Electronics and
Computer Science

UNIVERSITY OF
Southampton

Monitoring and Controlling Projects

COMP6204: Software Project Management and Secure Development

Dr A. Rezazadeh (Reza)
Email: ra3@ecs.soton.ac.uk or ar4k06@soton.ac.uk
November 21

Learning Objectives

- List several processes and outputs of project monitoring and controlling, and describe outputs common to all knowledge areas when using a predictive approach to project management
- Discuss monitoring and controlling project work and performing integrated change control as part of project integration management and how to use earned value management
- Explain the importance of validating and controlling scope
- Describe the schedule control process and schedule performance measurement tools, such as tracking Gantt charts
- Discuss tools and techniques to assist in cost control
- List the Seven Basic Tools of Quality, and provide examples of how they assist in performing quality control

Learning Objectives

- Explain the process of controlling resources
- Summarize methods for monitoring communications
- Discuss different approaches to monitoring stakeholder engagement
- Describe the process of monitoring risks
- Explain how to control procurements
- Apply the project management principles to monitoring and controlling projects
- Discuss unique aspects of monitoring and controlling agile/hybrid projects

Introduction

- *Monitoring* and *controlling* involves regularly measuring progress to ensure that the project is meeting its objectives and addressing current business needs
- The project manager and other staff monitor progress against plans and take corrective action when necessary

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work Perform integrated change control	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	Validate scope Control scope	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Knowledge area	Monitoring and controlling process	Outputs
Project quality management	Control quality	Quality control measurements Verified deliverables Work performance information Change requests Project management plan updates Project documents updates
Project resource management	Control resources	Work performance information Change requests Project management plan updates Project documents updates
Project communications management	Monitor communications	Work performance information Change requests Project management plan updates Project documents updates
Project stakeholder management	Monitor stakeholder engagement	Work performance information Change requests Project management plan updates Project documents updates
Project risk management	Monitor risks	Work performance information Change requests Project management plan updates Project documents updates Organizational process assets updates
Project procurement management	Control procurements	Closed procurements Work performance information Procurement documentation updates Change requests Project management plan updates Project documents updates Organizational process assets updates

Project Integration Management

- The main monitoring and controlling processes performed as part of project integration management include monitoring and controlling project work and performing integrated change control.
- These are crucial processes that must be done well to ensure project success.

Forecasting With Earned Value Management

- Earned value management (EVM) is a project *performance measurement* technique that integrates scope, time, and cost data
- Given a *baseline*, project managers and their teams can determine how well the project is meeting scope, time, and cost goals by entering actual information and then comparing it to the *baseline*
- The baseline information includes:
  - Scope data (WBS tasks)
  - Time data (start and finish estimates for each task)
  - Cost data (cost estimates for each task)
- Note that you can use earned value management at either a detailed or a summary level

Project Planning – A reminder

- At the planning stage, the project manager must do four things:
  - Divide the project into tasks.
    All of the project scheduling and control tasks are built on the foundation of project tasks.
  - Assign each task a start and end date.
    Project scheduling is done based on experience or actual past project data.
  - Assign each task a budget.
    Just like with the schedule, a budget for each task is necessary for the definition of the project.
  - Choose a project status period.
    The earned value calculations need to be performed at *regularly defined intervals* to be useful. A weekly status period works great for almost every project, big or small.

Earned Value Management – Cont.

- Earned value helps us manage a project by:
  - Providing data to enable objective measurement of project status;
  - Providing a basis for *estimating* final cost;
  - *Predicting* when the project will be complete;
  - Supporting the effective *management of resources*;
  - Providing a means of managing and *controlling change*.

Earned Value Management – Cont.

- Earned value provides information which enables effective decision making by knowing:
  - What has been achieved of the plan;
  - What it has cost to achieve the planned work;
  - If the work achieved is costing more or less than was planned;
  - If the project is ahead of or behind the planned schedule.
- Good planning leads to good project execution and good management information.

Earned Value Management Core Concepts

- EVM can be intimidating to some project managers, due to the *many terminologies* associated with it.
- So, let's break this down into easy-to-digest smaller concepts first.
- Each of these concepts plays a key role in improving project performance.

Gather Work Performance Information

- Effective earned value management requires the compilation of several pieces of information from the project.
- None of these are difficult; the four pieces of information that the project manager must gather for each task are:
  - Budget at Completion (BAC)
    - It represents the original project budget. It is determined during project planning and readily available.
  - Planned Value (PV)
  - Earned Value (EV)
  - Actual Cost (AC)

Planned Value (PV)

- Planned value is the budgeted cost for work scheduled (BCWS).
- PV varies based on the scope of work in consideration and the point where you're at in the overall schedule.
  - PV = Total project cost ✕ % of planned work
  - For example, let's say, the PV for your 5-month project is $25,000:
  - PV for the complete project = $25,000
  - PV at 2 months = $25,000 ✕ 40% = $10,000
- You can also calculate PV for a time period, say, month 2 to month 4 = $25,000 ✕ 60% = $15,000.

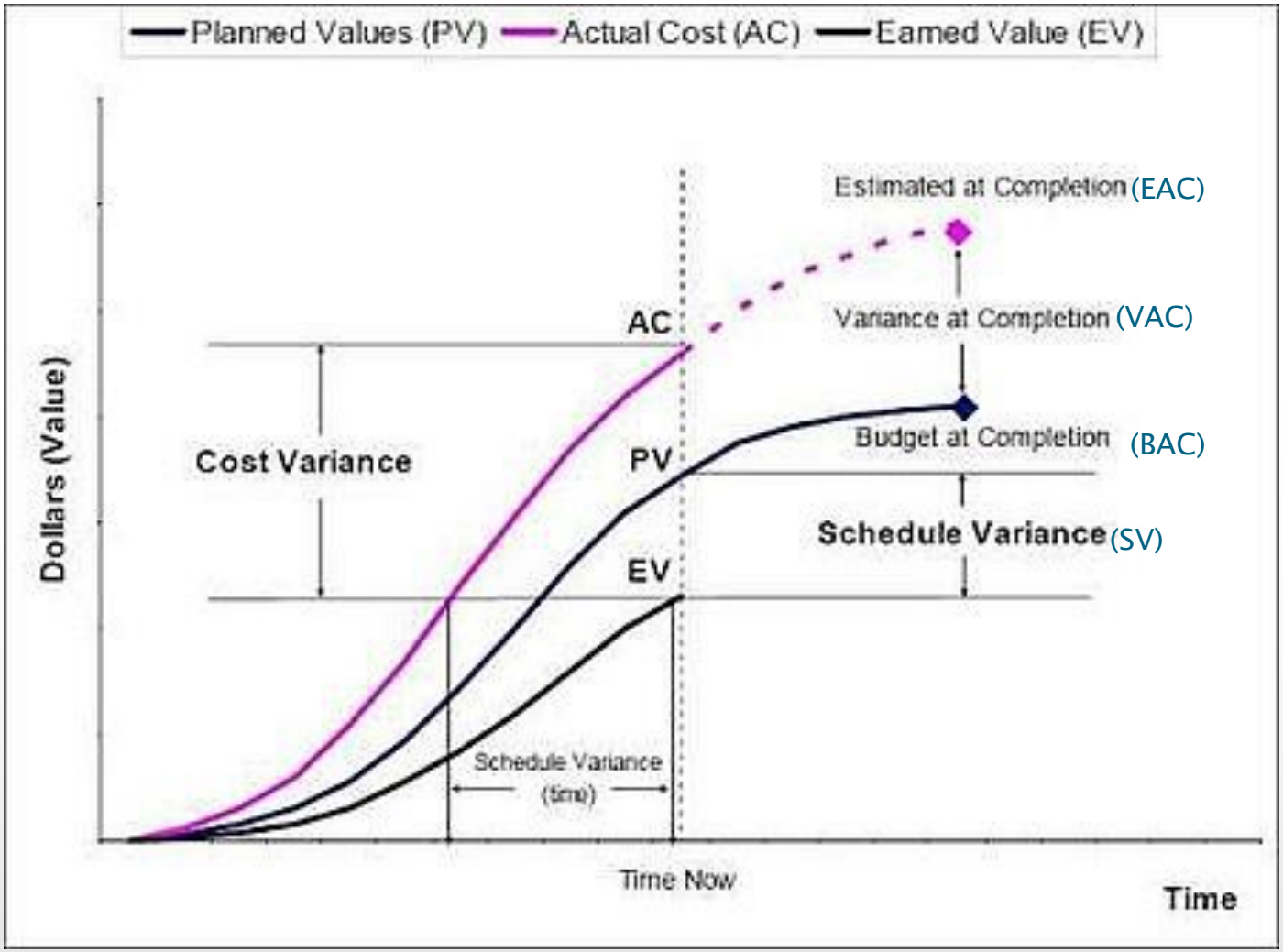
Actual Costs (AC)

- Actual costs, also referred to as actual cost of work performed (ACWP), is relatively straightforward.
  - If you are using a robust project cost management software, tracking actual costs should not be a challenge.
  - However, it's important to remember to include several hidden costs—material, resource, hardware, software licenses, overheads, etc.
- You can look at AC cumulatively, accounting for all the activities done from the beginning of the project to date or over a specific time period.
  - In our example, let's assume, AC at the end of 2 months = $15,000

Earned Value (EV)

- Now, this is where EVM gets interesting.
- You've made a plan to finish some amount of work and budgeted accordingly.
- But, from experience, you know that there is bound to be some discrepancy from your estimate.
  - At the end of 2 months, you may have planned to complete 40% of your work, but let's say you managed to just finish 30%.
- The question, then, is, *what is the budgeted cost for this work*? EV, also called as budgeted cost for work performed (BCWP), gives you the answer.
- In our example:
  EV = Total project cost ✕ % of actual work = $25,000 ✕ 30% = $7,500

Earned Value Management System (EVMS)



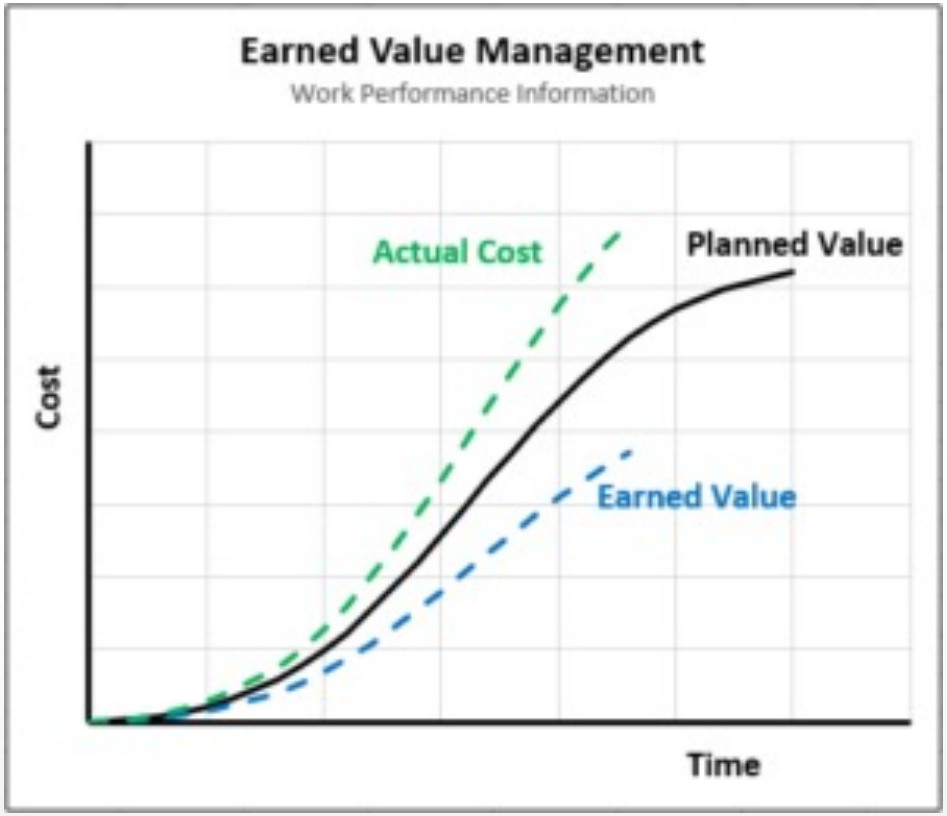
Old Terminology

- The following terms have been deprecated by the *Project Management Institute (PMI)* and most other official project management bodies.
- But since they are still being used in various places we will mention them.
- The following are identical definitions:

Old	New
Budgeted Cost of Work Schedule (BCWS)	Planned Value (PV)
Budgeted Cost of Work Performed (BCWP)	Earned Value (EV)
Actual Cost of Work Performed (ACWP)	Actual Cost (AC)

The Earned Value Mentality

- The PV is the target, whereas EV and AC are the "darts."
- The AC and EV are always changing.
- Every day another dart gets thrown at the board, and it's the project managers job to keep AC and EV close to the PV.



- Note that the EV should be above the PV to be "positive" while the AC should be below the PV.
- In this chart they are both showing *negative*.

Determine Schedule Status

- Using the calculation so far we have determined whether we are
  1. *ahead* or *behind* our schedule
  2. *under* or *above* the *estimated cost*.
- It's time to determine *how far ahead* or *behind* schedule
- Or how much *under* or *above* the *estimated cost*.
- To do this, we will calculate another four values from the initial four we *gathered* from the project data.

Variance Analysis

- At this point, the project manager wants to know how far off we are from the project *baseline*.
- This can be determined through
  - Schedule Status
    - Schedule Variance (SV)
    - Schedule Performance Index (SPI)
  - Cost Status
    - Cost Variance (CV)
    - Cost Performance Index (CPI)

Schedule Variance (SV)

- *Schedule variance* is a *quantitative indicator* of your *divergence* from the *initial planned schedule*.
- A negative SV indicates that we are behind schedule,
- A positive SV indicates that we are ahead of schedule and zero means that we are exactly on schedule.

$$SV = EV - PV$$

- In our example, SV at 2 months = \$7,500 – \$10,000 = -\$2,500
- SV% = (SV/PV) *100 = (-\$2,500/\$10,000) *100 = -25%
  - This implies that we are 25% behind schedule.

Schedule Variance (SV) – Con.

- It's interesting to note that we aim to understand schedule, a time component, from the perspective of costs.
- To arrive at these costs though, we needed to know the scope of work planned and completed.
- This is how the three pillars—*scope*, *time* and *cost* come together in *EVM*.

Cost Variance (CV)

- *Cost variance* is a quantitative indicator of your divergence from the initial planned budget.
- A negative CV indicates that we are over budget, a positive CV indicates that we are under budget and zero means that we are exactly on budget.

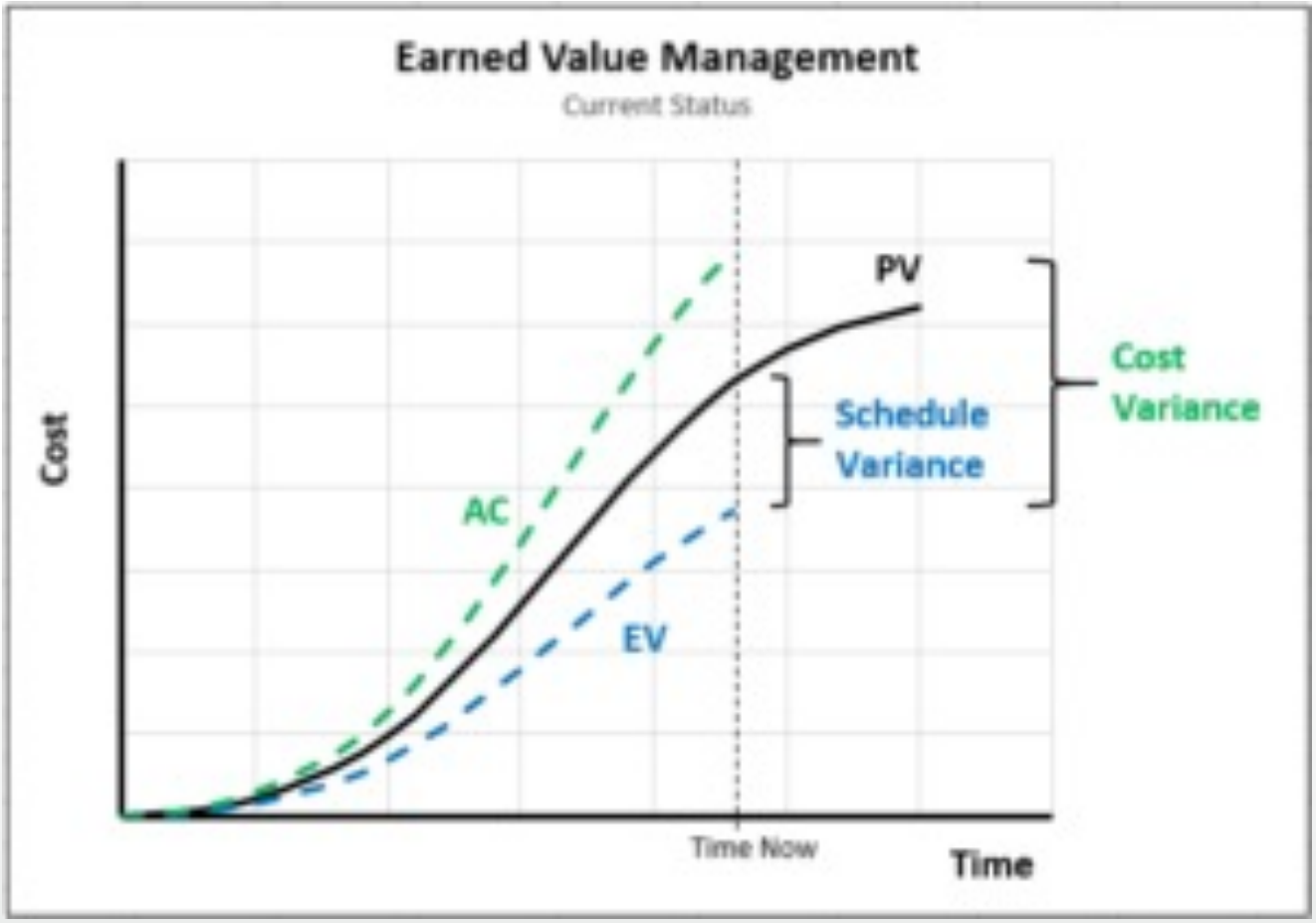
  CV = EV – AC

  – In our example, CV at 2 months = $7,500 – $15,000 = -$7500

  CV% = (CV/EV) *100 = (-$7,500/$7,500) *100 = -100%

- This implies that we are 100% over budget.
- Again, this is an instance of how scope, time and cost come together to give you a clear picture of where you stand at the moment in your project.

Schedule Variance (SV)/Cost Variance (CV)



Schedule Performance Index (SPI)

- Another way of looking at project performance, apart from variance, is through *indexes*.
- *Schedule Performance Index (SPI)* gives a sense of project performance from a schedule perspective.

$$SPI = EV/PV$$

  - SPI > 1 indicates the project is ahead of schedule and SPI < 1 indicates the project is behind schedule. The SPI, *greater than 1.0 is good*.

- In our example, SPI = $7,500/$10,000 = 0.75, indicating the project is only going 75% as per the original plan or it's 25% behind schedule.

Cost Performance Index (CPI)

- *Cost Performance Index (CPI)* gives a sense of project performance from a cost perspective.

  CPI = EV/AC

  - CPI > 1 indicates the project is under budget and CPI < 1 indicates the project is over budget.

- In our example, CPI = $7,500/$15,000 = 0.5
  - CPI = 0.5 means the project has spent *twice* amount that it should have at this point.
  - CPI = 1.0 means the project is on schedule.
  - CPI = 2.0 means the project has spent half the amount that it should have at this point.

Interpreting Earned Value Numbers

- In general, *negative numbers for cost and schedule variance indicate problems in those areas*
- Negative numbers mean the project is *costing more* than *planned* or *taking longer* than planned
- Likewise, *CPI and SPI less than one or less than 100 percent indicate problems*

Earned Value Forecasting

- Earned Value Management contains four calculations which give the project manager a *forecast* into future performance of the project:
    1. Estimate to Complete (ETC)
    2. Estimate at Completion (EAC)
    3. Variance at Completion (VAC)
    4. To Complete Performance Index (TCPI)
- Each of these are, in essence, an extrapolation from the previous calculation which was used to determine the status of the project right now.

Estimate to Complete (ETC)

- ETC represents the expected cost required to complete the project.
- It measures only the *future* budget needed to complete the project, not the *entire* budget (that's the EAC, next).
- It allows the project manager to compare the funding needs to finish the project with funding available.
- The ETC can be calculated either for each task or for the whole project.

Estimate to Complete (ETC) – Calculations

- There are two ways to calculate ETC:

  1. Based on past project performance

$$ETC = (BAC - EV) / CPI$$

- Since each of the input variables (right side of the equation) has been determined prior to this step, the ETC can be calculated either for each task or directly for the whole project.

  2. Based on a new estimate

  – This is called a *Management ETC*. This means that a new estimate of the remaining tasks in the project is performed.

ETC Calculations – Cont.

- In our example task we will calculate the ETC based on the past performance of the project – approach No 1 in previous slide:
  - *ETC = (BAC – EV) / CPI*
  - *ETC = ($25000 - $7500)/0.5 = $35000*
- This project is worth $25,000 and has already spent $7,500. Don't worry, be happy, right? Wrong.
- Based on its past performance we will need another $35000 to complete it.

BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
25000	10000	7500	15000	-2500	0.75	-7500	0.5	35000			

Estimate at Completion (EAC)

- The EAC is the full task or project cost expected at completion (the new project budget).
- It can be calculated on a task by task basis or once for the entire project.
- There are multiple ways to calculate it based on how you expect the future of the performance of the project to be.

EAC Method 1– Future performance will be based on the budgeted cost

- If you think the existing variance was a unique event and the rest of the project should go according to plan, simply add the remaining project budget to the actual cost incurred to date (AC).
- This method does not assume the project finishes on budget.
- Rather it takes into account the one time event and adjusts the whole project plan upward or downward to estimate the final result.

$$EAC = AC + (BAC - EV)$$

$$EAC = \$15000 + (\$25000 - \$7500) = \$32500$$

EAC Method 2 – Future cost performance will be based on past cost performance

- If you think the past performance is not unusual and the past performance is a good indicator of the future, you would use this formula.

  $$EAC = AC + [(BAC - EV) / CPI]$$

  $$EAC = 15000 + [(\$25000 - \$7500) / 0.5] = \$50000$$

- This is the *worst case* scenario that you have used forecasting using the current trajectory.

EAC Method 3

- Future cost performance will be influenced by past schedule performance
- Since schedule and cost performance are usually related, there could be a reason to adjust the cost performance based on the schedule performance.
- For example let's say the CPI (cost efficiency) is very low but SPI (schedule efficiency) is high, you would be justified in thinking that the final cost performance won't likely be as bad as the CPI would suggest.

EAC Method 3 – Cont.

- Future cost performance will be influenced by past schedule performance
- In the following formula an average of the CPI and SPI are used to extrapolate the final project cost.

$$EAC = AC + [(BAC - EV) / (CPI \times SPI)]$$

- You could also use a combination of the SPI and CPI instead of a straight average. In the formula below, 20% of the SPI and 80% of the CPI has been used to determine the final project cost.

$$EAC = AC + [(BAC - EV) / (0.8 \cdot CPI \times 0.2 \cdot SPI)]$$

EAC Method 4

- A new estimate is produced
  - In this case a Management ETC can be added to the to-date cost (AC) to determine the final EAC.

$$EAC = AC + ETC$$

Estimate at Completion (EAC) – Conclusion

- The first two forecasting methods represent the *low* and *high* extremes.
- The third represents an attempt to forecast *somewhere in between* those extremes.
- Finally, the fourth method represents a new estimate, a brand new value taken from other sources if none of the other methods are able to produce the desired result.

BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
25000	10000	7500	15000	-2500	0.75	-7500	0.5	35000	50000		

Estimate at Completion (EAC)

Variance at Completion (VAC)

- The VAC is a forecast of what the variance, specifically the Cost Variance (CV), will be upon the completion of the project.
- It is the size of the expected cost overrun or underrun.
- In many situations the project manager must request additional funding as early as possible, or at least report the potential for an overrun.
- The VAC represents the size of this request. The formula is:
  - *VAC = BAC – EAC*
    = Old Budget – New Budget

BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
$25000	10000	7500	15000	-2500	0.75	-7500	0.5	35000	50000	25000	

Variance at Completion (VAC) – Cont.

- This one is relatively simple. If you've calculated the EAC you've done the big math already and the 'new budget' can simply be subtracted from the 'old budget' to determine the cost overrun or underrun.
- The *Variance at Completion* is simply a future projected Cost Variance.
- It has the same units as CV.
- It is the same type of element.

To Complete Performance Index (TCPI)

- The TCPI represents the *efficiency level*, specifically the CPI, that will make the project finish on time.
- It can be a powerful indicator because it is generally easy to ascertain if your people will be as productive as the *indicator* tells you.
- This indicator tends to be a bigger red flag than other indicators.
- For example, if it says your people need to be *twice as efficient* as the schedule, it tends to make you take notice that action needs to be taken.

To Complete Performance Index (TCPI) – Calculation

- There are two ways to calculate the TCPI:

1. To achieve the original budget
   If the goal is to achieve the original project budget, that is, the overrun or underrun has not resulted in a change to the project schedule and/or budget, the following formula applies:

   $$TCPI = (BAC - EV) / (BAC - AC)$$

2. To achieve the EAC
   If the goal is to achieve the project's EAC, that is, a change has been made to the project and the EAC is the new project budget, use this formula. If additional funds covering the cost overrun have been requested and approved by the project sponsor, the EAC becomes the target of the project, and this scenario applies.

   $$TCPI = (BAC - EV) / (EAC - AC)$$

TCPI Calculation – An Example

- We will assume the project budget has not been revised (EAC is simply a projection) and the goal is still the original project budget (formula #1, above).

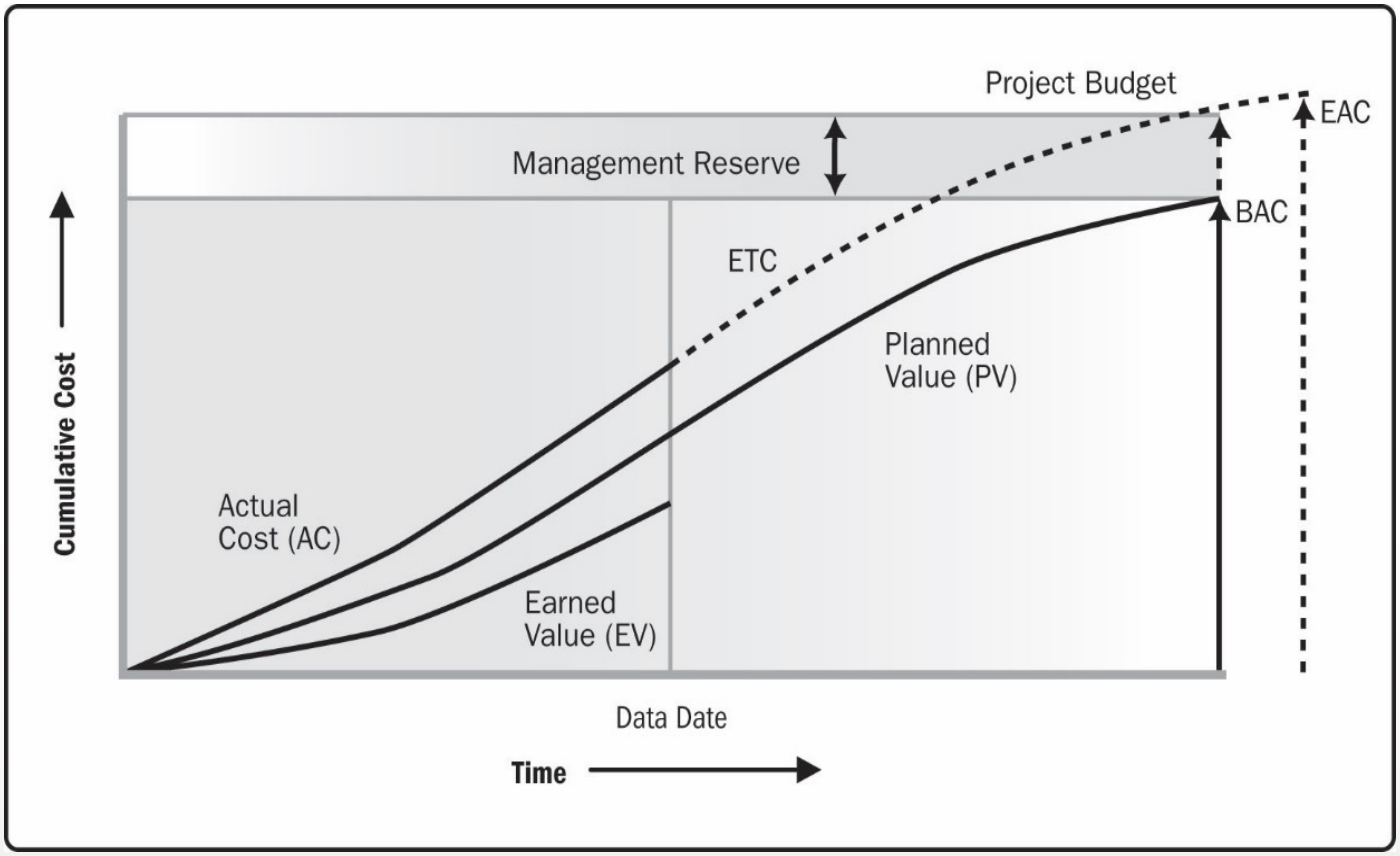
  TCPI = (BAC – EV) / (BAC – AC)

  TCPI = ($25000 -$7500)/ ($25000 - $15000) = 1.75

- This project team must be 75% more efficient than they have been to finish on budget. A seemingly difficult task.

BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
25000	10000	7500	15000	-2500	0.75	-7500	0.5	35000	50000	25000	1.75

Earned Value, Planned Value, and Actual Cost

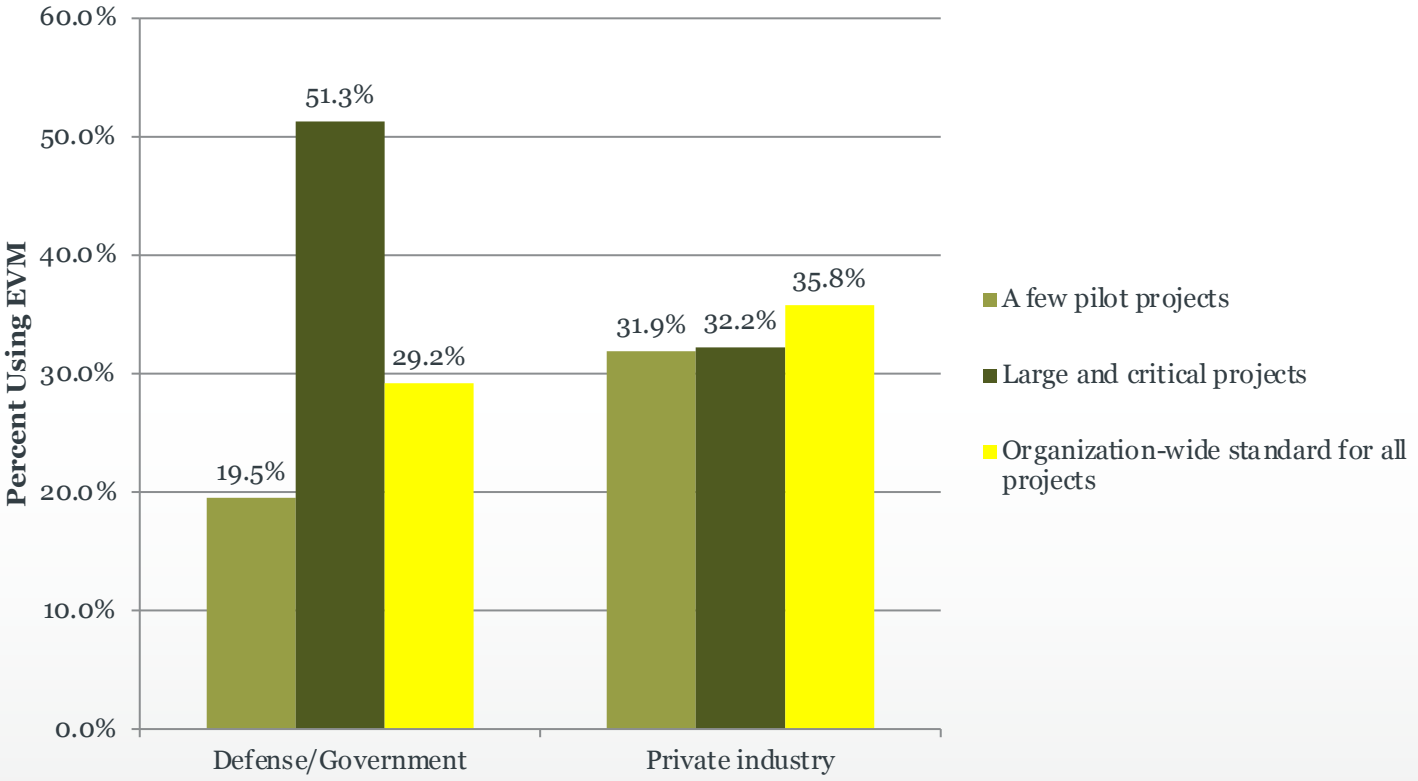


Source: Project Management Institute, Inc., *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Sixth Edition* (2017).

Study on EVM Practice

- PMI conducted a study in 2011 to help understand and gauge the current level of EVM practice.
- The researchers surveyed more than 600 project management practitioners in 61 countries
- Key findings:
  - EVM is used worldwide, and it is popular in the Middle East, South Asia, Canada, and Europe
  - Most countries require EVM for large defense or government projects
  - Project budget size appears to be the most important factor in deciding whether or not to use EVM

Percentage of Organizations Using Earned Value



Source: Lingguang Song, "Earned Value Management: A Global and Cross-Industry Perspective on Current EVM Practice," PMI (2011).

Performance Reports

- Status reports describe where the project stands at a specific point in time
- Progress reports describe what the project team has accomplished during a certain period
- Forecasts predict future project status and progress based on past information and trends

Sample Performance Report

Progress Report

Project Name: Just-In-Time Training Project
Project Manager Name: Kristin Maur
Date: February 3
Reporting Period: January 1 – February 1

Work completed this reporting period:

- Held first negotiating skills course (instructor-led) with 20 participants
- Held first supplier management executive course (instructor-led) with 17 participants
- Held second supplier management introductory course (instructor-led) with 20 participants
- Had 32 people begin the Web-based introductory supplier management course
- Continued developing other Web-based courses
- Prepared evaluations of all courses held to date

Work to complete next reporting period:

- Hold first advanced supplier management course
- Hold first project management course
- Hold first software applications course

Sample Performance Report (continued)

What's going well and why:

- Participation in all courses is good. Every instructor-led course was full, except the supplier management executive course. All of the courses were advertised well, and we had more than enough people sign-up for the classes. We put several people on the list for later courses after courses were filled in the registration system.
- The average course ratings were above 3.8 on a 5.0 scale. Comments were generally very positive.
- More people than expected started the first Web-based course. Development of new Web-based courses is going well.

What's not going well and why:

- We did not fill the supplier management executive course as planned. Three people could not attend at the last minute, and it was too late to get replacements. We will work on a policy to help prevent this problem in the future for all instructor-led classes.
- We were surprised that so many people started the Web-based introductory supplier management course. We can handle the numbers, but we could have done a better job at forecasting demand.

Suggestions/Issues:

- Develop a policy to handle people not being able to attend instructor-led courses at the last minute.
- Try to do a better job at forecasting demand for Web-based courses.

Project changes:

No major changes to report. The earned value chart in Attachment 1 shows planned value, actual cost, and earned value information to date. We are very close to our plans, running slightly ahead of schedule and a bit over budget.

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work **Perform integrated change control**	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	Validate scope Control scope	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Integrated Change Control

- Integrated change control involves *identifying*, *evaluating*, and managing changes throughout the project's life cycle
- Objectives are as follows:
  - Influence the factors that cause changes to ensure that changes are beneficial
  - Determine that a change has occurred
  - Manage actual changes as they occur
- The project team must focus on delivering the work as planned.
- However, if changes are necessary the initial plan should be revised.

What Went Right?

- Chicago's Museum of Contemporary Art (MCA) provides a great example of tracking key project performance information to ensure project success.
- In September 2014 MCA became the first U.S. venue to stage the "David Bowie Is" exhibit. The $2 million project took thirteen months to complete.
- The MCA team knew they had to sell a lot of tickets for the four-month run of the exhibit—about 150,000, which was more than half if its annual average. They put metrics in place to track several key items, including ticket sales. Their online ticket sales dashboard allowed the team to compare sales each day with projections so they could adjust the marketing strategy as needed.

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work **Perform integrated change control**	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	Validate scope Control scope	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Project Scope Management

- The main monitoring and controlling processes performed as part of *project scope management* are *validating* scope and *controlling* scope
- Key outputs are accepted deliverables and work performance information
- It is difficult to create a good project scope statement and WBS.
- It is often even more difficult to *validate* the project scope and *minimize* scope changes

Scope Creep

- Even when the project scope is fairly well defined, many projects suffer from scope creep—the tendency for project scope to grow bigger and bigger
- There are many horror stories about projects failing due to scope creep
- Even for fairly simple projects, people have a tendency to want more
- How many people do you know, for example, who said they wanted a simple wedding, or a basic new house constructed, only to end up with many more extras than they initially planned?

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work Perform integrated change control	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	**Validate scope** **Control scope**	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Validating Scope

- Scope validation involves formal acceptance of the completed project deliverables by the project customer or designated stakeholders
- Acceptance is often achieved through customer *inspection* and then *sign-off* on key deliverables
- Recall from Chapter 4 that a verified deliverable has been completed and checked for correctness as part of quality control
- The customer is often more than one person, so group decision-making is often required for the inspection and acceptance

Sample Deliverable Acceptance Form (partial)

1. Was this deliverable completed to your satisfaction? Yes_____No X

2. Please provide the main reasons for your satisfaction or dissatisfaction with this deliverable.

As stated in the contract statement of work, the course materials are not completed until all constructive feedback from the prototype course has been incorporated or the supplier has provided strong rationale as to why the feedback should not be incorporated. We requested that a new section be added to the course to cover issues related to working with suppliers in virtual settings. The final materials delivered did not include this new section or discuss why it was not added. We believe it was an oversight that can be corrected with a minimal amount of additional work.

3. If the deliverable is not acceptable, describe in detail what additional work must be done to complete it.

The supplier will add a new section to the course on working with suppliers in a virtual setting. This section should take about thirty minutes of class time in a face-to-face or e-learning setting. This new section will follow the format and review process used for other topics in the course. We request delivery of the draft of this new section within one week and the final delivery within two weeks.

Controlling Scope

- You cannot control the scope of a project unless you have first clearly defined the scope and set a scope validation process in place
- You also need to develop a process for soliciting and monitoring changes to project scope.
- Stakeholders should be encouraged to suggest beneficial changes and discouraged from suggesting unnecessary changes

Best Practice

- Northwest Airlines developed a new reservation system in the late 1990s that took several years and millions of dollars to develop
- They knew that users would request changes and enhancements to the system, so they built in a special function key for submitting change requests and assigned three full-time programmers to work exclusively on them
- Users made over 11,000 enhancement requests the first year the system was in use, which was much more than the three programmers could handle
- Although they only implemented 38% of the requested enhancements, these were the most important, and users were very satisfied with the system and process

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work Perform integrated change control	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	**Validate scope** **Control scope**	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Project Schedule Management

- The main monitoring and controlling process performed as part of project schedule management is controlling the schedule or schedule control
- Project managers often cite delivering projects on time (schedule control) as one of their biggest challenges, because schedule problems often cause more conflict than other issues
- During project initiation, priorities and procedures are often most important, but as the project proceeds, especially during the middle and latter stages of the project, schedule issues become the predominant source of conflict

Why Schedules Cause Conflicts

- Time is the variable with the least amount of flexibility; time passes no matter what happens on a project
- Individual work styles and cultural differences may also cause schedule conflicts.
  - People who prefer the Perceiving (P) vs. Judging (J) in the MBTI profile may not like having schedules and deadlines
  - Different cultural views of time affect meeting schedules and attitudes toward work

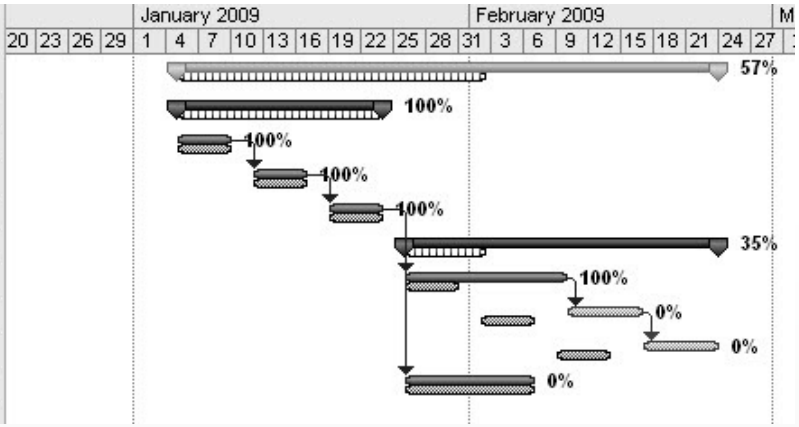
Schedule control

- The goal of schedule control is to know the status of the schedule, influence the factors that cause schedule changes, determine whether the schedule has changed, and manage changes when they occur
- Key outputs of schedule control are forecasts and work performance information

Schedule Performance Measurement

Tracking Gantt Chart that compares planned and actual project schedule information can be used to illustrate schedule progress

	Task Name	Duration	Start	Finish	Predecessors
0	**trackinggantt**	**36 days**	**Mon 1/5/09**	**Mon 2/23/09**	
1	**Main task 1**	**15 days**	**Mon 1/5/09**	**Fri 1/23/09**	
2	Subtask 1	1 wk	Mon 1/5/09	Fri 1/9/09	
3	Subtask 2	1 wk	Mon 1/12/09	Fri 1/16/09	2
4	Subtask 3	1 wk	Mon 1/19/09	Fri 1/23/09	3
5	**Main task 2**	**21 days**	**Mon 1/26/09**	**Mon 2/23/09**	
6	Subtask 1	2.2 wks	Mon 1/26/09	Mon 2/9/09	4
7	Subtask 2	1 wk	Tue 2/10/09	Mon 2/16/09	6
8	Subtask 3	1 wk	Tue 2/17/09	Mon 2/23/09	7
9	Subtask 4	2 wks	Mon 1/26/09	Fri 2/6/09	4



- The tracking Gantt chart shows bars for both planned and actual start and finish dates for each task as well as the percent of work completed.
- A **slipped milestone** refers to a milestone activity that was actually completed later than originally planned

No Surprises

- Top management hates surprises, so the project manager must be clear and honest in communicating project status
- By no means should project managers create the illusion that the project is going fine when, in fact, serious problems have emerged

Knowledge area	Monitoring and controlling process	Outputs
Project integration management	Monitor and control project work Perform integrated change control	Work performance reports Change requests Project management plan updates Project documents updates Approved change requests Project management plan updates Project documents updates
Project scope management	**Validate scope** **Control scope**	Accepted deliverables Work performance information Change requests Project documents updates Work performance information Change requests Project management plan updates Project documents updates
Project time management	Control schedule	Work performance information Schedule forecasts Change requests Project management plan updates Project documents updates
Project cost management	Control cost	Work performance information Cost forecasts Change requests Project management plan updates Project documents updates

Project Cost Management

- Cost control includes monitoring cost performance, ensuring that only appropriate project changes are included in a revised cost baseline, and informing project stakeholders of authorized changes to the project that will affect costs
- Outputs include work performance information, cost forecasts, change requests, project management plan updates, and project documents updates

Tools and Techniques for Controlling Costs

- Expert judgment
- Data analysis
- Project management information systems
- To-complete performance index (TCPI), which is a measure of the cost performance that must be achieved on the remaining work in order to meet a specified goal, such as the BAC or EAC

BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
25000	10000	7500	15000	-2500	0.75	-7500	0.5	35000	50000	25000	1.75

What Went Wrong?

- Cost overruns tend to be the norm for construction projects. Below are a few recent statistics:
  - 85% of construction projects completed in 20 countries over the course of a 70-year period experienced cost overrun. The overall average overrun was 28%.
  - Large construction projects take 20% longer to finish than expected and are up to 80% over budget.
  - 45% of construction professionals reported spending more time than expected on non-optimal activities, such as fixing mistakes, looking for project data, and managing conflict resolution.
  - Common causes of cost overrun include inaccurate project estimates/unclear project scope, project design errors, unforeseen project changes, administration errors, and poor communication.

What Went Wrong?

- Technology projects also have a terrible track record.
- What can be done?
- Dr. Steve Andiole, author of several books, including IT's All About the People, says:
  - *You have to focus on the people*!
  - Vet project managers based on their experience.
  - Find and reward real leaders,
  - Build the right teams,
  - Fix training by making it more hands-on, like a medical residency.

Knowledge area	Monitoring and controlling process	Outputs
Project quality management	Control quality	Quality control measurements Verified deliverables Work performance information Change requests Project management plan updates Project documents updates
Project resource management	Control resources	Work performance information Change requests Project management plan updates Project documents updates
Project communications management	Monitor communications	Work performance information Change requests Project management plan updates Project documents updates
Project stakeholder management	Monitor stakeholder engagement	Work performance information Change requests Project management plan updates Project documents updates
Project risk management	Monitor risks	Work performance information Change requests Project management plan updates Project documents updates Organizational process assets updates
Project procurement management	Control procurements	Closed procurements Work performance information Procurement documentation updates Change requests Project management plan updates Project documents updates Organizational process assets updates

Project Quality Management

- Key outputs of *quality control* include quality-control measurements, verified deliverables, work performance information, change requests, project management plan updates, and project documents updates
- Outcomes are acceptance decisions, rework, and process adjustments
- What is quality?
  - Quality, simplistically, means that a product should meet its specification.

Challenges of Software Quality

- There is a tension between customer quality requirements (*efficiency*, *reliability*, etc.) and developer quality requirements (*maintainability*, *reusability*, etc.).
- Some quality requirements are *difficult* to specify in an *unambiguous* way.
- Software specifications are usually *incomplete* and often *inconsistent*.
- Therefore with the previous definition:
  - "Quality, simplistically, means that a product should meet its specification."

We face a difficult dilemma

Software Quality Programme

- For physical manufactured products like cars or televisions
  - quality control is able to control the quality of the generated product by controlling the physical manufacturing process
  - such control can compensate for weaknesses in design and/or materials.
  - monitoring items produced, adjusting processes as necessary to achieve acceptable rates of failure (in testing or in use).

Software Quality Programme

- In software development there is no equivalent,
  - as there is no opportunity for action at production time to compensate for analysis and design issues.
  - For example, there is no equivalent in software production of resolving a problem with a car component which fails too often in service by specifying a higher grade of steel during production.

The quality compromise

- We cannot wait for specifications to improve before paying attention to quality management.
- We must put quality management procedures into place to improve quality in spite of imperfect specification.

Quality-Control Tools

- Data gathering tools such as check sheets, statistical sampling, questionnaires, and surveys
- Data analysis: Performance reviews and root cause analysis
- Inspection/ Checklists
- Testing/product evaluations
- Data representation: cause-and-effect diagrams, control charts, histograms, and scatter diagrams
- Meetings

Seven Basic Tools of Quality (ASQ*)

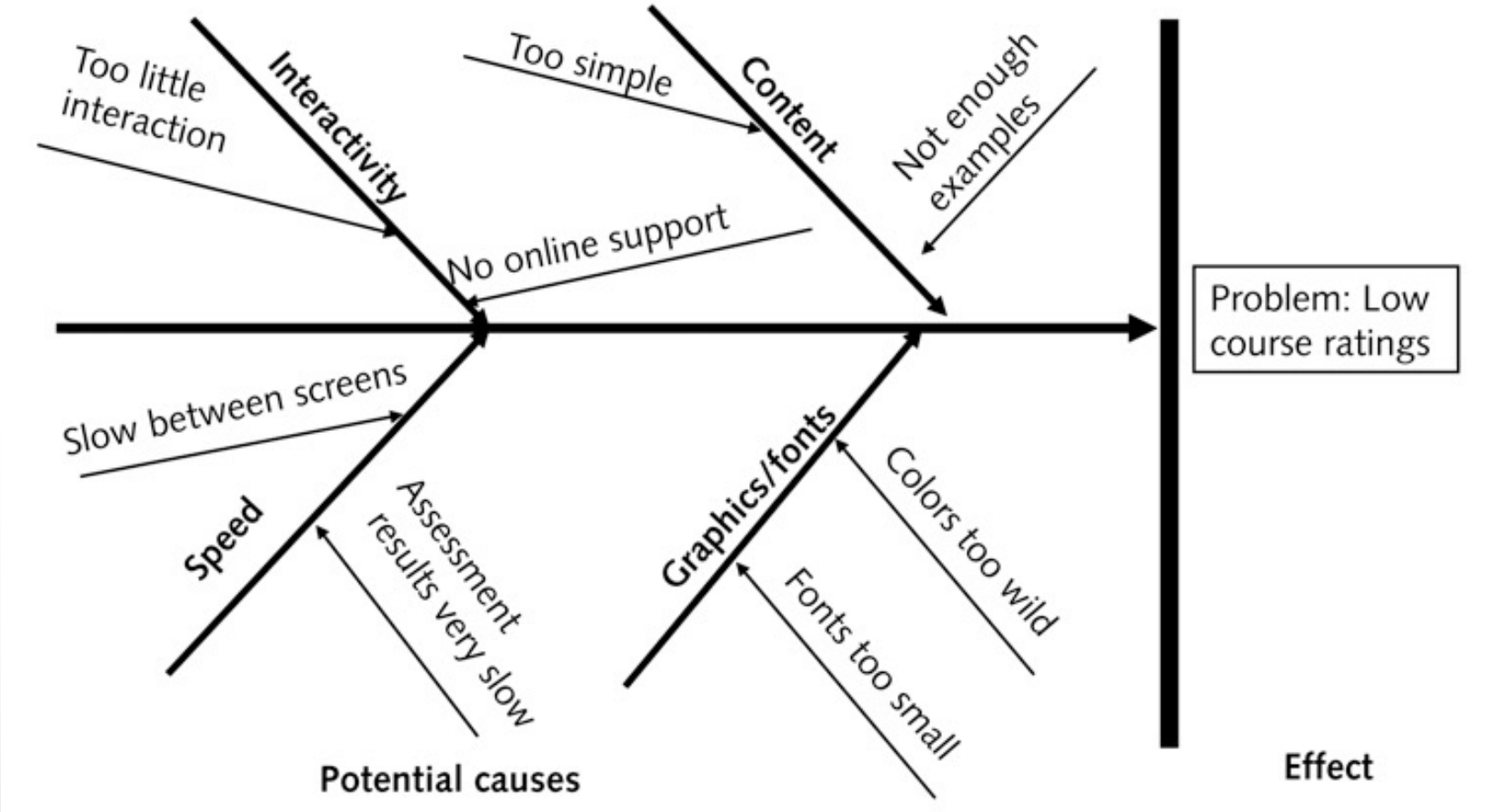
1. Cause-and-effect diagrams: Help you find the root cause of quality problems
2. Check sheets: A Check Sheet is a tool to collect both qualitative and quantitative facts about quality problems.
   - When it is used to collect quantitative data, then known as tally sheet
3. Control charts: Illustrate the results of a process over time and show if a process is in control
4. Histograms: Show a bar graph of a distribution of variables

* *American Society for Quality (ASQ)*

Seven Basic Tools of Quality (ASQ)

5. Pareto charts: Help you identify and prioritize problem areas
6. Scatter diagrams: Show if there is a relationship between two variables
7. Stratification: A technique used to separate data to see patterns in data.
   - A run chart displays the history and pattern of variation of a process over time.
   - A flow chart is a graphical display of the logic and flow of processes that help you analyze how problems occur and how processes can be improved

Sample Cause-and Effect Diagram

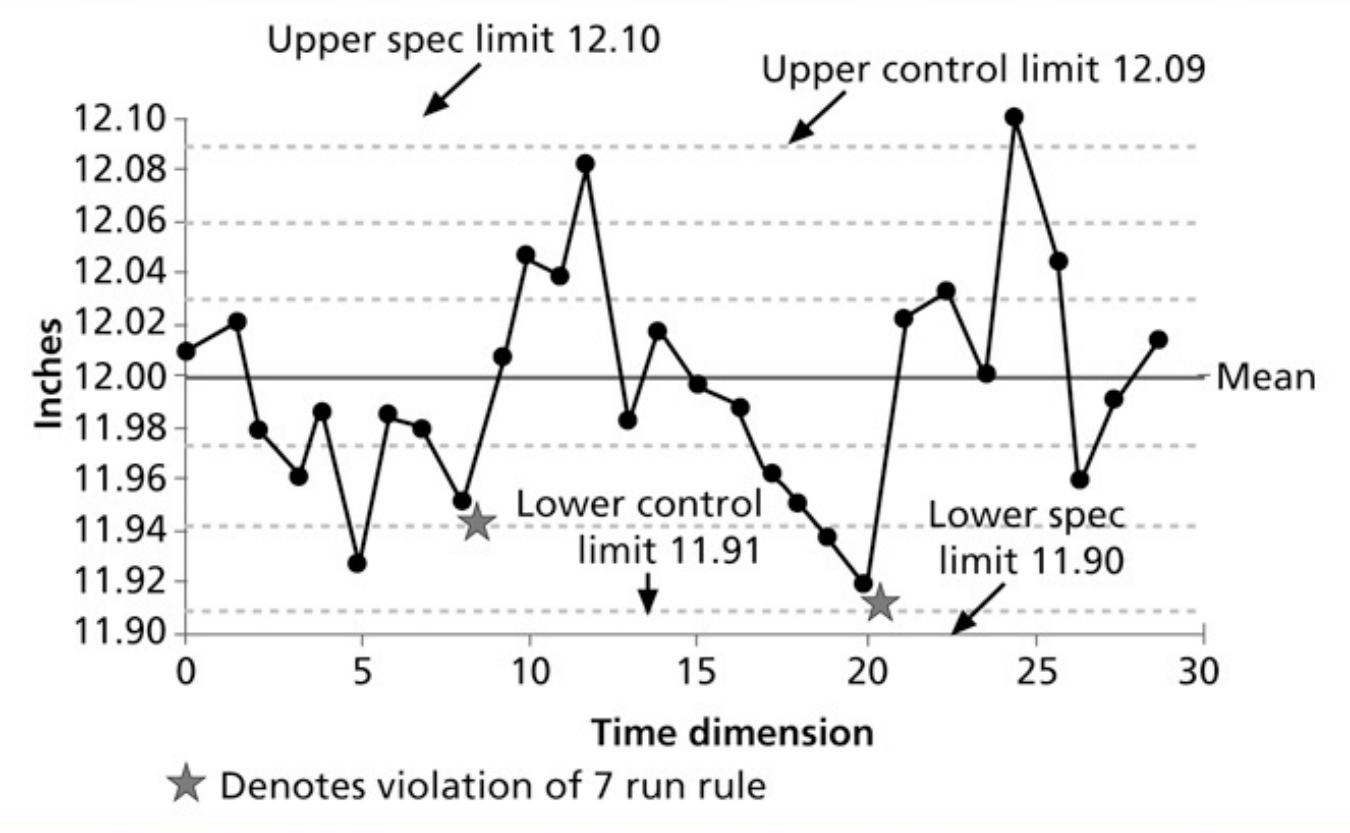


Sample check sheet

Defect	Day 1	Day 2	Day 3	Day 4	Total
Broken link	5	3	2	4	14
Spelling error	2	1	2	2	7
Wrong format	3	2	4	1	10

Sample Control Chart

A control chart is a graphical display of data that illustrates the results of a process over time.



Schwalbe, Information Technology Project Management, Sixth Edition, 2010

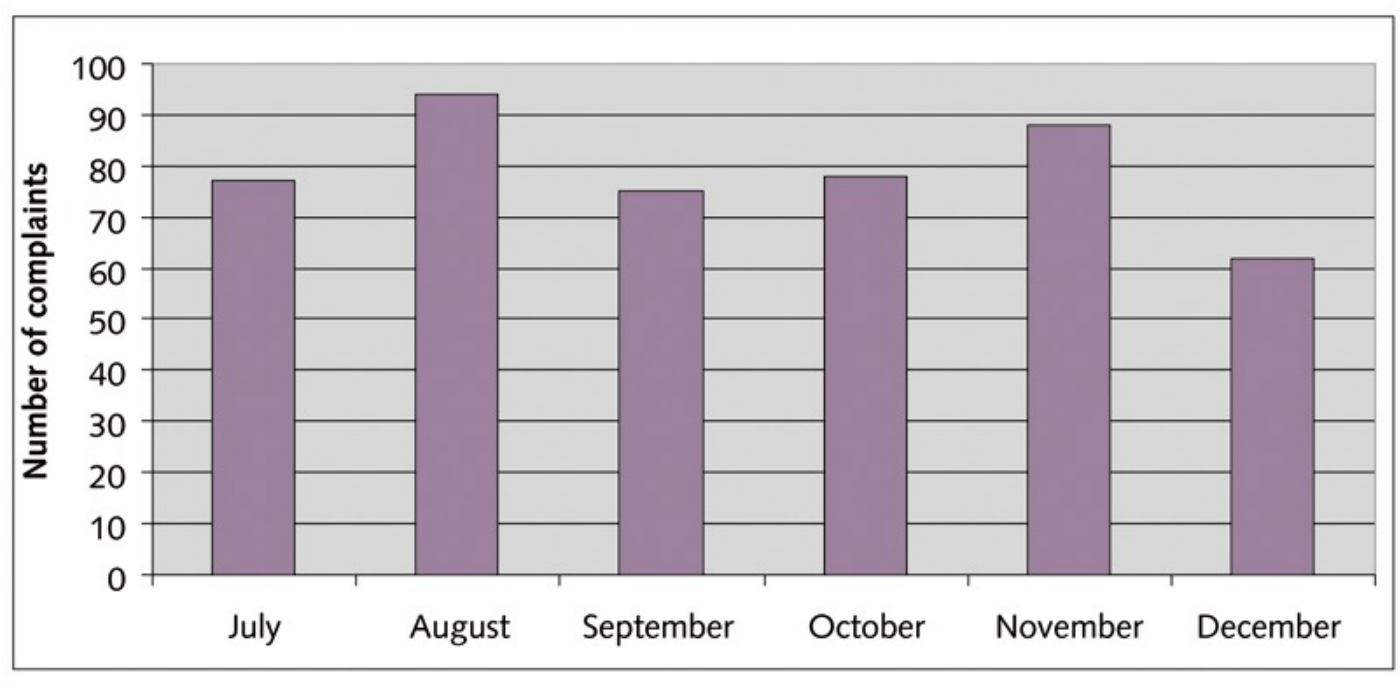
Control chart - Cont.

- Control charts allow you to determine whether a process is *in control* or *out of control*.
- When a process is *in control*, any variations in the results of the process are created by *random* events.
- Processes that are in control do not need to be *adjusted*.
- When a process is *out of control*, variations in the results of the process are caused by *non-random* events.
- When a process is out of control, you need to identify the causes of those non-random events and adjust the process to correct or eliminate them.

Control chart - The seven run rule

- You can use control charts and the *seven run rule* to look for patterns in data.
- The *seven run rule* states that if seven data points in a row are all below the mean, above the mean, increasing, or decreasing, then the process needs to be examined for non-random problems.
- In the previous Figure data points that violate the seven run rule are starred.
  - The first starred point has seven data points in a row that are all below the mean. The second one has seven data points in a row that are all decreasing.

Sample Histogram

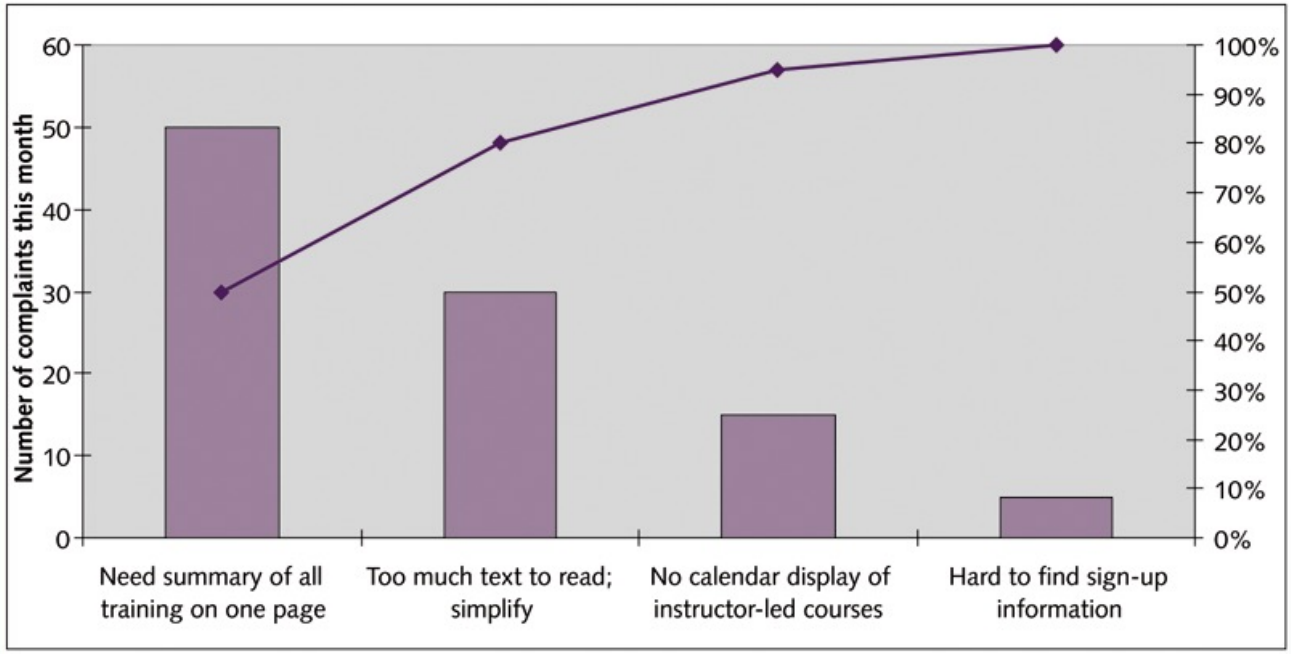


Each bar represents an attribute or a characteristic of a problem or a measurement point, and the height of the bar represents its frequency.

Pareto charts

- A Pareto chart is a histogram that can help you *identify* and *prioritize problem* areas.
- The variables described by the histogram are *ordered* by *frequency* of *occurrence* in a column chart, and a *line chart* is added to show *cumulative percentage* on the right of the chart.
- Pareto charts help you identify the *vital few contributors* that *account* for *most quality problems* in a system.
- Pareto analysis is sometimes referred to as the *80/20 rule*, meaning that 80% of problems are often due to 20% of the causes.

Sample Pareto Chart



- The solid line represents the cumulative amount of problems. Note that Pareto charts work best when the problem areas are of equal importance.

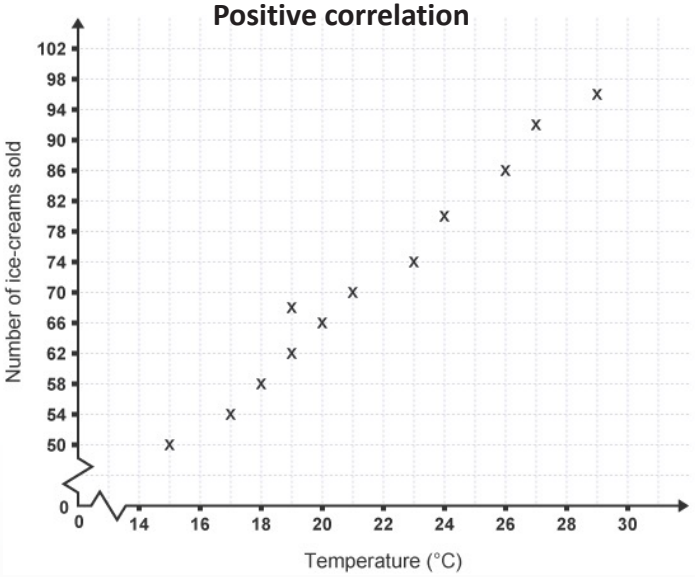
- For example, if a life-threatening problem was reported, it should be considered before less important problems.

Scatter diagram

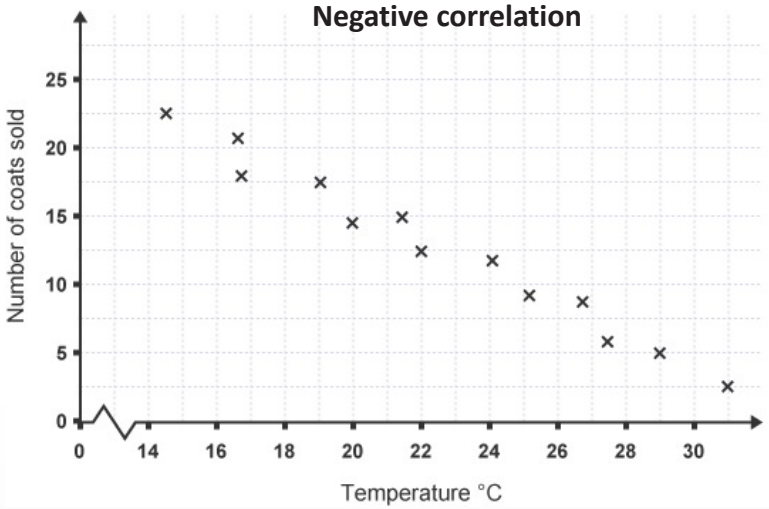
- A scatter diagram helps show if there is is a correlation, or connection between two sets of data.
- The closer data points are to a diagonal line, the more closely the two variables are related.
- Types of correlation : Graphs can either have *positive* correlation, *negative* correlation or *no correlation*.
- Note: it is important to remember that correlation does not imply causation. If data plotted on a scatter graph shows correlation, we cannot assume that the increase in one of the sets of data caused the increase or decrease in the other set of data – it might be coincidence or there may be some other cause that the two sets of data are related to.

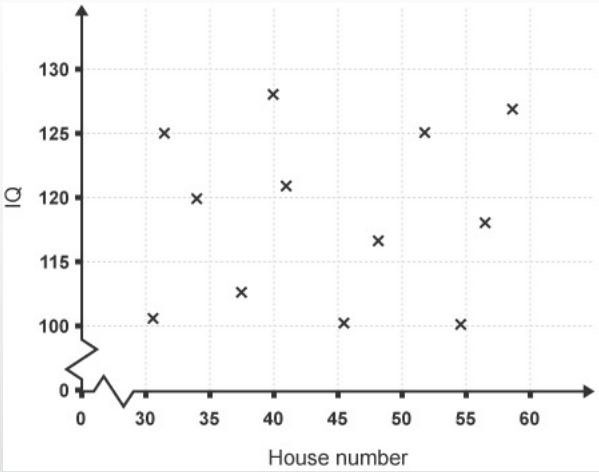
Types of correlation

Positive correlation



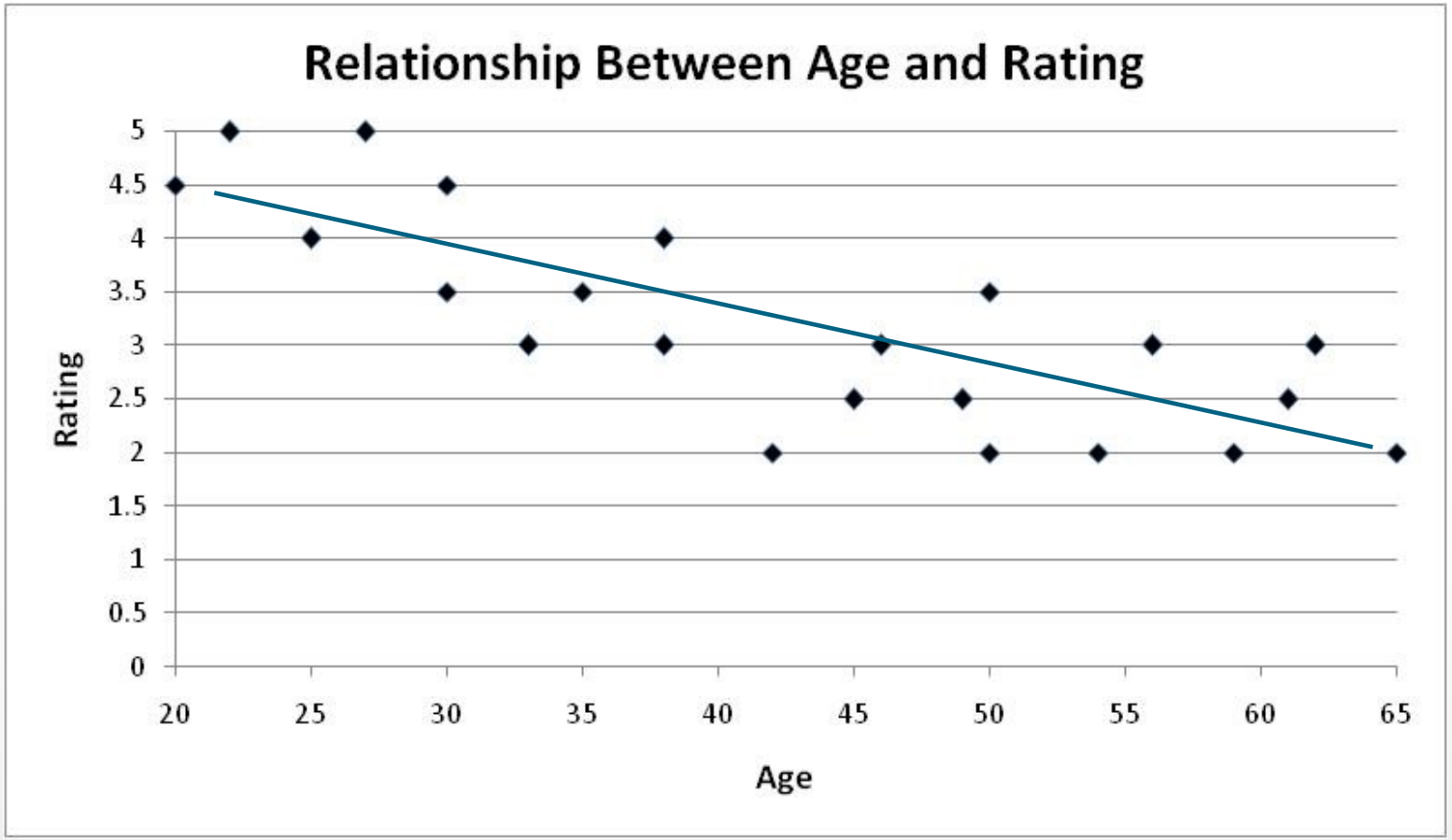
Negative correlation





No correlation

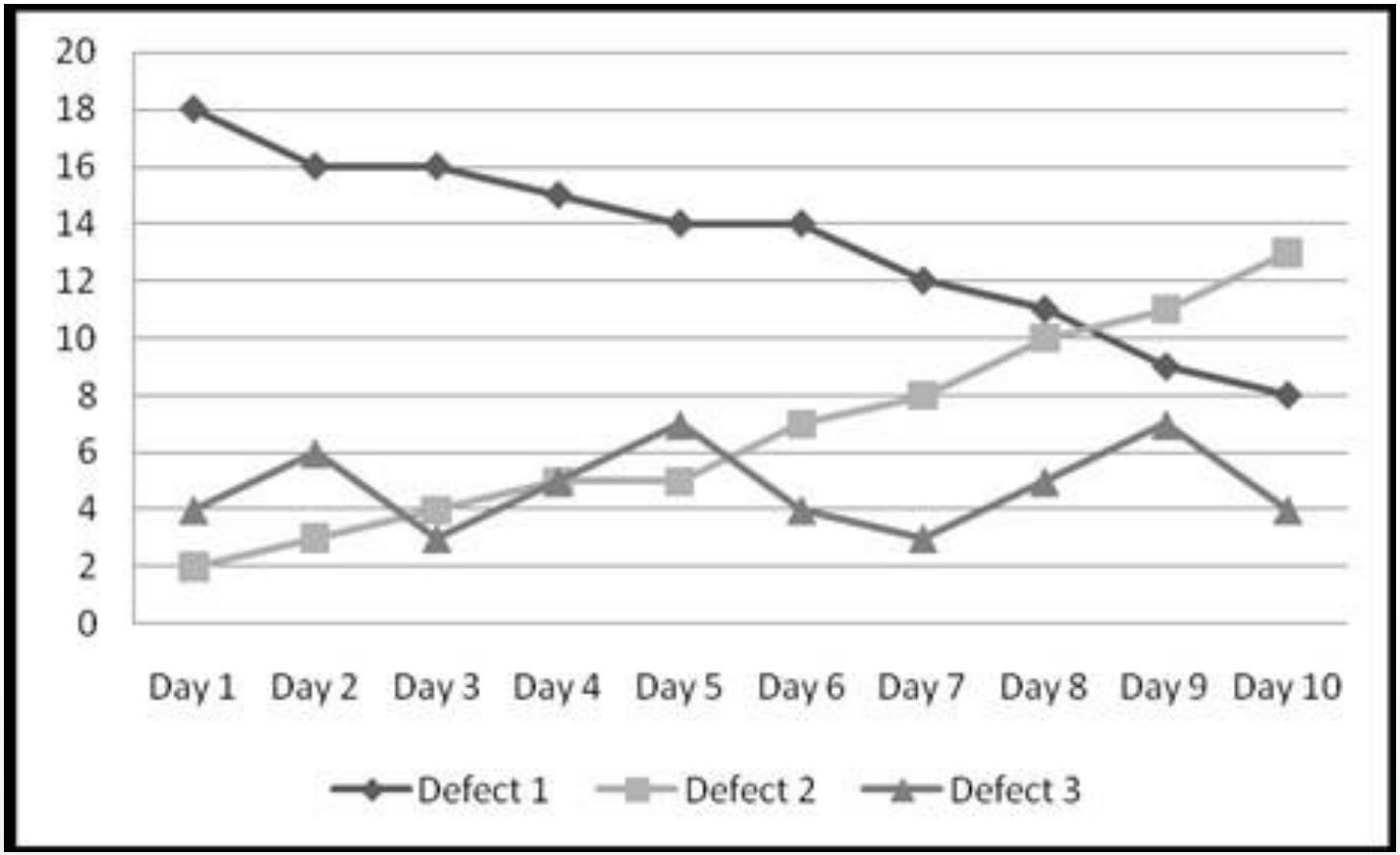
Sample Scatter Diagram



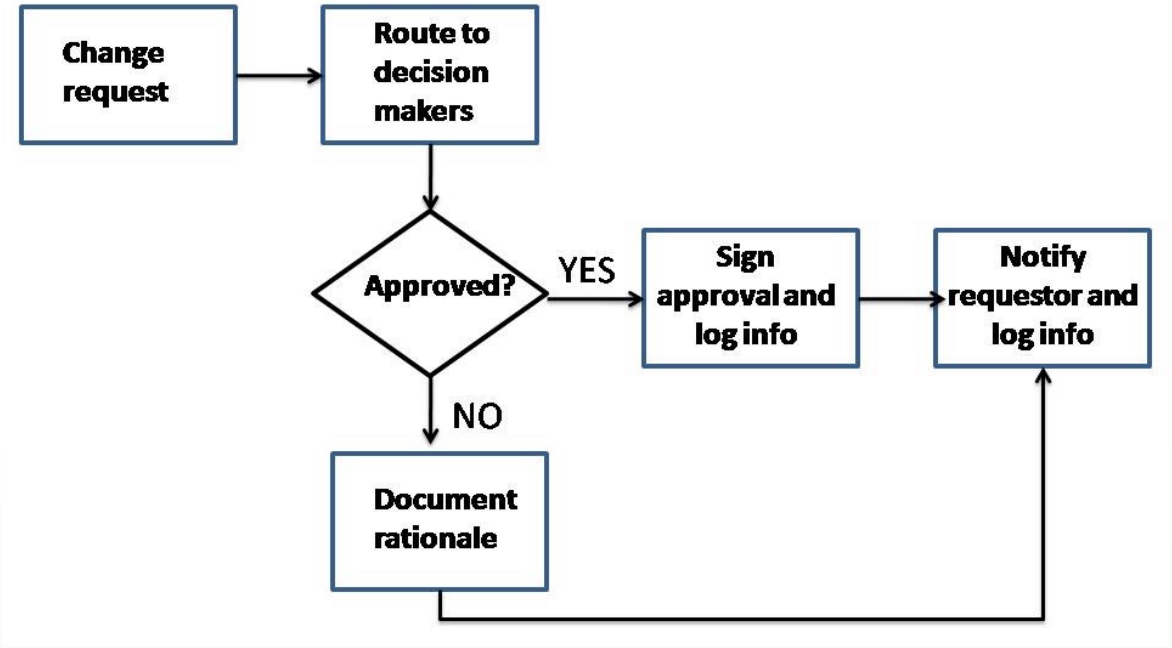
Stratification

- *Stratification* is a technique used to *separate* data to see patterns in data.
- Some sources use *run charts* or *flow charts* in place of stratification.
- A *run chart* displays the history and pattern of variation of a process over time. It is a line chart that shows data points plotted in the order in which they occur.
- You can use run charts to perform trend analysis to forecast future outcomes based on historical results.
- For example, trend analysis can help you analyse how many defects have been identified over time to determine if there are trends.

Sample Run Chart



Sample Flowchart



A **flow chart** is a graphical display of the logic and flow of processes that help you analyse how problems occur and how processes can be improved. They show activities (using the square symbol), decision points (using the diamond symbol), and the order of how information is processed (using arrow symbols).

Knowledge area	Monitoring and controlling process	Outputs
Project quality management	Control quality	Quality control measurements Verified deliverables Work performance information Change requests Project management plan updates Project documents updates
Project resource management	Control resources	Work performance information Change requests Project management plan updates Project documents updates
Project communications management	Monitor communications	Work performance information Change requests Project management plan updates Project documents updates
Project stakeholder management	Monitor stakeholder engagement	Work performance information Change requests Project management plan updates Project documents updates
Project risk management	Monitor risks	Work performance information Change requests Project management plan updates Project documents updates Organizational process assets updates
Project procurement management	Control procurements	Closed procurements Work performance information Procurement documentation updates Change requests Project management plan updates Project documents updates Organizational process assets updates

Project Resource Management

- *Controlling resources* involves *ensuring* that the *physical resource*s assigned to the project are *available as planned* and *monitoring* the *planned* versus *actual resources* utilisation, taking corrective actions as needed
- Making *effective use* of *team* members is addressed under the Manage Team process
- Tools and techniques include data analysis, problem solving, interpersonal and team skills, and project management information systems
- Key outputs include *work performance* information, *change requests*, project management plan updates, and project documents updates.

Project Communications Management

- *Controlling communications* involves *monitoring* and controlling communications throughout the project life cycle to ensure that *stakeholder information* needs are met
- Key outputs include *work performance* information, change requests, project management plan updates, and project documents updates

Project Stakeholder Management

- You *cannot control stakeholders*, but you can control their level of engagement
- Controlling stakeholder engagement involves monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders as needed
- Outputs include work performance information, change requests, project management plan updates, and project documents updates
  - *On some projects key stakeholders are members of the project team*

Video Highlights

- The German firm PERI not only printed Germany's first home (meeting all permit requirements) but also Europe's largest 3-D-printed apartment building. Errors on site have been almost completely eradicated with 3-D printing, saving time, money, and waste material.
- Customers seem to be flocking toward the new technology in some areas. Rancho Mirage, California, near Palm Springs, is the site of the first 3-D-printed community in the U.S., set for completion in spring 2022. Pari development group and Mighty Buildings are working together to build 15 eco-friendly homes, each with three-bedrooms, two-bathrooms, and 1,450 square feet on a 10,000 square-foot lot with a swimming pool and deck for $595,000. "The presale campaign started in late February and sold out within days, with buyers paying $1,000 to reserve a spot, said Palari Chief Executive Basil Starr. 'It was reassuring to see such demand for these homes.'

Project Risk Management

- Monitoring and controlling risks involves implementing the risk response plans, while continuing to identify and analyse new risks and evaluate risk process effectiveness
- Carrying out individual risk management plans involves monitoring risks based on defined milestones and making decisions regarding risks and their response strategies
- Project teams sometimes use workarounds—unplanned responses to risk events—when they do not have contingency plans in place
- Outputs of risk control include work performance information, change requests, project management plan updates, project documents updates (especially updating the risk register), and organizational process assets updates

Sample Risk Register Updates

- Recall that the number one risk event in the risk register for the Just-In-Time
  - Training project was a poor survey response.
  - Because the project was now halfway completed, the risk register would have to change significantly
- For example, senior management informed Kristin that Global Construction, Inc. was growing faster than expected, and they thought the number of people needing training would be higher than expected.
  - This information resulted in the identification of several new risks related to accommodating this growth in trainees

Project Procurement Management

- Controlling procurements involves managing procurement relationships, monitoring contract performance, making changes and taking corrective actions as needed, and closing out contracts
- The contractual relationship is a legal relationship and, as such, is subject to state and federal contract laws
- Someone from the procurement or legal department in organisations usually closes out contracts
- In addition to work performance information, change requests, project management plan updates, project documents updates, and organizational process asset updates, key outputs of controlling procurements include closed procurements and procurement documentation updates

Watch for Constructive Change Orders

- Constructive change orders are oral or written acts or omissions by someone with actual or apparent authority that can be construed to have the same effect as a written change order
- For example, if a project team member has met with a supplier or contractor on a weekly basis for three months to provide guidelines for performing work, he or she can be viewed as an apparent authority
- If he or she tells the contractor to redo part of a report that has already been delivered and accepted by the project manager, that action can be viewed as a constructive change order, and the contractor can legally bill the buyer for the additional work

Sample Contract Closure Notice

Global Construction, Inc. Contract Closure Notice
September 16

As described in our service agreement, this letter provides formal notice that the work you were contracted to perform for Global Construction has been completed. ABC Training developed a qualified sellers list containing thirty potential sellers and a report with one-page of key information on each seller. Payment is being processed based on the invoice provided by ABC Training.

Kristin Maur, the project manager, has provided the following performance assessment for the work provided:

"We were very pleased with the work of ABC Training. Members of the firm were professional, knowledgeable, and easy to work with. Global Construction depended on ABC Training to develop a qualified sellers list for this important project, and we were extremely happy with the results. On a scale of 1 to 10, you earned a 10!"

Lawrence Scheller

By: Lawrence Scheller, Contract Specialist
Date September 16

Applying Project Management Principles to Monitoring And Controlling Projects

- Embracing adaptability and resiliency.
- According to the PMBOK® Guide – Seventh Edition,
  - Adaptability is the ability to respond to changing conditions.
  - Resiliency is the ability to absorb impacts and to recover quickly from a setback or failure.
- It's important for project teams to expect changes, plan for them, and be adaptable and resilient in responding to them.

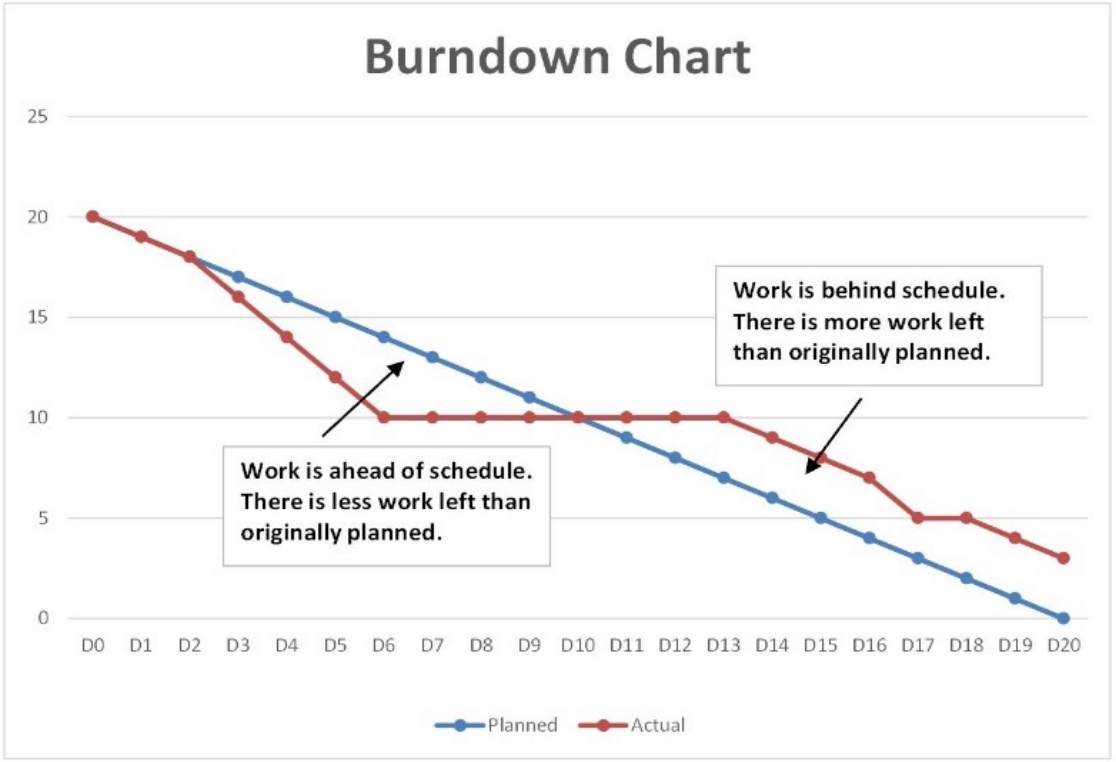
Monitoring And Controlling Agile/Hybrid Projects

- The daily Scrum and sprint review meetings assist in monitoring and controlling agile projects
- Burn charts show project team velocity. Velocity measures the productivity rate at which the deliverables are produced, validated, and accepted within a predefined interval.
- You can create the following types of burn charts:
  - Burndown charts show the amount of work (number of tasks) remaining compared to the plan. They are often used for each sprint and discussed during sprint retrospectives.
  - Burnup charts show the amount of work (tasks) completed compared to the plan. They can be used during each sprint, and they can also show progress for several sprints.
  - Combined burn charts show how much work has been completed and how much remains.

Sprint Burndown Chart

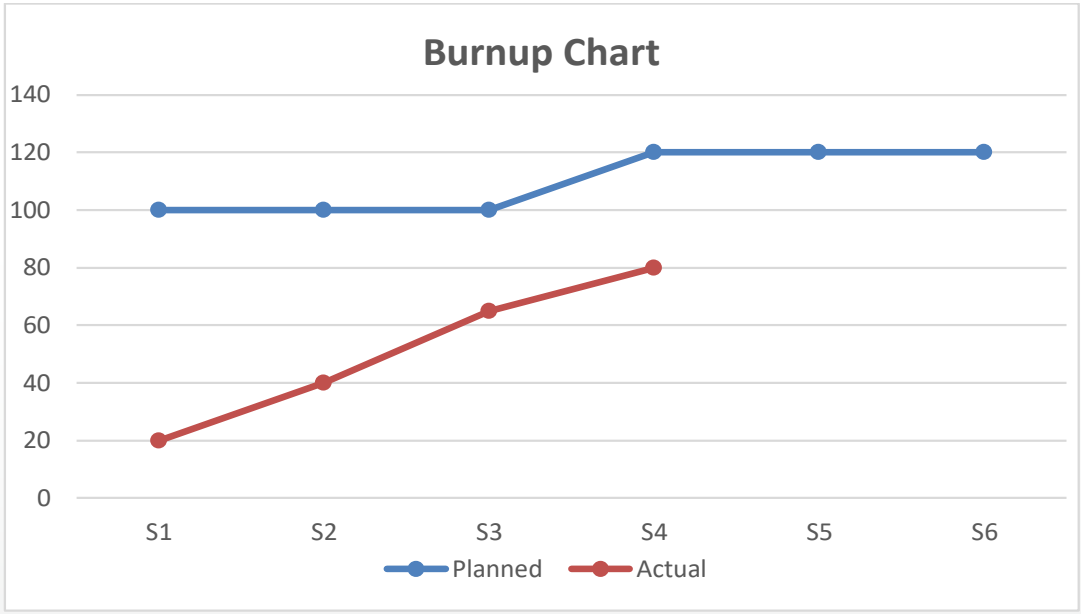
Number of Tasks

Days	Planned	Actual
D0	20	20
D1	19	19
D2	18	18
D3	17	16
D4	16	14
D5	15	12
D6	14	10
D7	13	10
D8	12	10
D9	11	10
D10	10	10
D11	9	10
D12	8	10
D13	7	10
D14	6	9
D15	5	8
D16	4	7
D17	3	5
D18	2	5
D19	1	4
D20	0	3



Sample Burnup Chart

Sprints	Planned	Actual
S1	100	20
S2	100	40
S3	100	65
S4	120	80
S5	120	
S6	120	



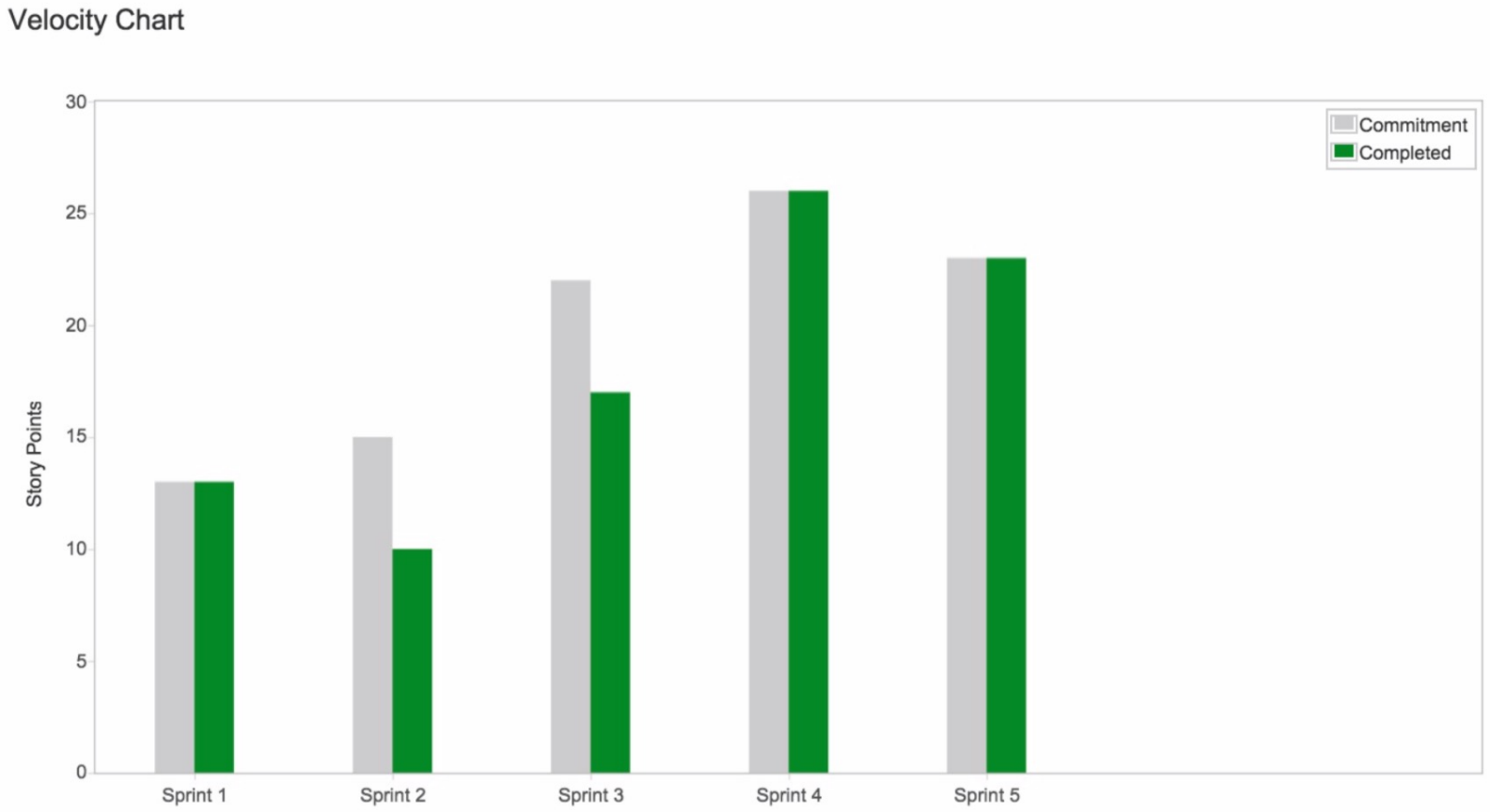
Velocity Charts

- Sprint teams use velocity to measure how much work they can complete in each iteration.
- It is widely used to help teams create accurate and efficient timelines.
- Sprint team velocity is not constant; rather, it varies.
  - Note that velocity charts are not intended to be a tool for monitoring the team.
  - They are most useful as a tool for release planning.
- The velocity chart is created after the first sprint and updated after each completed sprint.
- The velocity of the sprints helps managers to calibrate the release plan.

Velocity Charts – Cont.

- The Velocity Chart shows the amount of value delivered in each sprint, enabling you to predict the amount of work the team can get done in future sprints.
- It is useful during your sprint planning meetings, to help you decide how much work you can feasibly commit to.

Sample Velocity Chart



Sprint	Commitment	Completed
Sprint 1	13	13
Sprint 2	15	10
Sprint 3	22	17
Sprint 4	26	26

Chapter Summary

- Monitoring and controlling involves regularly measuring progress to ensure that the project is meeting its objectives and addressing current business needs. The project manager and other staff monitor progress against plans and take corrective action when necessary.
- Every knowledge area includes processes and outputs to help monitor and control projects. Outputs common to several knowledge areas include change requests, work performance information, organizational process assets updates, project management plan updates, and project document updates.
- Project managers should apply the project management principle of embracing adaptability and resiliency when monitoring and controlling projects.
- Agile teams also monitor and control their projects. Daily Scrums and sprint reviews are events that assist in monitoring and controlling on a regular basis. Burn charts, task boards, and velocity charts are artifacts that assist in showing progress to all interested stakeholders.

References

- Chapter 8: Monitoring and Controlling Projects