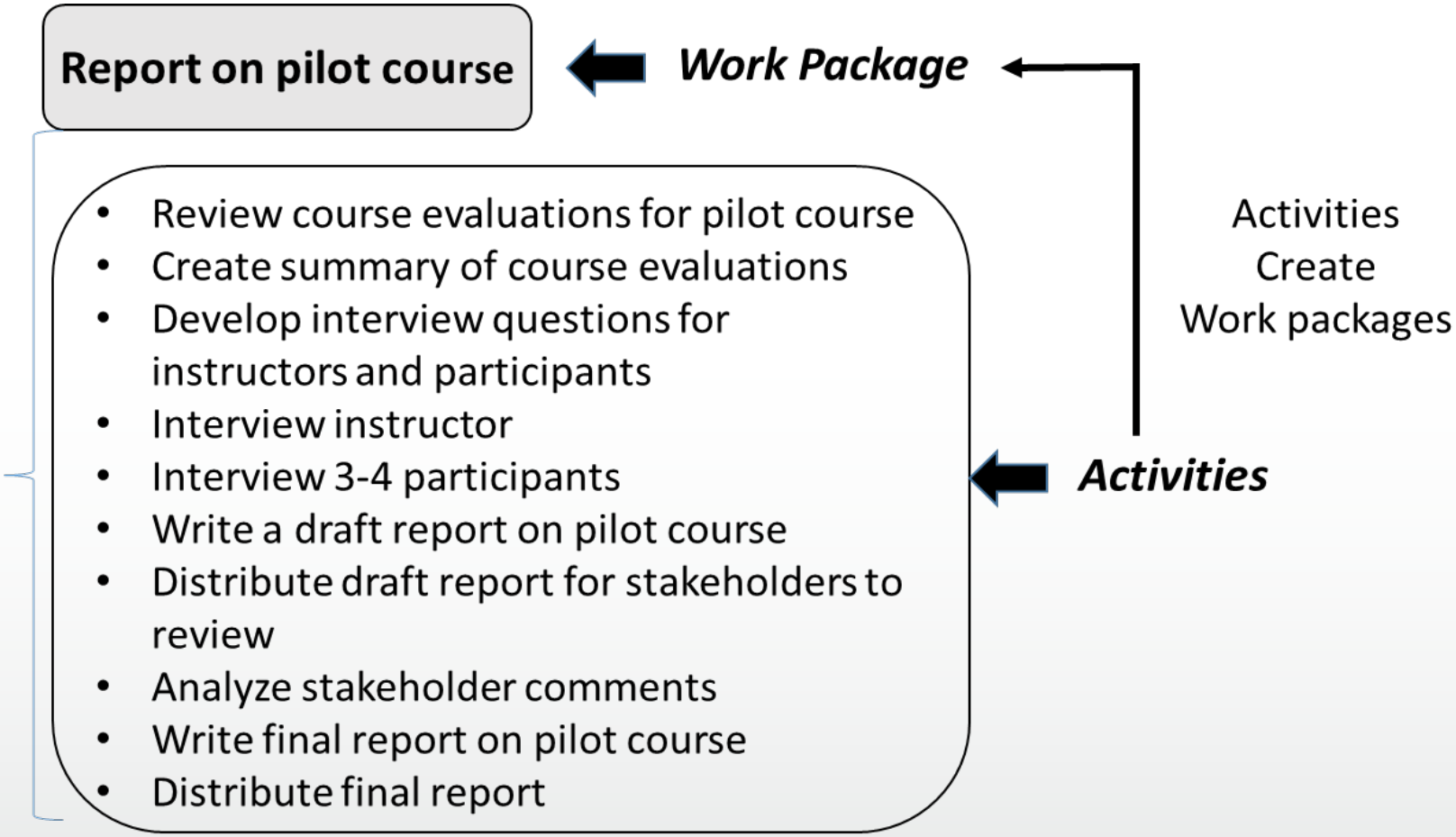
- The *activity list* is a tabulation of activities to be included on a project schedule
- It should include the activity name, an activity identifier or number, and a brief description of the activity
- The *activity attributes* provide schedule-related information about each activity, such as predecessors, successors, logical relationships, leads and lags, resource requirements, constraints, imposed dates, and assumptions related to the activity
  - Both should be in agreement with the WBS and WBS dictionary and be reviewed by key project stakeholders

WBS 100% Rule



- When a deliverable is decomposed into smaller deliverables (and eventually the work packages), all work required for a deliverable is included in its sub-deliverables, known as the WBS 100% rule.

Report on Pilot Course Activity List



Sample Activity List and Attributes

Activity List and Attributes
August 1

Project Name: Just-In-Time Training Project
WBS Item Number: 3.1.1.1.2
WBS Item Name: Survey administration
Predecessors: 3.1.1.1.1 Survey development
Successors: 3.1.1.1.3 Survey results analysis
Logical Relationships: finish-to-start
Leads and Lags: None
Resource Requirements: IT personnel, corporate survey software, corporate Intranet
Constraints: None
Imposed dates: None
Assumptions: The survey for the supplier management training will be administered online using the standard corporate survey software. It should include questions measured on a Likert scale. For example, a question might be as follows: I learned a lot from this course. Respondents would enter 1 for Strongly Agree, 2 for Agree, 3 for Undecided, 4 for Disagree, or 5 for Strongly Disagree. There also should be several open-ended questions, such as "What did you like most about the pilot course? What did you like least about the pilot course?" After the project steering committee approves the survey, the IT department will send it to all employees of grade level 52 or higher in the purchasing, accounting, engineering, information technology, sales, marketing, manufacturing, and human resource departments. The project champion, Mike Sundby, VP of Human Resources, will write an introductory paragraph for the survey. Department heads will mention the importance of responding to this survey in their department meetings and will send an e-mail to all affected employees to encourage their inputs. If the response rate is less than 30% one week after the survey is sent out, additional work may be required, such as a reminder e-mail to follow-up with people who have not responded to the survey.

Creating a Milestone List

- A *milestone* is a significant point or event in a project
- It often takes several activities and a lot of work to complete a milestone, but the milestone itself is like a marker to help identify necessary activities
- There is usually no cost or duration for a milestone
- Project sponsors and senior managers often focus on major milestones when reviewing projects
- Sample milestones for many projects include:
  - Sign-off of key documents
  - Completion of specific products
  - Completion of important process-related work, such as awarding a contract to a supplier

Sample Milestone List

Milestone	Initial Estimated Completion Date*
Draft survey completed	8/3
Survey comments submitted	8/8
Survey sent out by IT	8/10
Percentage of survey respondents reviewed	8/17
Survey report completed	8/22
Survey results reported to steering committee	8/24

*Note: Dates are in U.S. format. 8/3 means August 3.

Milestones List – Best Practice

- The SMART criteria suggest that milestones should be:
  - **S**pecific
  - **M**easurable
  - **A**ssignable
  - **R**ealistic
  - **T**ime-framed

Milestones List – Best Practice

- You can also use milestones to help reduce schedule risk by following these best practices:
  - Define milestones early in the project and include them in the Gantt chart to provide a visual guide
  - Keep milestones small and frequent
  - The set of milestones must be all-encompassing
  - Each milestone must be binary, meaning it is either complete or incomplete
  - Carefully monitor the milestones on the critical path

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Sequencing Activities

- *Sequencing activities* involves reviewing the activity list and attributes, project scope statement, and milestone list to determine the relationships or dependencies between activities
- A dependency or relationship relates to the sequencing of project activities or tasks
  - For example, does a certain activity have to be finished before another one can start?
  - Can the project team do several activities in parallel?
  - Can some overlap?
- Sequencing activities has a significant impact on developing and managing a project schedule

Reasons for Creating Dependencies

- Mandatory dependencies are inherent in the nature of the work being performed on a project
  - You cannot hold training classes until the training materials are ready
- Discretionary dependencies are defined by the project team
  - A project team might follow good practice and not start detailed design work until key stakeholders sign off on all of the analysis work

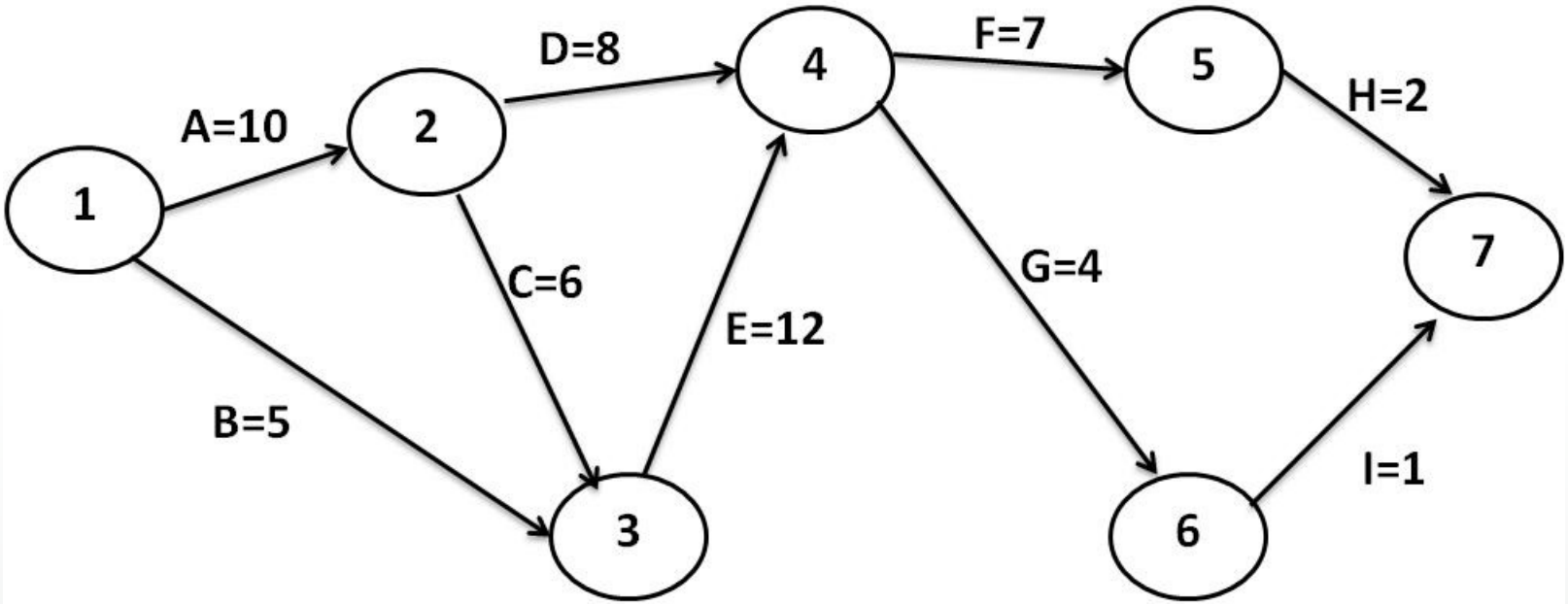
Reasons for Creating Dependencies – Cont.

- External dependencies involve relationships between project and non-project activities
  - The installation of new software might depend on delivery of new hardware from an external supplier.
  - Even though the delivery of the new hardware might not be in the scope of the project, it should have an external dependency added to it because late delivery will affect the project schedule
- Internal dependencies are within the project team's control, such as *testing a machine* that must be first assembled, where all the work is done inside the team.

Network Diagrams

- Network diagrams are the preferred technique for showing activity sequencing
- A network diagram is a schematic display of the logical relationships among, or sequencing of, project activities
  - In the activity-on-arrow (AOA) approach, or the arrow diagramming method (ADM), activities are represented by arrows and connected at points called nodes (starting and ending point of an activity) to illustrate the sequence of activities; only show finish-to-start dependencies (most common type of dependency)
  - The precedence diagramming method (PDM) (also called activity on node, or AON) is a network diagramming technique in which boxes represent activities These are more widely used as they can show all dependency types

Activity-on-Arrow (AOA) Network Diagram for Project X



Note: Assume all durations are in days;
A=10 means Activity A has a duration of 10 days.

More on Network Diagrams

- Keep in mind that the network diagram represents *activities* that must be done to complete the project; it is not a race to get from the first node to the last
- *Every* activity on the network diagram must be completed for the project to finish
- Not every item on the WBS needs to be on the network diagram; only activities with dependencies need to be shown on the network diagram

Steps for Creating an AOA Network Diagram

1. Find all of the activities that start at Node
2. Draw their finish nodes, and draw arrows between Node 1 and each of those finish nodes. Put the activity letter or name on the associated arrow.
   - If you have a duration estimate, write that next to the activity letter or name
3. Continue drawing the network diagram, working from left to right. Look for bursts and merges
   - Bursts occur when two or more activities follow a single node
   - A merge occurs when two or more nodes precede a single node
4. Continue drawing the AOA network diagram until all activities with dependencies are included on the diagram
5. As a rule of thumb, all arrowheads should face toward the right, and no arrows should cross on an AOA network diagram.
   - You might need to redraw the diagram to make it look presentable

Activity on Arrow vs. Activity on Node

Distinguishing Factor	Activity on Arrow	Activity on Node
Line information	Represents activities & precedence	Represents precedence
Node shape	Circle shape	Box shape
Activity information	Only duration typically shown	Often includes duration, start date, end date, and assigned resource
Line shape	Straight	Uses right angles
Line direction	Always moves rightward	Can move backwards, depending upon relationship (FF, FS, SF, SS)

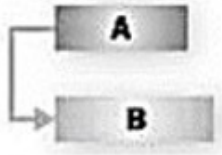
Activity Dependency Types

Finish-to-Start link (fs)

Task B can't start until Task A is done. This is the default link type in Project, and the most commonly used.

Example: *Dig foundation* (Task A) must be complete before your team can start *Pour concrete* (Task B).

Start-to-Start link (ss)

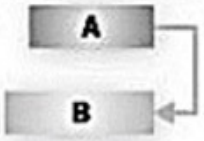


Task B can't start until Task A starts. They don't have to start at the same time: Task B can begin any time after Task A begins.

Example: To save time, you want to level concrete at one end of the foundation while it is still being poured at the other end. But *Level concrete* (Task B) can't start until *Pour concrete* (Task A) has also started.

Activity Dependency Types

Finish-to-Finish link (ff)



Task B can't finish until Task A is done. They don't have to end at the same time: Task B can end any time after Task A ends.

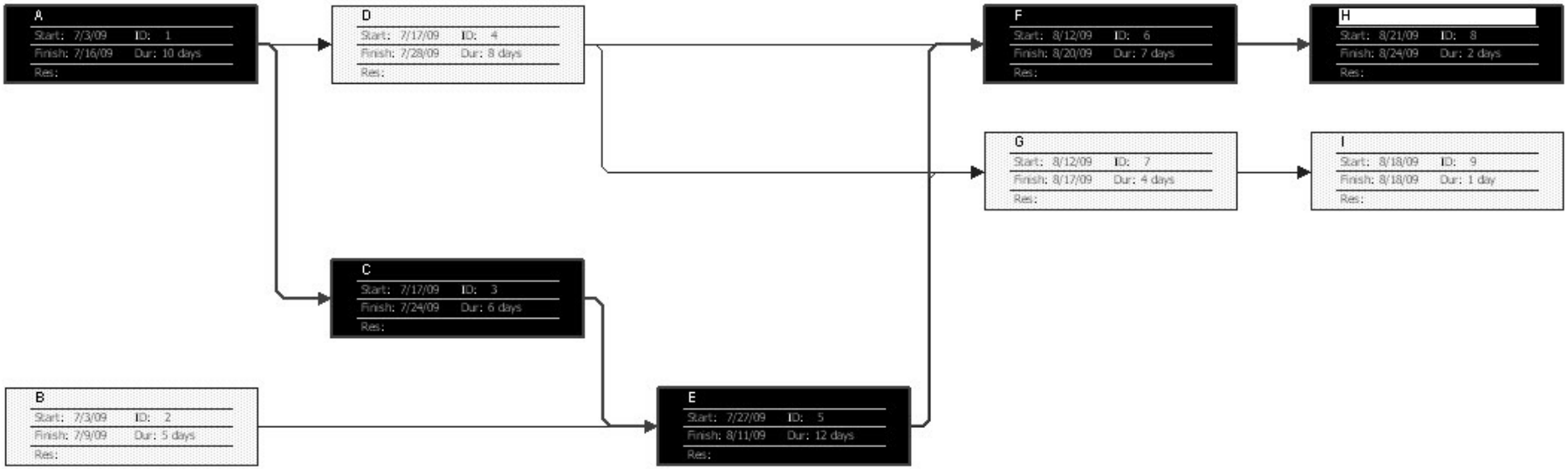
Example: Your team is adding the wiring to the building and inspecting it at the same time. Until *Add wiring* (Task A) gets done, you won't be able to finish *Inspect electrical* (Task B).

Start-to-Finish link (sf)

Task B can't finish until Task A begins. Task B can finish any time after Task A begins. This type of link is rarely used.

Example: The roof trusses for your building are built off-site. You can't finish *Assemble roof* (Task B) until *Truss delivery* (Task A) begins.

Precedence Diagramming Method (PDM) Network Diagram for Project X



Activity on Node

Lead vs Lag

- Lead and lag are two terms associated with the relationships that may occur between multiple schedule activities.
- Lead is the acceleration of a successor activity.
  - In other words, the second activity can begin (and be conducted in parallel) as the first activity.
- Lead is only found in activities with finish-to-start relationships: A must finish before B can start.
- Lag is the delay of a successor activity and represents time that must pass before the second activity can begin.
  - There are no resources associated with a lag.
- Lag may be found in activities with all relationship types: finish-to-start, start-to-start, finish-to-finish, and start-to-finish.

Example of Lead & Lag

- The photo shoot will take four days and the photo editing will take six days. Instead of waiting until the end of the 4-day photo shoot to begin editing the pictures, we start editing after the first day of shooting.
- This brings the total duration from ten days down to seven days by leveraging the lead.
- The photo proofs are sent to the customer upon completion of the shoot, however, there is a 15-day lag associated with the customer review before the printing of the photos can begin.

Lead and Lag

- Kristin and her team reviewed all the project activities and determined which ones had dependencies
- They also determined which activities had *lag* time or required a gap in time and which ones had *lead* time or could be overlapped
- For example, you might want to wait a certain period of time, perhaps 30 days, after holding the first training class before holding the second one (a lag of 30 days); or you might want to get started on writing a long research report 5 days before all of your reference materials are gathered (a lead of -5 days)

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Activity Duration Estimating – Effort vs Duration vs Elapsed Time

- During the "*Estimate Activity Durations*" process, the effort, duration, and elapsed time are determined for the schedule activities.
- *Effort* is the number of work units required to complete the activity.
- *Effort* may also be referred to as staff-hours, days, or weeks.
- In order to determine the activity duration, the effort required to complete the activity must be determined first.

Activity Duration Estimating – Effort vs Duration vs Elapsed Time

- Duration is the total time to complete the activities based on the resources available to the project.
  - Duration does not include holidays or non-working days and may be referred to workdays or weeks.
- *Elapsed time* is the calendar time or span required to complete the activities based on the resources available.
  - Elapsed time does include holidays and non-working days.
- Duration is used to determine the schedule; effort is used to determine labor costs.

An Example

- Installing the new drip system for the landscaping is estimated to take 80 hours of effort.
- If there is one worker committed to 40 hours per week, the duration would be 10 workdays.
  (Effort = 80 hours, Duration = 10 workdays, Elapsed time = 2 weeks)
- However, if there are two workers each committed to 40 hours per week, the duration would be 5 workdays.
  (Effort = 80 hours, Duration = 5 workdays, Elapsed time = 1 week)
- Or if there are two workers committed to 10 hours per week each, the duration would be 20 workdays.
  (Effort = 80 hours, Duration = 20 workdays, Elapsed time = 4 weeks)

Discrete, Range, and Three-Point Estimates

- Duration estimates are often provided as discrete estimates, such as four weeks
- A range estimate might be between three and five weeks
- A three-point estimate is an estimate that includes an optimistic, most likely, and pessimistic estimate, such as three, four, and five weeks

Program Evaluation and Review Technique (PERT)

- Program Evaluation and Review Technique (PERT) is a network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual activity duration estimates.
- PERT weighted average =

$$\frac{\text{optimistic time} + 4 \times \text{most likely time} + \text{pessimistic time}}{6}$$

- Example: PERT weighted average =

$$(1 \text{ workday} + 4 \times 2 \text{ workdays} + 9 \text{ workdays})/6 = 3 \text{ workdays}$$

- Instead of using the most likely time of two workdays for this task, you'd use three workdays with a PERT estimate

Monte Carlo Simulations and Probabilities

- Some people prefer using a Monte Carlo simulation over PERT because it accounts for various probabilities
- To perform a Monte Carlo simulation, in addition to the three-point estimate, you also collect probabilistic information for each activity duration estimate
  - For example, estimators must provide a probability of each activity being completed between the optimistic and most likely times
  - You then run a computer simulation to find probability distributions for the entire schedule being completed by certain times

Monte Carlo vs PERT Analysis – An Example

Suppose that you have three activities with the following duration estimates (in months):

Activity	Optimistic	Most Likely	Pessimistic	PERT Estimate
A	5	4	6	4.5
B	5	6	7	6
C	6	7	8	7
Total	16	17	21	17.5

According to the PERT estimate, you can complete these activities in 17.5 months.

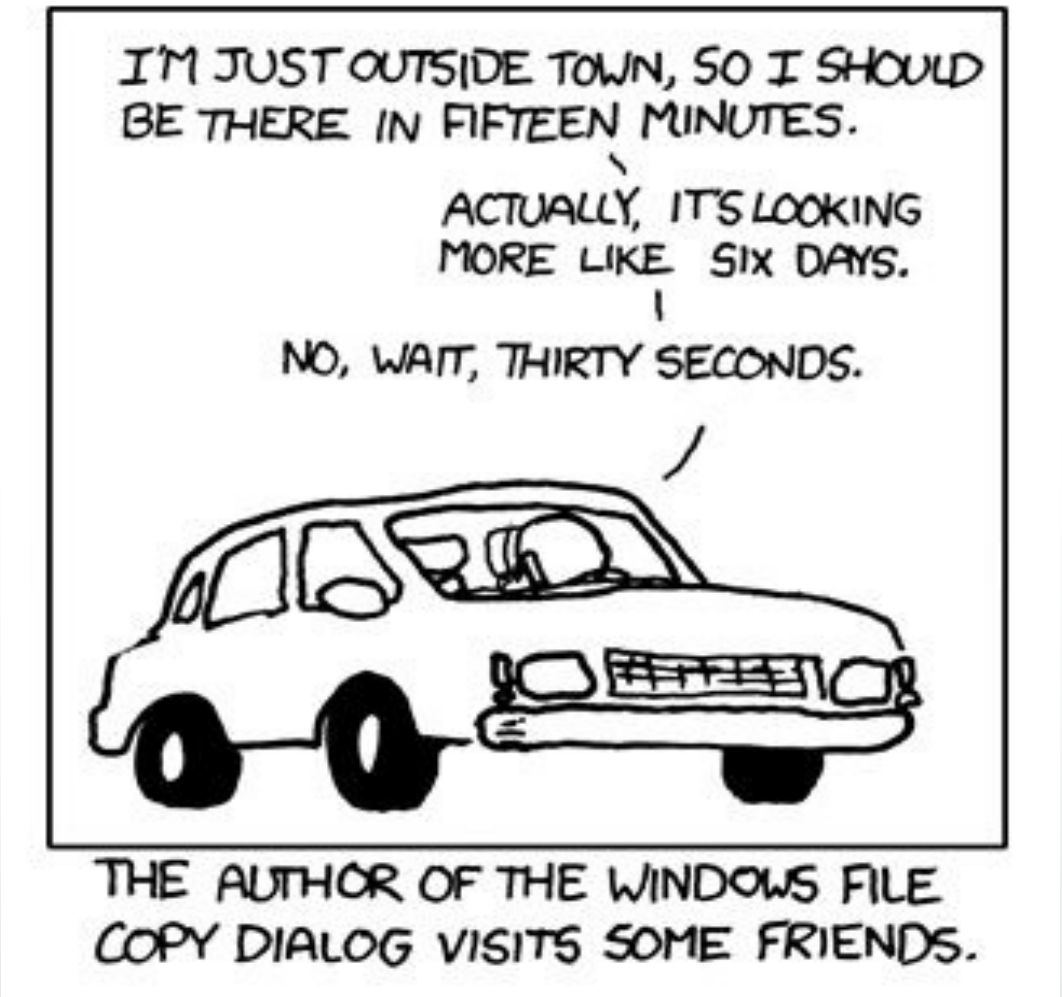
Now, if we run the Monte Carlo simulation for these tasks 500 times, it will show the following:

Duration (in months)	Chances of Completion
16	2%
17	8%
18	55%
19	70%
20	95%
21	100%

Sample Activity Duration Estimates

- Kristin and her team decided to enter realistic discrete estimates for each activity instead of using PERT or a Monte Carlo simulation
- She stressed that people who would do the work should provide the estimate, and they should have 50 percent confidence in meeting each estimate
- If some tasks took longer, some took less time, and some were exactly on target, they should still meet their overall schedule

Estimating Can Be Difficult! (www.xkcd.com)



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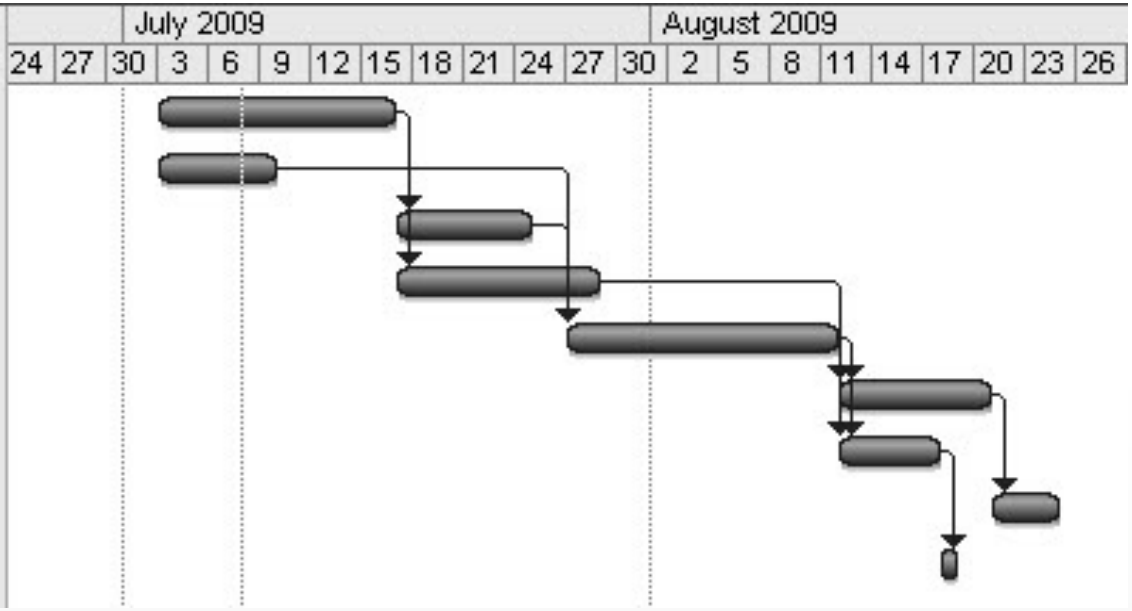
Developing the Project Schedule

- *Schedule development* uses the results of all the preceding project time management processes to determine the start and end dates of project activities and of the entire project
- The resulting project schedule is often shown on a *Gantt chart*, a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in a calendar format
- The ultimate goal of schedule development is to create a realistic project schedule that provides a basis for monitoring project progress for the time dimension of the project

Gantt Chart for Project X

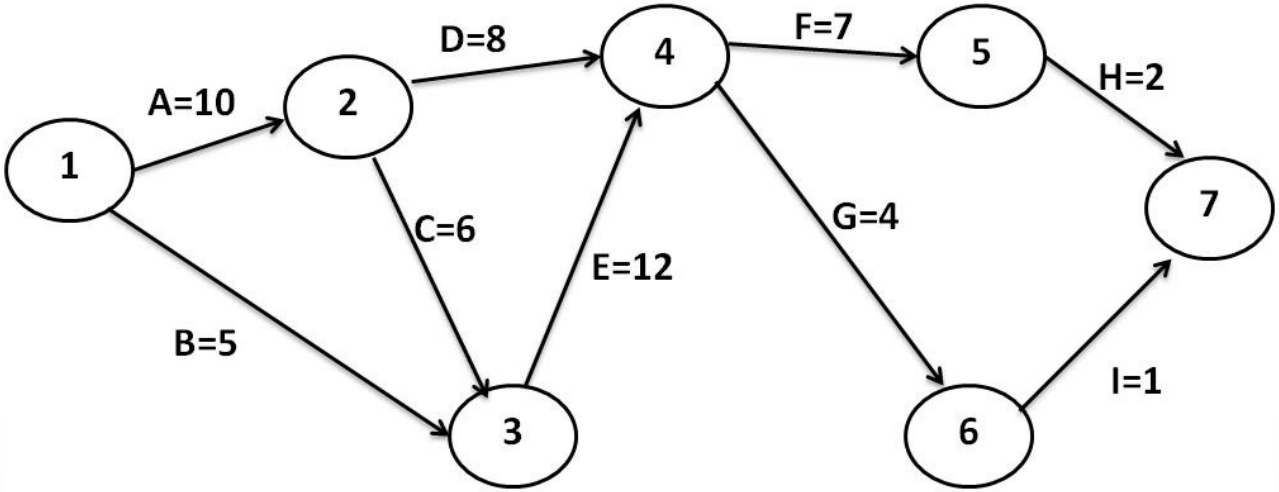
Task Name	Duration
A	10 days
B	5 days
C	6 days
D	8 days
E	12 days
F	7 days
G	4 days
H	2 days
I	1 day



Critical Path Analysis

- Critical path method (CPM)—also called critical path analysis—is a network diagramming technique used to predict total project duration
- A critical path for a project is the series of activities that determine the *earliest* time by which the project can be completed. It is the *longest* path through the network diagram and has the least amount of slack or float
  - Slack or float is the amount of time an activity may be delayed without delaying a succeeding activity or the project finish date
- The longest path or the path containing the critical tasks is what is driving the completion date for the project

Critical Path Calculation for Project X



Note: Assume all durations are in days.

Path 1: A-D-F-H	**Length = 10+8+7+2 =27**
Path 2: A-D-G-I	**Length = 10+8+4+1=23**
Path 3: A-C-E-F-H	**Length = 10+6+12+7+2=37**
Path 4: A-C-E-G-I	**Length = 10+6+12+4+1 = 33**
Path 5: B-E-F-H	**Length = 5+12+7+2=26**
Path 6: B-E-G-I	**Length = 5+12+4+1=22**

What Does the Critical Path Really Mean?

- *The critical path shows the shortest time in which a project can be completed*
- If one or more of the activities on the critical path takes longer than planned, the whole project schedule will slip *unless* the project manager takes corrective action
- For example: Apple Computer team members put a stuffed gorilla on top of the cubicle of whoever was in charge of a critical task, so they would not distract him or her

Growing Grass Can Be on the Critical Path

- The fact that its name includes the word "critical" does *not* mean that the *critical path* includes all *critical activities*
- Frank Addeman, executive project director at Walt Disney Imagineering, explained in a keynote address at the May 2000 PMI-ISSIG Professional Development Seminar that growing grass was on the critical path for building Disney's Animal Kingdom theme park
- This 500-acre park required special grass for its animal inhabitants, and some of the grass took years to grow
- So, growing grass was driving the completion date of the theme park; not what most people would think of as a critical activity

Using Critical Path Analysis to Make Schedule Trade-offs

- It is important to know what the critical path is throughout the life of a project so that the project manager can make trade-offs
- If one of the tasks on the critical path is behind schedule, should the schedule be renegotiated with stakeholders, or should more resources be allocated to other items on the critical path to make up for that time?
- It is also common for project stakeholders to want to shorten project schedule estimates, so you need to know what tasks are on the critical path

Schedule Compression Techniques

- Crashing is a technique for making cost and schedule trade-offs to obtain the greatest amount of schedule compression for the least incremental cost
  - If two critical tasks each take two weeks, and it will take $100 to shorten Task 1 by a week and $1,000 to shorten Task 2 by a week, shorten Task 1
- Fast tracking involves doing activities in parallel that you would normally do in sequence
  - Instead of waiting for Task 1 to be totally finished before starting Task 2, start Task 2 when Task 1 is halfway done
- Schedule compression often backfires by causing cost, human resource, and quality problems, which lead to even longer schedules

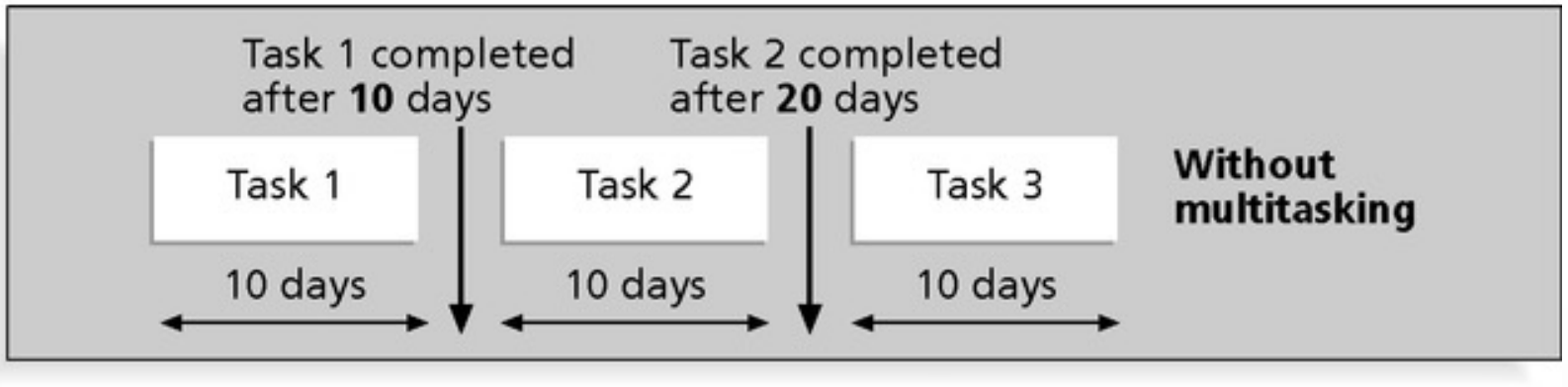
The critical path - Inherent drawbacks

- Any delay in any critical activity will delay the project.
- It assumes an unlimited supply of resources.
- The chances of completing the project within the schedule are low.
- Moreover, since the duration of the critical path is the duration of the project, project managers tend to inflate the duration of activities on a critical path to keep an extra margin for completing the project.
  - These miscalculations affect the schedule.
  - Therefore, the critical path method was upgraded to remove these drawbacks, and named the critical chain method.

Critical Chain Scheduling

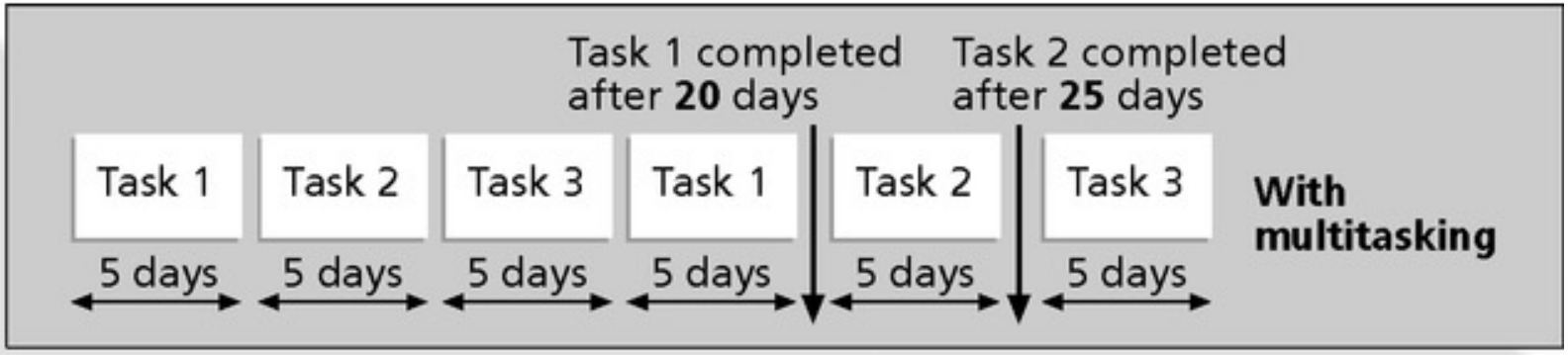
- Critical chain scheduling is a method of scheduling that considers limited resources when creating a project schedule and includes buffers to protect the project completion date.
  - Critical chain takes CPM a step further by adding time buffers to account for limited resources.
- It uses the Theory of Constraints (TOC), a management philosophy developed by Eliyahu M. Goldratt and introduced in his book *"The Goal* and *Critical Chain"*
- It attempts to minimize multitasking, which occurs when a resource works on more than one task at a time

Three Tasks Without Multitasking



Schwalbe, Information Technology Project Management, Sixth Edition, 2010

Three Tasks With Multitasking



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Media Snapshot

- Forbes got readers' attention by running an article entitled, "Multitasking Damages Your Brain and Career, New Studies Suggest." The article summarizes three different studies as follows:

  1. Multitasking is less productive than doing a single thing at a time.
  2. Multitasking lowers your IQ.
  3. Cognitive impairment from multitasking may be permanent.

Media Snapshot – Cont.

- Cleveland Clinic's website includes several resources to assist in mental health issues, especially during the pandemic.

  – "Trying to do too much at once makes it harder to be mindful and truly present in the moment – and mindfulness comes with a plethora of benefits for our minds and our bodies. In fact, many therapies based on mindfulness can even help patients suffering from depression, anxiety, chronic pain and other conditions."

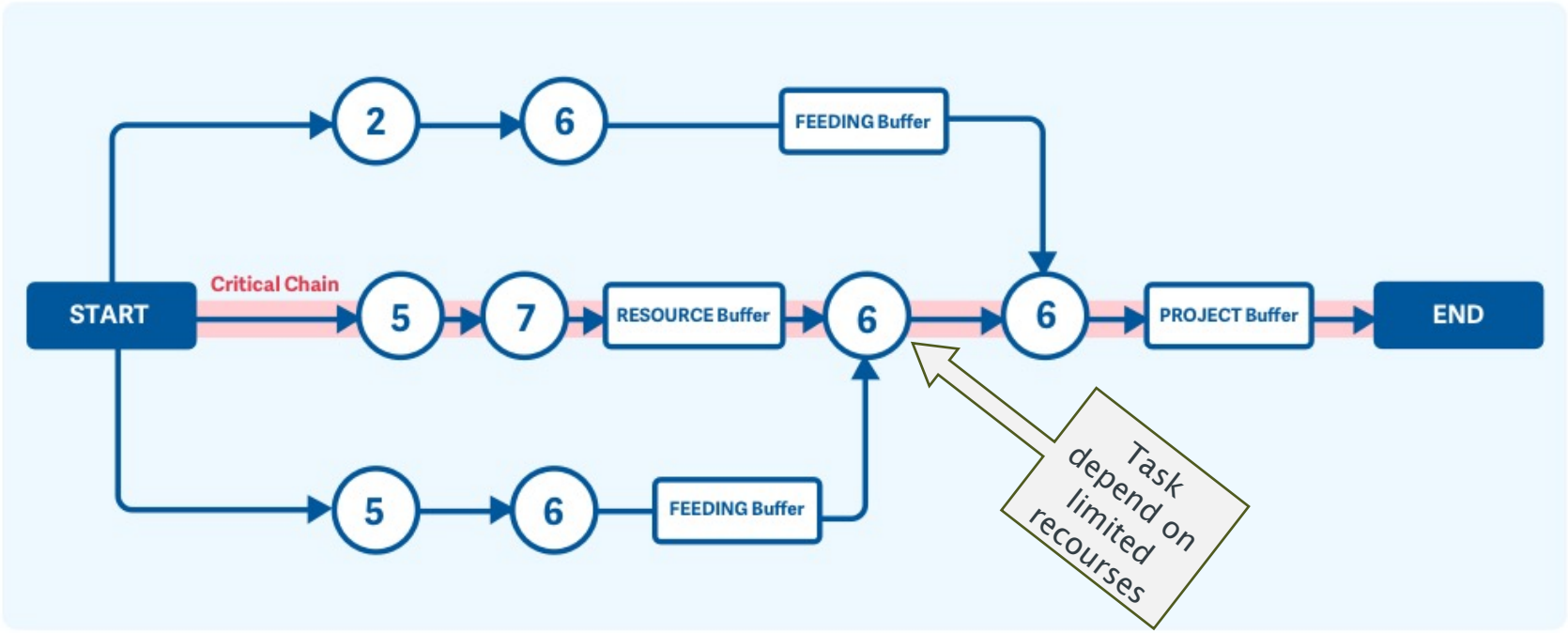
Buffers and Critical Chain

- A buffer is additional time to complete a task.
- Murphy's Law states that if something can go wrong, it will.
- Parkinson's Law states that work expands to fill the time allowed.
- In *traditional estimates*, people often add a buffer to each task and use it if it's needed or not.
- *Critical chain scheduling* removes buffers from individual tasks and instead creates
  - a project buffer or additional time added before the project's due date.
  - feeding buffers or additional time added before tasks on the critical path.

The critical chain – More on Buffers

- In the critical chain method, instead of the term “float” the term “buffer” Is used. There are three types of buffer:
  1. Project Buffer
  2. Feeding Buffer
  3. Resource Buffer
- The Project Buffer is added at the end of the project. Any activities which are delayed will eat up this buffer.
- The Feeding Buffer is added to the non-critical chain so any activities that get delayed will use the feeding buffer.
- The Resource Buffer is a resource that is kept alongside the critical chain to ensure continuity of the work.

Critical chain – Example of Buffers

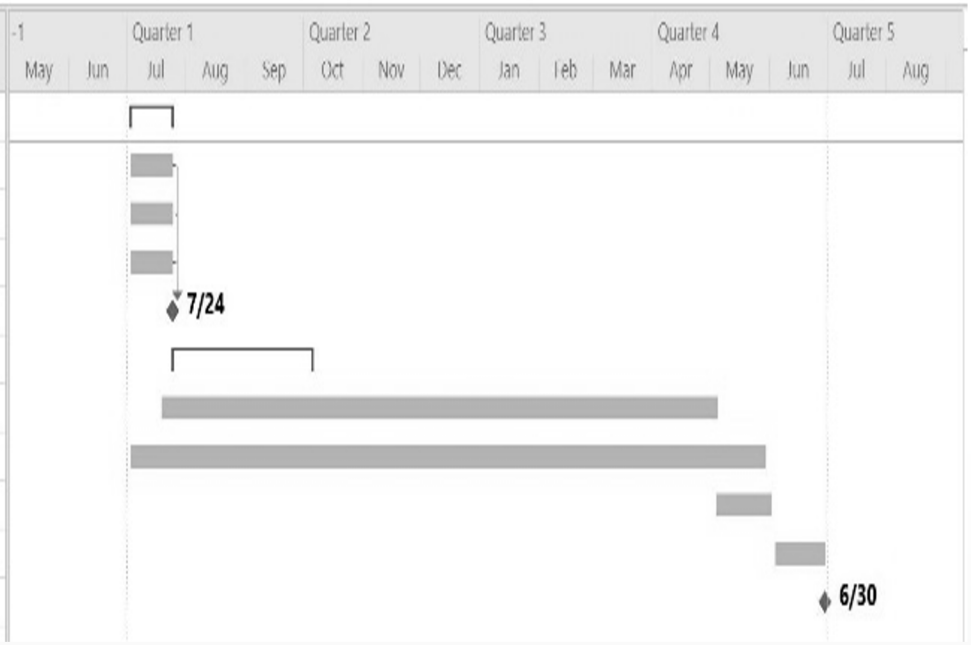


Critical Chain versus Critical Path

Critical Chain	Critical Path
No multitasking allowed	Multitasking allowed
Buffer for the whole project	Buffer for individual activities
Estimated durations don't include buffers	Estimated durations include buffers
Delayed start of non-critical activities	Non-critical activities start as soon as possible
Activities often completed ahead of schedule	Activities often completed on time or delayed
No simultaneous critical activities	Simultaneous critical activities possible
Relief from day-to-day business when working on critical activities	Project tasks need to be completed in addition to the workload of day-to-day operations

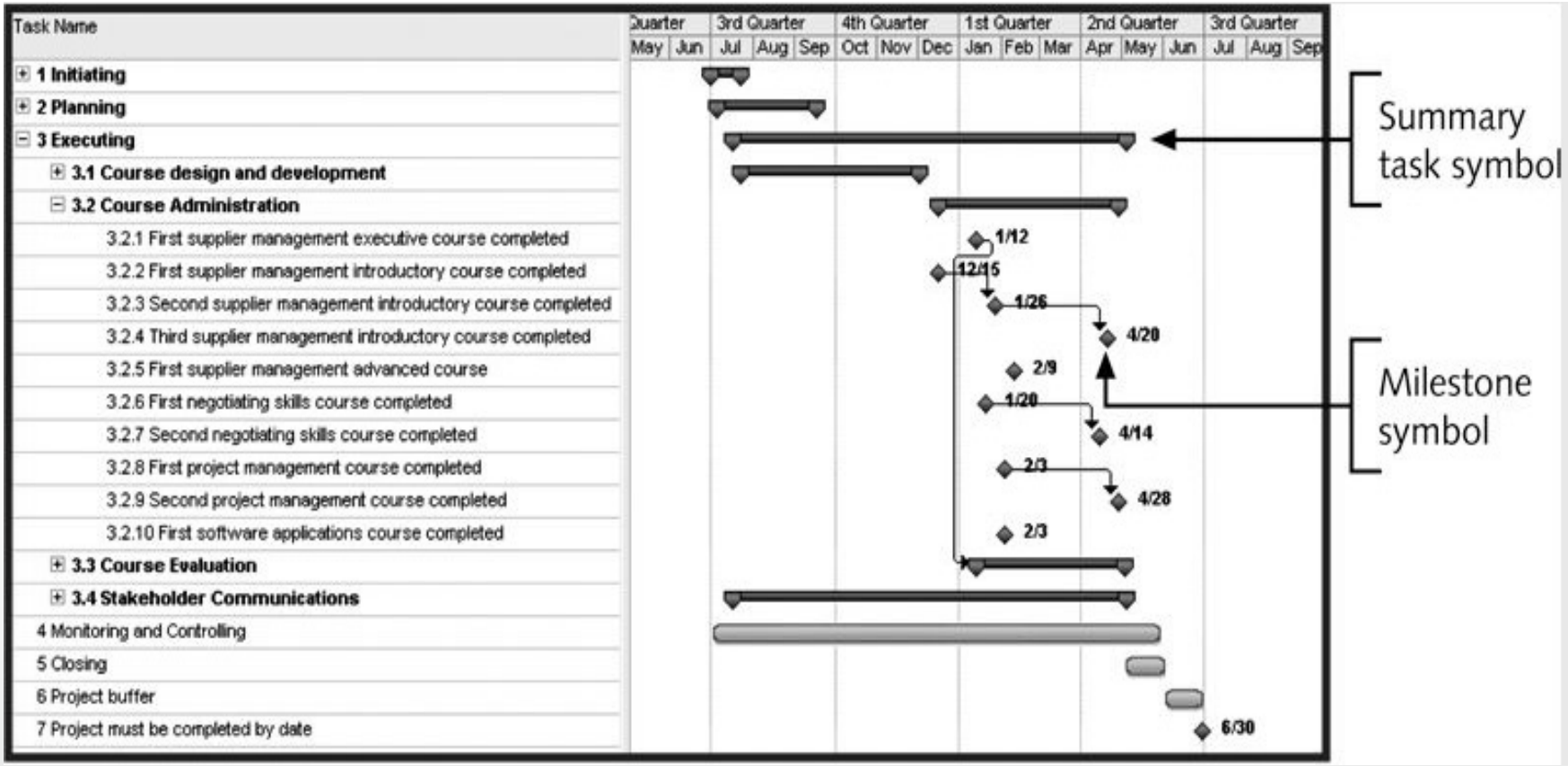
Sample Project Schedule

Task Name	Duration	Start	Finish	Predecessors
1 Initiating	**16 days**	**Mon 7/3/17**	**Mon 7/24/17**	
1.1 Stakeholder register	16 days	Mon 7/3/17	Mon 7/24/17	
1.2 Project charter	16 days	Mon 7/3/17	Mon 7/24/17	
1.3 Assumption log	16 days	Mon 7/3/17	Mon 7/24/17	
1.4 Project kickoff meeting	0 days	Mon 7/24/17	Mon 7/24/17	2,3,4
2 Planning	**53 days**	**Tue 7/25/17**	**Thu 10/5/17**	
3 Executing	208 days	Wed 7/19/17	Fri 5/4/18	
4 Monitoring and Controlling	237 days	Mon 7/3/17	Tue 5/29/18	
5 Closing	21 days	Fri 5/4/18	Fri 6/1/18	
6 Project buffer	20 days	Mon 6/4/18	Fri 6/29/18	
7 Project must be completed by date	0 days	Sat 6/30/18	Sat 6/30/18	



Notice that the items in the Task Name column come from the WBS from Chapter 4, Figure 4-15 (and activity list, once broken down in more detail), and duration estimates are entered in the "Duration" column. Also, notice the flow between the initiating, planning, executing, monitoring and controlling, and closing activities. Dependencies between activities are shown by the entries in the "Predecessors" column and the arrows connecting symbols on the Gantt chart. Milestones (represented by black diamonds

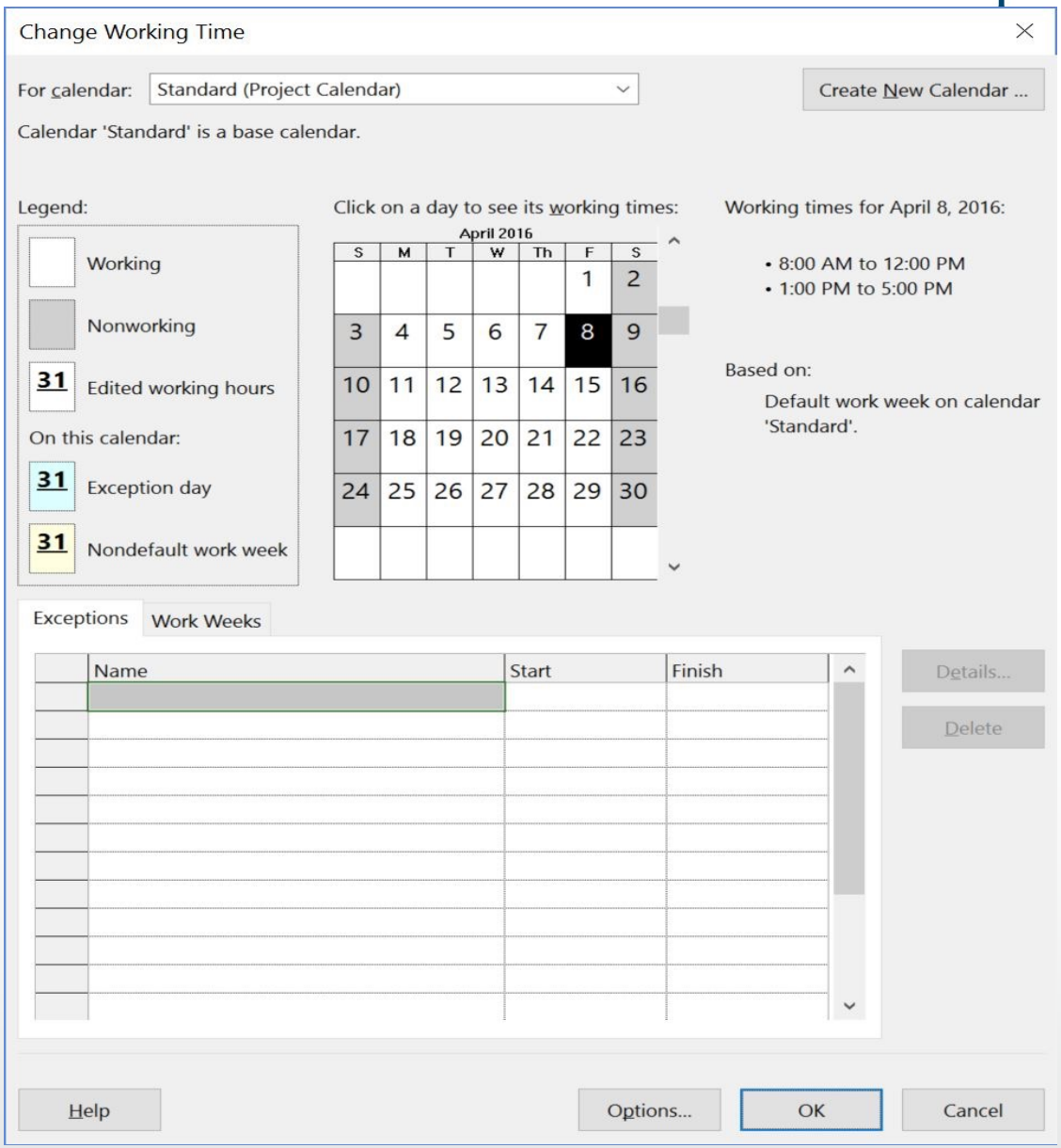
Sample Gantt Chart Showing Summary Tasks and Milestones



Sample Project Calendar

A project calendar shows work days and shifts available for scheduled activities.

Notice that working times are 8:00 AM to 12:00 PM and 1:00 PM to 5:00 PM on Mondays through Fridays.



Planning Processes and Outputs for Project Schedule and Cost Management

Knowledge area	Planning process	Outputs
Project schedule management	Plan schedule management	Schedule management plan
	Define activities	Activity list
		Activity attributes
		Milestone list
		Change requests
		Project management plan updates
	Sequence activities	Project schedule network diagrams
	Estimate activity durations	Project documents updates
		Activity duration estimates
		Basis of estimates
		Project documents updates
	Develop schedule	Schedule baseline
		Project schedule
		Schedule data
		Project calendars
		Project management plan updates
		Project documents updates
Project cost management	**Plan cost management**	Cost management plan
	Estimate costs	Cost estimates
		Basis of estimates
		Project documents updates
	Determine budget	Cost baseline
		Project funding requirements
		Project documents updates

Project Cost Management

- Project cost management includes the processes required to ensure that a project team completes a project within an approved budget
- The main planning tasks are planning cost management, estimating costs, and determining the budget
- The main documents produced include a cost management plan, a cost estimate, and a cost performance baseline

Planning Cost Management

- The purpose of this process is to determine the *policies*, *procedures*, and *documentation* for *planning*, *managing*, *executing*, and *controlling* project *costs*
- The project team holds *meetings*, consults with *experts*, and analyzes data to help produce a *cost management* plan, which becomes a component of the project management plan

Possible Contents of a Cost Management Plan

- Units of measure, such as staff hours or days or a lump sum amount, currency to be used, inflation assumptions, etc.
- Level of *precision* for cost estimates, such as how to round numbers
- Level of accuracy, such as +/-10%
- Organizational procedure links
- Control *thresholds* for monitoring cost performance, such as a percentage deviation from the baseline plan
- Rules of performance measurement, especially if earned value management is used
- Reporting formats and frequency for cost reports
- Additional details about cost activities, such as *strategic funding* choices, procedures to account for currency fluctuations, and procedures for recording costs

What Went Right?

- Crowdsourcing provides an interesting approach to funding projects, especially those involving new products. Instead of obtaining funding from traditional sources, you can solicit funds from a large group of people online.
- For example, the three co-founders of Inspiration Medical, a Minneapolis-based start-up firm, used crowdsourcing to finance the research and development work they need to develop a product to help people with bleeding problems.
- They used social media to introduce their product to potential customers and get feedback before spending hundreds of thousands of dollars on marketing.

Estimating Costs

- Project teams normally prepare *cost estimates* at various stages of a project, and these estimates should be fine-tuned as time progresses
- It is also important to provide *supporting details* for the estimates, including ground rules and assumptions (sometimes called the basis of estimates)
- A large percentage of total project costs are often *labor costs*, so it is important to do a good job estimating labor hours and costs

Cost Estimating Techniques

- Analogous estimates, also called top-down estimates, use the actual cost of a previous, similar project as the basis for estimating the cost of the current project. This technique requires a good deal of expert judgment and is generally less costly than others are, but it can also be less accurate
- Bottom-up estimates involve estimating individual activities and summing them to get a project total. This approach can increase the accuracy of the cost estimate, but it can also be time intensive and, therefore, expensive to develop
- Parametric modeling uses project characteristics (parameters) in a mathematical model to estimate project costs

Cost Estimating Process

- See the detailed steps, ground rules, and assumptions that Kristin's team used for developing their cost estimate
- Summary information was documented in a cost model
- Just as projects are unique, so are cost estimates
- Consult with internal and external experts and organizations for assistance

Sample Cost Estimate

WBS Categories	Internal Labor	$/hour	Internal $ Total	External Labor	$/hour	External $ Total	Total Labor	Non-labor $	Total Cost
1. Initiating	200	$ 65	$ 13,000			$ -	$ 13,000		$ 13,000
2. Planning	600	$ 60	$ 36,000			$ -	$ 36,000		$ 36,000
3. Executing			$ -			$ -	$ -		$ -
3.1 Course design and development			$ -			$ -	$ -		$ -
3.1.1 Supplier management training	600	$ 60	$ 36,000	600	$ 150	$90,000	$ 126,000	$ 100,000	$ 226,000
3.1.2 Negotiating skills training	300	$ 55	$ 16,500	300	$ 150	$45,000	$ 61,500	$ 50,000	$ 111,500
3.1.3 Project management training	400	$ 60	$ 24,000	400	$ 150	$60,000	$ 84,000	$ 50,000	$ 134,000
3.1.4 Software applications training	400	$ 60	$ 24,000	400	$ 150	$60,000	$ 84,000	$ 50,000	$ 134,000
3.2 Course administration	400	$ 55	$ 22,000	300	$ 250	$75,000	$ 97,000	$ 80,000	$ 177,000
3.3.Course evaluation	300	$ 55	$ 16,500			$ -	$ 16,500		$ 16,500
3.4 Stakeholder communications	300	$ 55	$ 16,500			$ -	$ 16,500		$ 16,500
4. Monitoring and Controlling	500	$ 55	$ 27,500			$ -	$ 27,500		$ 27,500
5. Closing	200	$ 55	$ 11,000			$ -	$ 11,000		$ 11,000
Subtotal									$ 903,000
Reserves			$ -			$ -	$ -		90,300.0
Total	4,200		243,000	2,000		330,000	573,000	330,000	**$ 993,300**

Assumptions:

Internal labor rates include benefits and overhead. Average hourly rates based on skill levels and departments.

External labor rates are based on historical average; may change as contracts are awarded.

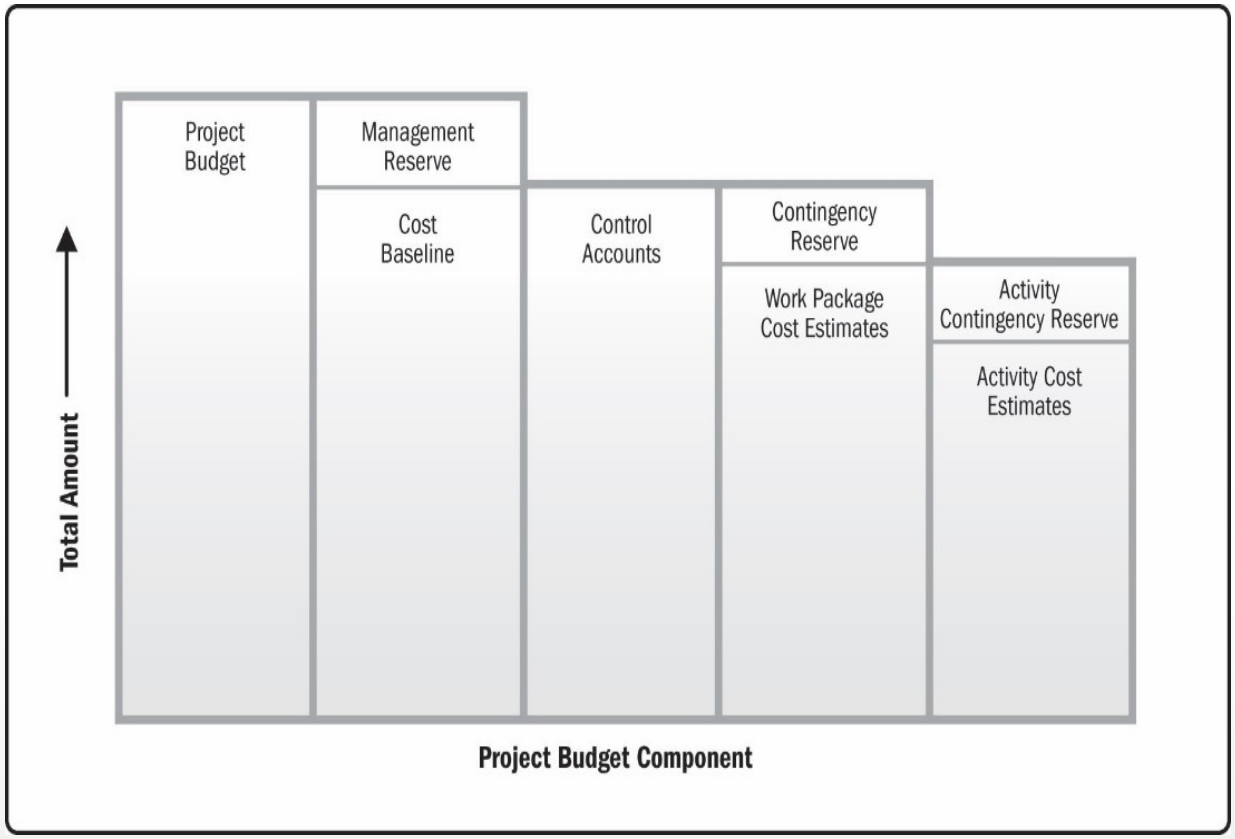
Non-labor costs include purchasing licenses for using training materials, books, DVDs, travel expenses, etc.; may change as contracts are awarded.

Reserves are calculated by taking 10% of the subtotal for the estimate. These contingency reserves are based on known risks.

Cost Budgeting

- Project *cost budgeting* involves allocating the project cost estimate to tasks over time
- The tasks are based on the work breakdown structure for the project
- The main goal of the cost budgeting process is to produce a cost baseline, or time-phased budget, that project managers use to measure and monitor cost performance

Project Budget Components

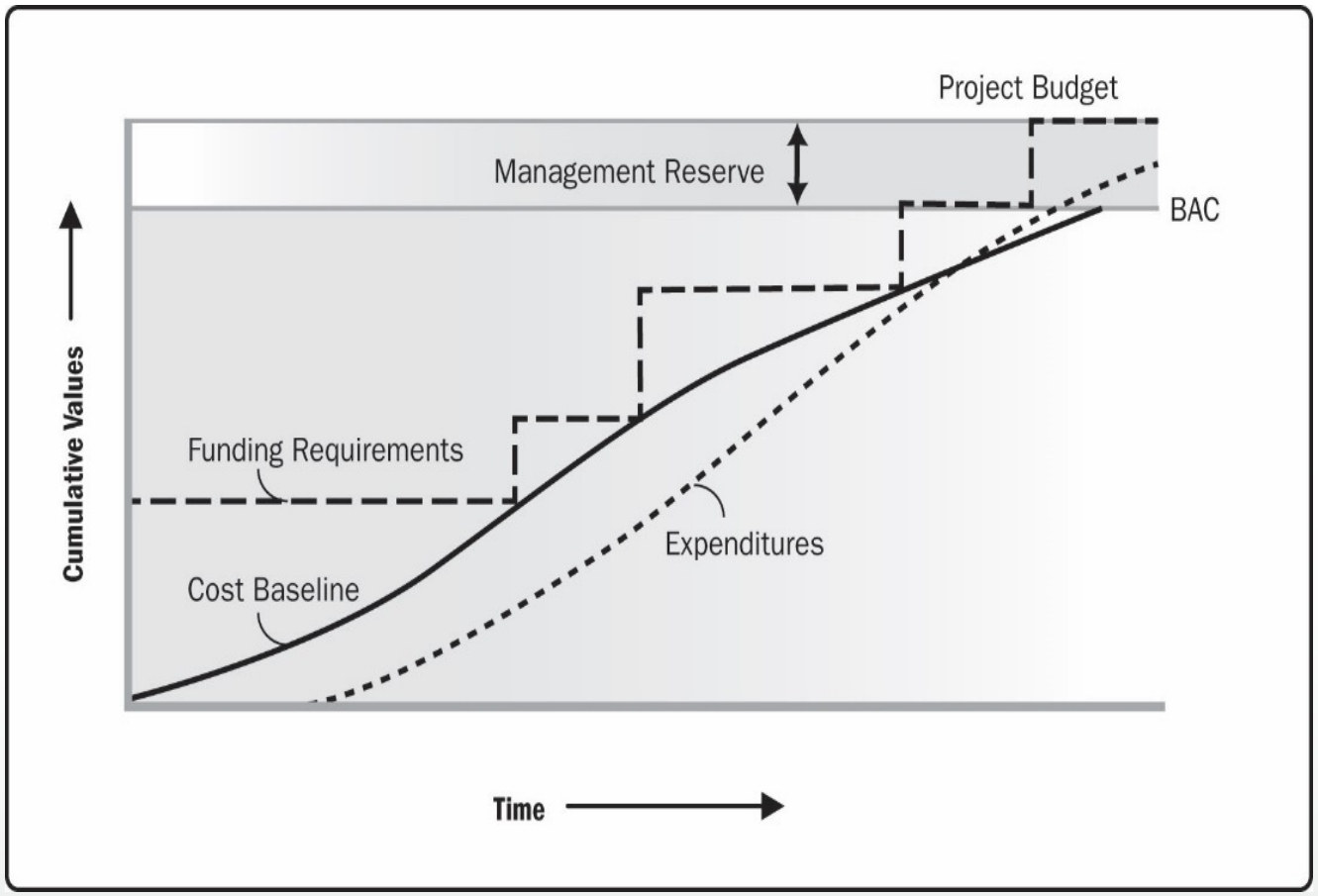


Source: Project Management Institute, Inc., *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Sixth Edition* (2017).

Budget Components – Some notes

- Cost estimates from the various activities along with any contingency reserves associated with them create the work package cost estimates.
- The work package cost estimates plus any contingency reserves associated with them create the control accounts.
- The summation of all control accounts equals the cost baseline.
- Management reserve plus the cost baseline equals the project budget.
- Management reserve is money set aside to address unidentified risks

Cost Baseline, Expenditures, and Funding Requirements



Source: Project Management Institute, Inc., *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Sixth Edition* (2017).

Cost Baseline – Some notes

- The cost baseline is often represented as an S-curve.
- Notice the uneven, step-like pattern for the funding requirements.
  - This is due to the fact that many projects are funded in incremental amounts that may not be equally distributed.

What Went Wrong?

- The United Kingdom's National Health Services (NHS) IT modernization program has been called the greatest IT disaster in history. This 10-year program was created to provide an electronic patient records system, appointment booking, and a prescription drug system in England and Wales. Britain's Labor government estimated that the program eventually cost more than $55 billion, a $26 billion overrun.
- The Olympic Games also provide great examples of cost overruns, especially when the dates are fixed years in advance. The average sports-related costs of hosting the Olympics are $12.0 billion, and non-sports-related costs are typically much more. "Every Olympics since 1960 has run over budget, at an average of 172 percent in real terms, the highest overrun on record for any type of megaproject."

Sample Cost Baseline

	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total Cost
WBS Categories													
1. Initiating	13,000												$ 13,000
2. Planning	6,000	16,000	8,000	1,000	1,000	1,000	1,000	1,000	1,000				$ 36,000
3. Executing			-			-	-						$ -
3.1 Course design and development			-			-	-						$ -
3.1.1 Supplier management training			5,000	73,667	73,667	73,667							$226,000
3.1.2 Negotiating skills training			5,000	35,500	35,500	35,500							$111,500
3.1.3 Project management training			5,000	43,000	43,000	43,000							$134,000
3.1.4 Software applications training			5,000	43,000	43,000	43,000							$134,000
3.2 Course administration						17,000	53,333	53,333	53,333				$177,000
3.3.Course evaluation							3,000	3,000	3,000	7,500			$ 16,500
3.4 Stakeholder communications		1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	$ 16,500
4. Monitoring and Controlling	1,000	2,000	2,000	2,000	3,000	3,500	3,000	3,000	2,000	3,000	2,000	1,000	$ 27,500
5. Closing											8,000	3,000	$ 11,000
Subtotal													$903,000
Reserves*			-			-	-					90,300	$ 90,300
Total	20,000	19,500	31,500	199,667	200,667	218,167	61,833	61,833	60,833	12,000	11,500	95,800	993,300

*Reserves are all entered in month 12

The Just-In-Time Training project team used the cost estimate from the pervious table along with the project schedule and other information to allocate costs for each month.

Schedule Planning for an Agile/Hybrid Project

- Instead of creating a detailed schedule for all of the activities required to complete an entire project, agile teams focus on the *most valuable work* they can complete within each iteration. This approach is often called *time-boxing*.
  - A *timebox* is a previously agreed upon time period during which a team works towards completion of a goal.
  - A sprint, for example is a timebox of 30 days or less.

What About Dependencies?

- Ideally, one Scrum team can perform all the work in their *scrum backlog*.
  - If there are dependencies within backlog items, the team should identify those and work on them accordingly.
- When there are multiple Scrum teams, you can hold a Scrum of Scrums, where representatives from each team meet to *coordinate efforts* and dependencies.

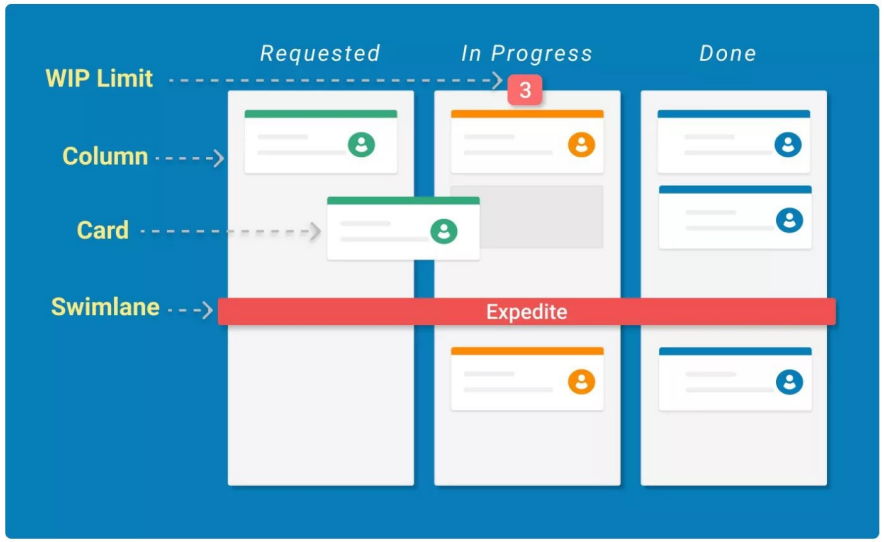
Kanban Method

- The term *kanban* is a Japanese term meaning *visual board*.
- The Kanban method is a means to design, manage, and improve flow systems for knowledge work.
- It also allows organizations to start with their existing workflow and drive evolutionary change by visualizing their flow of work, limit work in progress (WIP), and stop starting and start finishing.
- The Kanban method does not use time-boxing, does not define any specific roles for the team, and focuses on cycle time.

Figure 5-23. Sample Kanban Board

Main Components of the Kanban board

Kanban boards use Card, Column, Swimlanes, and WIP Limits to enable teams to visualize and manage their workflows effectively. Let us introduce you to the main components more closely:



Source: https://kanbanize.com/kanban-resources/getting-started/what-is-kanban-board (2021)

Kanban Board – Elements

- Kanban Cards – This is the visual representation of tasks. Each card contains information about the task and its status, such as deadline, assignee, description, etc.
- Kanban Columns – Each column on the board represents a different stage of your workflow. The cards go through the workflow until their full completion.
- Work-in-Progress Limits – They restrict the maximum amount of tasks in the different stages of the workflow. Limiting WIP allows you to finish work items faster by helping your team focus only on current tasks.
- Kanban Swimlanes – These are horizontal lanes you can use to separate different activities, teams, classes of service, and more.

Cost Planning for an Agile/Hybrid Project

- Unlike predictive projects, therefore, there is no *total project budget* or *detailed cost estimate* for the entire project for agile project.
- There is some estimating involved when using an agile approach, but instead of using *hours* or *dollars*, most estimates are done in a *relative* fashion.
- Relative estimates are created by comparing work or grouping it by equivalent difficulty based on factors like risk, complexity, and required labor.

Agile Estimating Methods

- T-shirt sizing: S, M, L, XL, XXL
- Planning poker: Each team member estimates user stories with numbered cards (1, 2, 3, 5, 8, 13, 21)
- The bucket system: Extension of planning poker when there are many user stories, and the team is large
- Affinity estimates: Three steps:
  1. Silent relative estimates (Sticky note “small” on the left and “large” on the right)
  2. Editing the wall (discussion done by group)
  3. Placing items into more specific sizes (S, M, L, XL, XXL)

Sample Relative Sizing Estimates

Team	User Story Name	Relative Size
A. Incentives	Determine new hire assessment content	M
	Develop hiring days event plan	L
	Develop hiring and retention survey	M
	Administer hiring and retension survey	S
	Analyze hiring and retention survey	S
	Research hiring and retention strategies	L
	Summarize hiring and retention research and survey results	M
	Draft new hiring policies	M
	Draft retention policies	M
B. Education	Determine content for Course 1 for new hires	L
	Develop content for Course 1 for new hires	XL
	Deliver Course 1 for new hires	XL
	Determine content for Course 2 for new hires	L
	Develop content for Course 2 for new hires	XL
	Deliver Course 2 for new hires	XL
	Research potential education partners	L
	Summarize education partner research	S
C. Adoption	Create website for hiring information	M
	Create assessment quiz for new hires	S
	Create website for Course 1	XXL
	Create website for Course 2	XXL
	Advertise for hiring days event on website and social media	M
	Advertise for hiring days event via radio, TV, signage, etc.	L

Video Highlights

- Several videos describe how to create schedules and estimates using predictive and agile methods. Many companies that sell project management software provide videos on several schedule and cost planning techniques.
  - Smartsheet has a detailed explanation of critical path method including a short video by Dr. Larry Bennett.
  - Mike Cohn of Mountain Goat Software has video on planning poker.
  - Kanbanize, a software platform for the Kanban method, includes demos for using their products.
- These companies realize that any project management software, for predictive, agile, or hybrid projects, is only as good as the people using it.

Chapter Summary

- Planning processes for schedule management using a predictive approach include planning schedule management, defining activities, sequencing activities, estimating activity durations, and developing a project schedule. It is also important to understand critical path analysis to make schedule trade-off decisions.
- Planning processes for cost management include planning cost management, estimating costs, and determining the project budget.

Chapter Summary

- For agile projects, teams use a very different approach for planning schedule and cost management. Work is prioritized and time-boxed into sprints, which often last only 2-4 weeks. Some teams use the Kanban method or kanban boards to focus on improving the flow of work. Teams use relative estimates to determine how long it will take them to complete user stories.
- Samples of several planning documents for schedule and cost management are provided for the Just-In-Time Training project and the GCHC project.

Reference

- Chapter 5: Planning Projects, Part 2 (Schedule and Cost Management)