Monitoring and Controlling the Project

Control vs. Risk

- Controls are used to discover the out-of-balance situations early and put the project back to track as quickly as we can.
- Senior managers generally aren't interested in reading long reports only to find out that everything is on schedule.
- Variety of repots as control tools:
  - Numeric and tabular form,
  - Graphics.

Purpose of Controls

- Controls are actions taken as a result of reports.
- Controls are designed to bring actual projects status back into conformance with the project plan.
- The reports are designed to support control activities by drawing attention to certain aspects or characteristics of the project, such as planned versus actual schedule, trends in the schedule, and actual versus planned resource use.

- Typically we want to track
  - performance levels,
  - costs,
  - time schedules.

Three Reasons to use Reports in a Project

- **To track progress**. Project manager needs a periodic (biweekly or weekly) reporting system that identifies the status of every activity scheduled for work since the last progress report. These reports summarize progress for the current period as well as the cumulative progress for the entire project.

- **To detect variance from plan**. Variance reports are important to management. To get the variance, the project manager compares planned performance to actual performance.

- **To take corrective action**. If there is significant variance from plan, the next step is to determine whether corrective action is needed and then act appropriately.

Progress Reporting System

- A reporting system would have the following characteristics:
  - Provides timely, complete, and accurate status information
  - Doesn't add so much overhead time as to be counter productive
  - Is readily acceptable and understood to the project team and senior management
  - Warns of pending problems in time to take action

Types of Project Status Reports

- There are five types of project status reports:
  1. **Current period reports**. These reports report progress on those activities that were open or scheduled for work during the period. These reports might highlight activities completed and variance between scheduled and actual completion dates.
  2. **Cumulative reports**. These reports contain the history of the project from the beginning to the end of the current report period. They show trends in project progress.

Types of Project Status Reports

3. **Exception reports**. Exception reports report variances from plan. Mainly designed for senior management.
4. **Stoplight reports**. Use stickers to signal the status of your project.
    1. On Track : green sticker on the top right of the first page of the project status report.
    2. Under Control: yellow sticker when there are problems but under control
    3. Out of Control: red sticker.
5. **Variance reports**. Variance reports report differences between what was planned and what actually happened. The report has three columns: the planned number, the actual number, and the difference, or variance.

Measuring Duration and Cost Variances

- There are five reasons why we want to measure duration and cost variances:

1. **Catch deviations from the curve early**. The cumulative actual cost or actual duration can be plotted against the planned cumulative cost or cumulative duration.
2. **Dampen oscillation**. Planned versus actual performance should display a similar pattern over time. Wild fluctuations between the two may imply a project that is not under control.
3. **Allow early corrective action**. The project manager be alerted to a schedule or cost overrun early.
4. **Determine weekly schedule variance**. Reporting progress on activities open for work should be reported on a weekly basis. This allows the project manager to discover overrun and take corrective action before the situation escalates to a point where it will be difficult to avoid schedule slippages.
5. **Determine weekly effort (person hours/day) variance**. The differences between the planned effort and actual effort has a direct impact on both planned cumulative cost and schedule. If effort is less than planned, it may suggest a potential schedule slippage.

What to report?

- The list of what should be reported by the activity manager and project manager:
  1. **Determine a set period of time and day of week to submit the updated information**.
  2. **Report actual work accomplished during this period**. What was planned to be accomplished and what was actually accomplished are two different things.
  3. **Record historical and re-estimate remaining (in-progress work only)**.
  4. **Report start and finish dates**. These are the actual start and finish dates of activities started or completed during the report period.
  5. **Record days of duration accomplished and remaining**.
  6. **Report resource effort (hours/day) spent and remaining (in-progress work only)**. The above numbers report calendar time and these numbers report labor time over the duration of the activity. There are two numbers. One reports labor completed over the duration accomplished. The other reports labor spent over the remaining duration.

Variances

- Variances are deviations from plan.
- A variance is the difference between what was planned and what actually occurred.
- There are two types of variances:
  - **Positive Variances:** These are deviations from plan that indicate that an ahead-of-schedule situation has occurred or that an actual cost was less than a planned cost.
  - **Negative Variances:** Negative variances are deviations from plan that indicate that a behind-schedule situation has occurred or that an actual cost was greater than a planned cost.

Graphical Reporting Tools

- Senior managers are interested in brief reports only because they are always short on time
- There is no need to read several pages to know that the project is on schedule.
- Always summarize the data in a way that will be easy to find out that status of the project within few minutes NOT hours

Gantt Charts

- A Gantt chart is one of the easiest ways to understand the status of the project activities.
- The chart is formatted as a two-dimensional representation of the project schedule with activities shown in the rows and time shown across the horizontal axis.
- It can be used during planning, for resource scheduling, and for status reporting.
- As you recall, the main drawback for Gantt charts is that they do not contain dependency relationships.

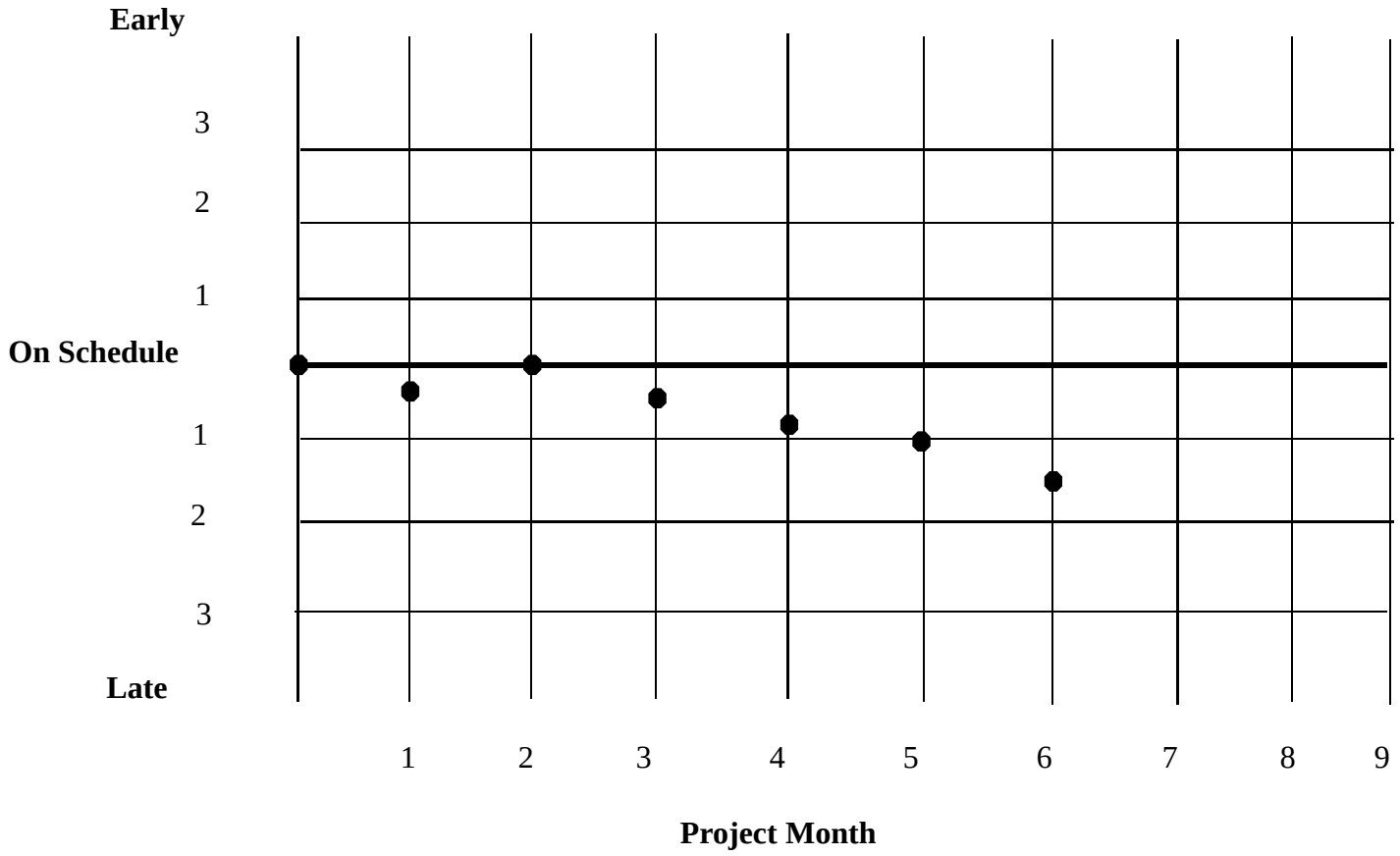
Milestone Trend Charts

- Milestones are zero-duration activities and merely represent that a certain condition exists in the project.
- For example, a milestone event might be that the approval of several different component designs has been given.
- This event consumes no time in the project schedule. It simply reflects the fact that those approvals have all been granted.
- The completion of this milestone event may be the predecessor of several build-type activities in the project plan.

Milestone Trend Charts

- The following milestone trend chart plots the difference between the planned and estimated date of a project report period.
- In the original project plan the milestone is planned to occur at the ninth month of the project. That is the last project month on this milestone chart.
- The horizontal line represents one, two, and three standard deviations above or below the forecasted milestone date.
- Any activity in the project has an expected completion date that is approximately normally distributed.

Milestone Trend Charts



Milestone Trend Charts

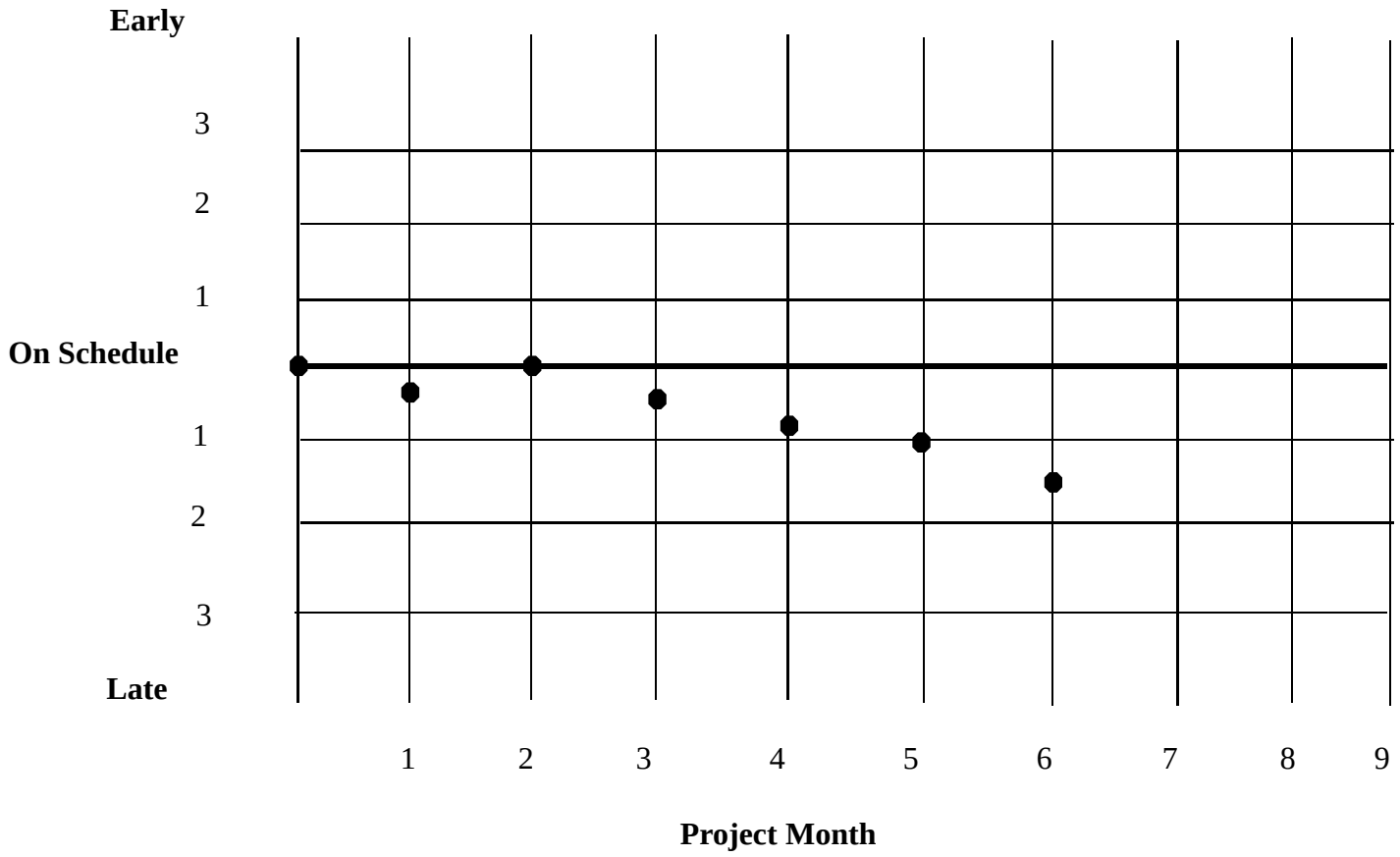
- The first project report (at month 1) shows that the new forecasted milestone date will be one week later than planned.
- The second project date (month two of the project) shows that the milestone date is forecasted on target.
- The next three project reports indicate a slippage to two weeks late, then three weeks late, then four weeks late, and finally six weeks late (at month 6).
- In other words, the milestone is forecasted to occur six weeks late, and there are only three more projects months in which to recover the slippage.
- Obviously, the project is in trouble. The project appears to be drifting out of control. Some remedial action is required of the project manager.

Milestone Trend Charts

- The following are examples of certain patterns that signal out-of-control situations:

1. **Successive slippages**. The following figure depicts a project that is drifting out of control. Each report shows additional slippage since the last report period. And require special corrective action from the project manager.

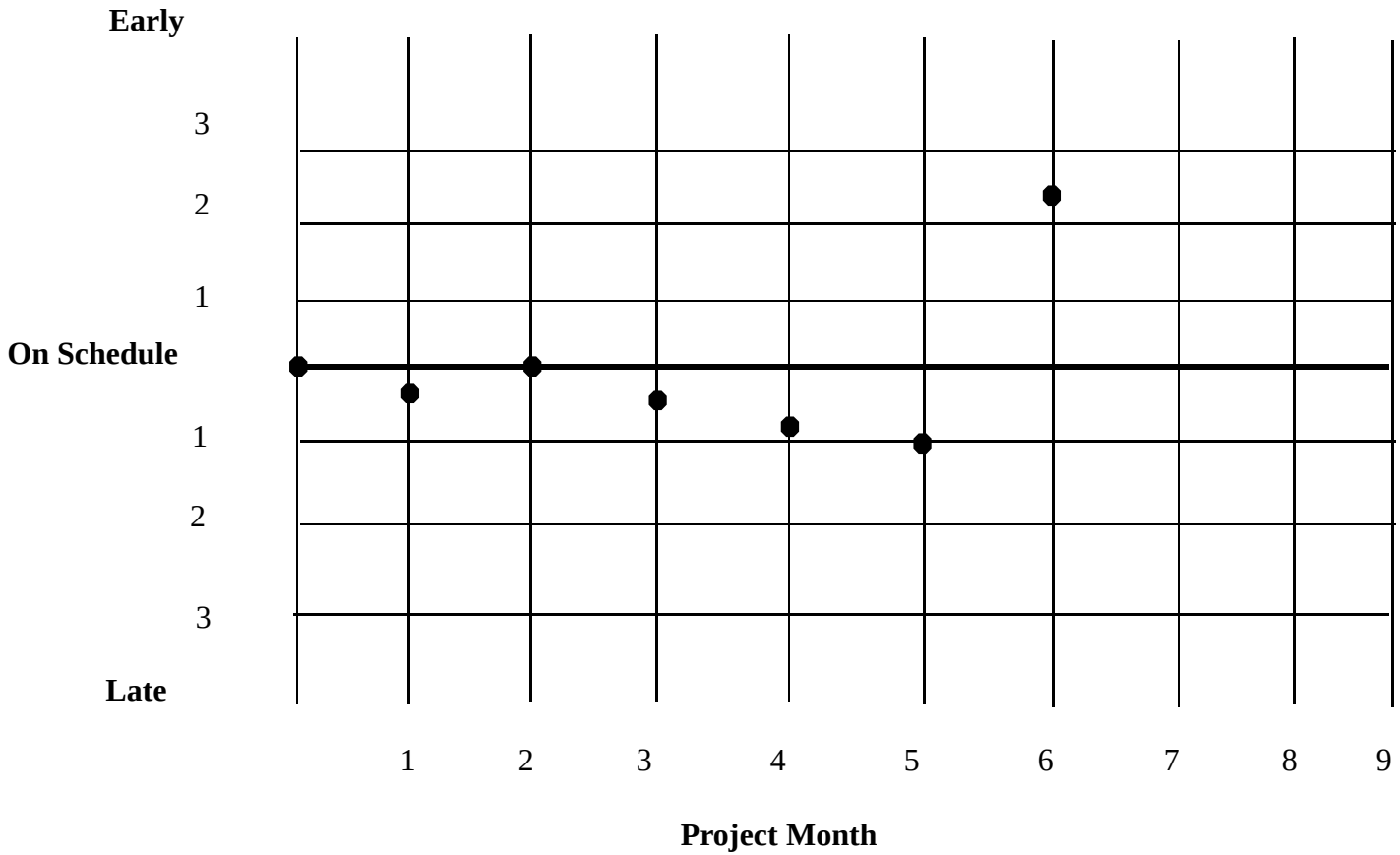
Milestone Trend Charts



Milestone Trend Charts

2. **Radical change**. The following Figure while it shows the milestone to be ahead of schedule, reports a radical change between report periods. Activity duration may have been grossly over-estimated. There may be a date error. In any case, the situation requires further investigation.

Milestone Trend Charts

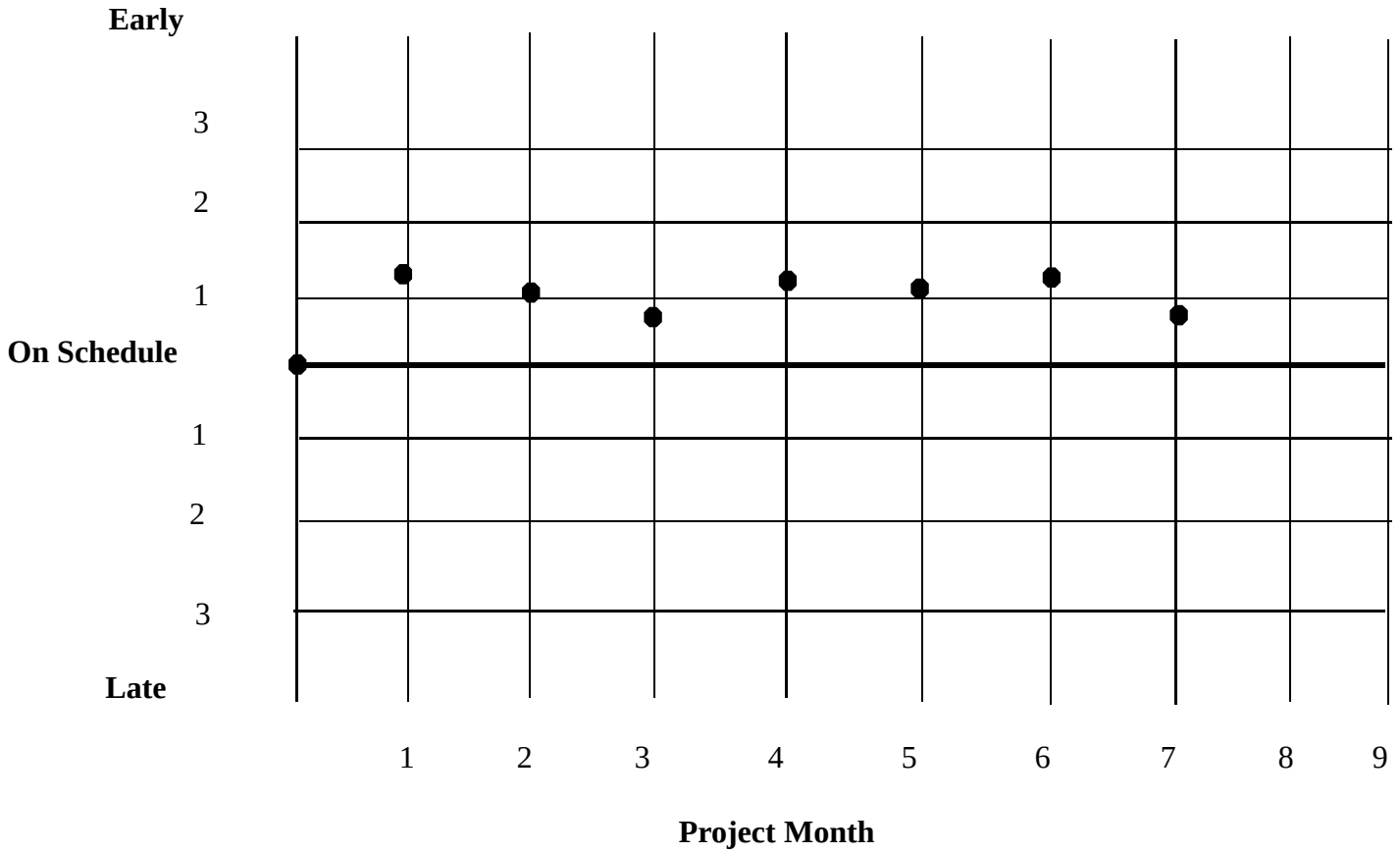


A change of more than three standard deviations

Milestone Trend Charts

3. **Successive runs**. The following Figure signals a project that may have encountered a permanent schedule shift. In the example, the milestone date seems a permanent to be varying around one month ahead of schedule. Barring any radical shifts and the availability of resources over the next two months, the milestone will probably come in one month early.

Milestone Trend Charts

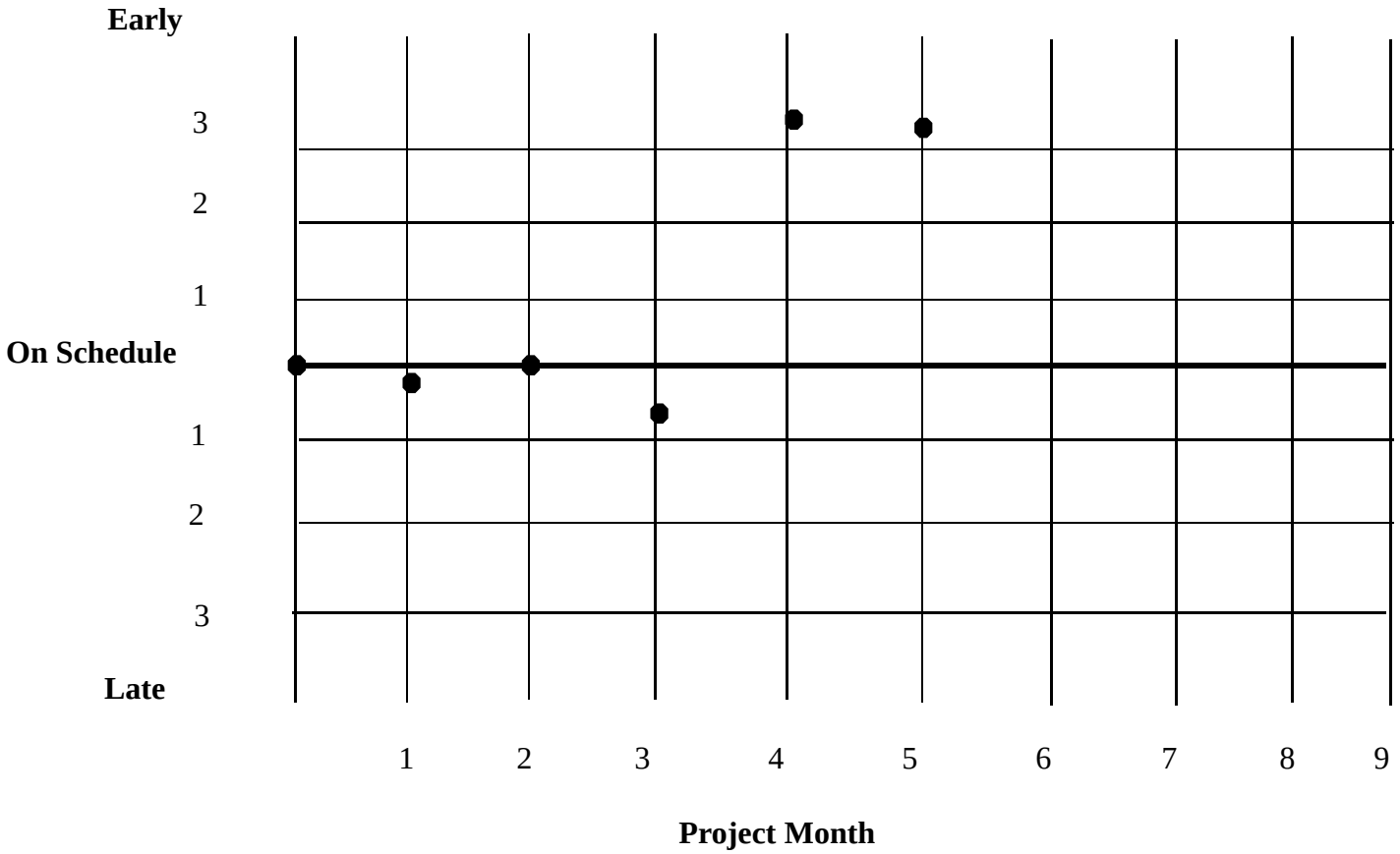


Seven successive data points above the planned milestone date

Milestone Trend Charts

4. **Schedule shifts**. The following figure depicts a major shift in the milestone schedule. The cause must be isolated and the appropriate corrective measures taken. One possibility is the discovery that a downstream activity will not be required. Perhaps the project manager can buy a deliverable rather than build it and remove the associated build activities from the project plan.

Milestone Trend Charts



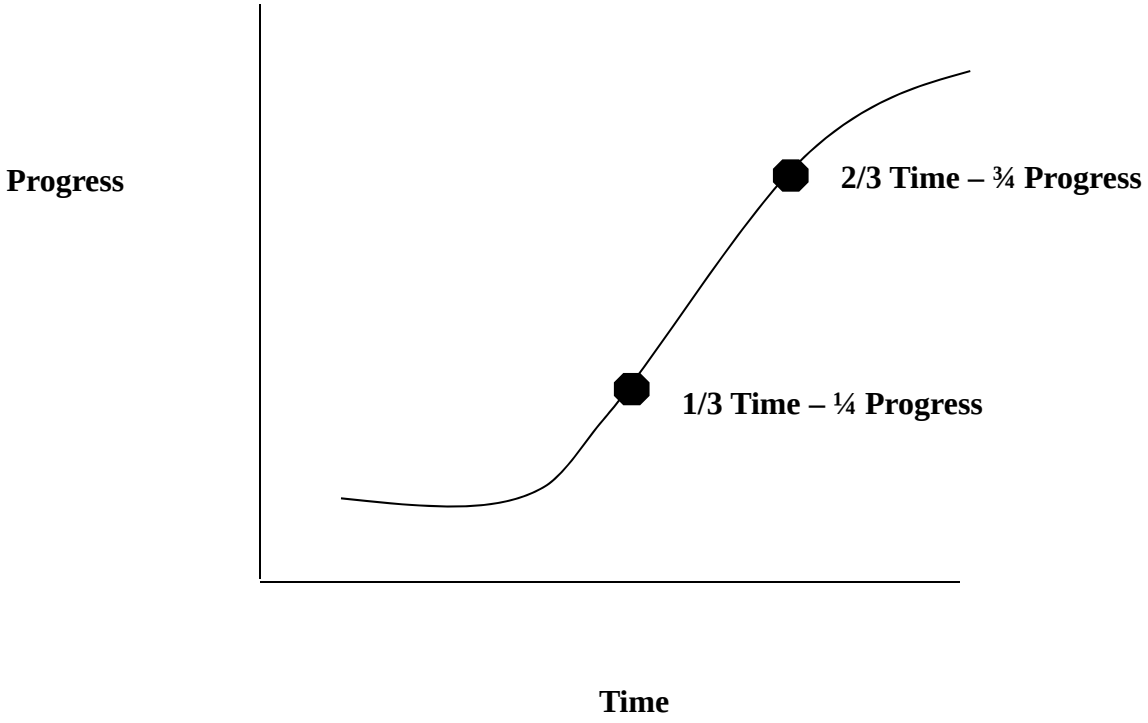
Two successive data points outside three standard deviations from the planned milestone date

Cost Schedule Control

- Cost schedule control is used to measure project performance and uses the dollar value of work as the metric. Or the resource person hours / day can be used when the project manager does not directly manage the project budget.
- Actual work performed is compared against planned and budgeted work expressed in these equivalents.
- These metrics are used to determine schedule and cost variances for both the current period and cumulative to date.
- One drawback that these metrics have is that they report history.

Cost Schedule Control

- The following figure shows an S curve, which represents the baseline progress curve for the original project plan. It can be used as a reference point.
- You can compare your actual progress to date against the curve and determine how well the project is doing; progress can be expressed as either dollars or person hours / day.



Cost Schedule Control

- As shown in **Figure A**, by adding the actual progress curve to the baseline curve, you can now see the current status versus the planned status which shows the actual progress curve to be below the planned curve.
- If this represented dollars, we may falsely conclude that the project is running under budget; Projects rarely run significantly under budget.
- A more common reason for the actual curve to be below the baseline is that the activities that should have been done and thus the dollars or person hours / day that were planned to be expended have not been.
- The schedule variance is depicted in **Figure B** below.

Cost Schedule Control

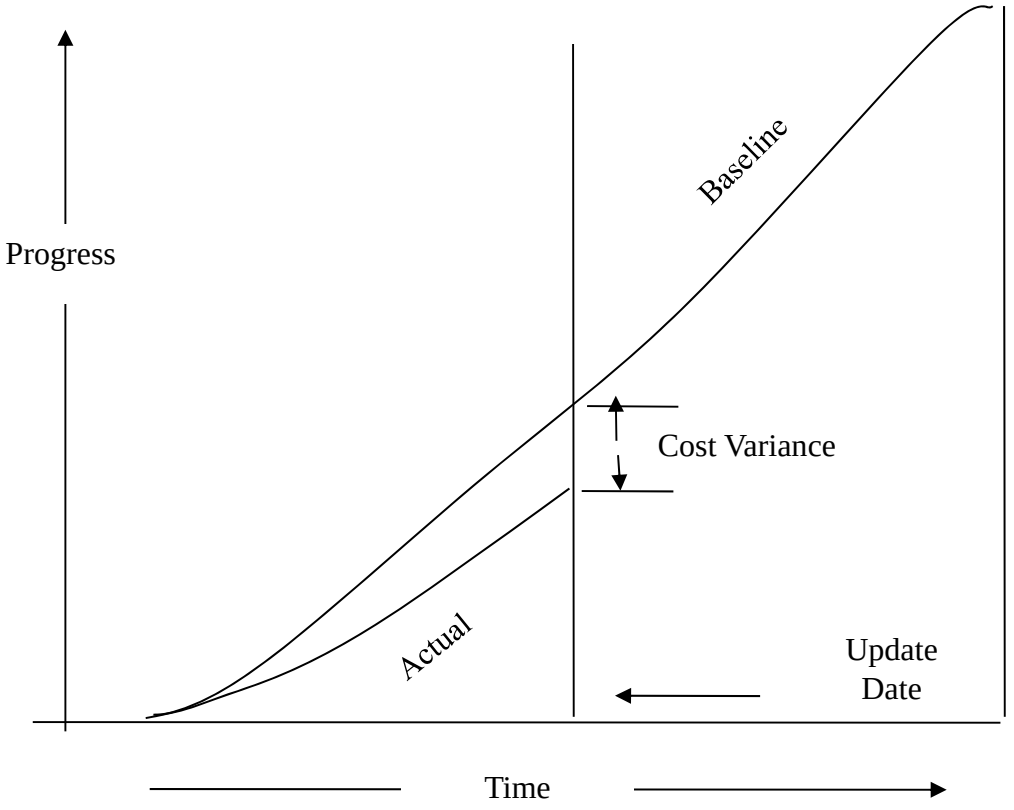


Figure A

Cost Schedule Control

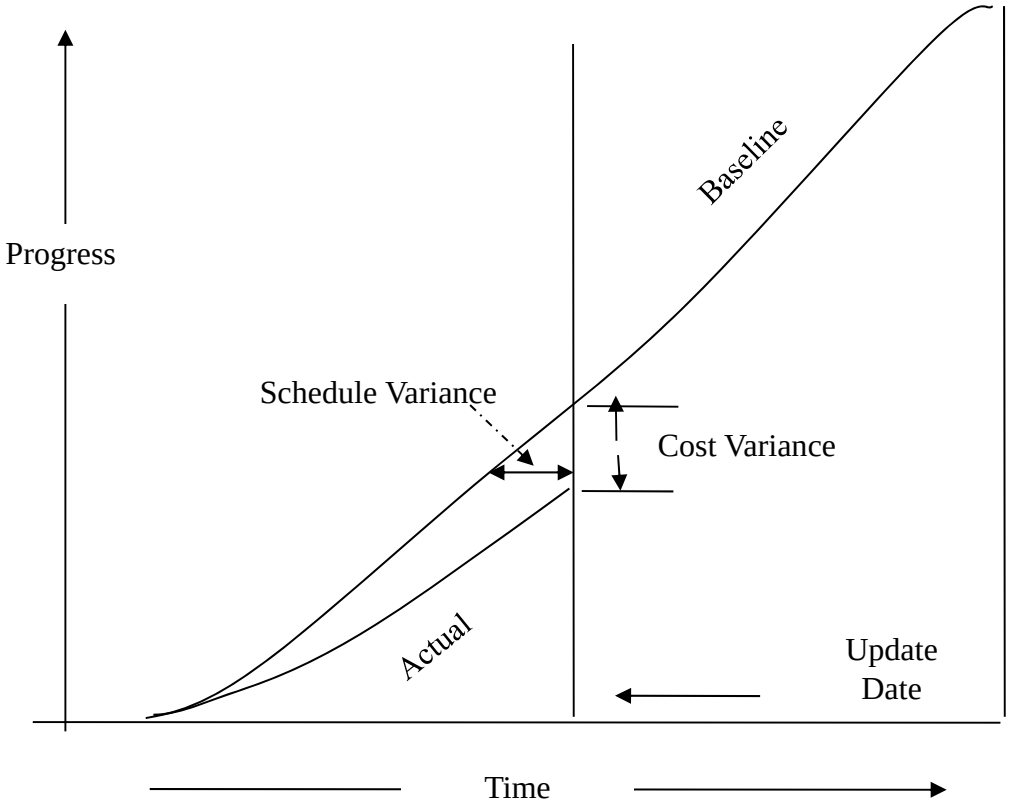


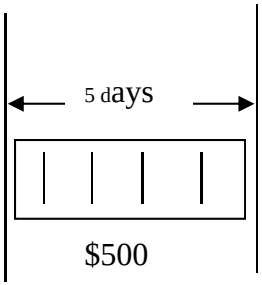
Figure B

Cost Schedule Control

- To determine whether there has really been a progress schedule variance, you need some additional information.
- Cost schedule control (CSC) comprises three basic measurements:
  - budgeted cost of work scheduled,
  - budgeted cost of work performed,
  - and actual cost of work performed
- These measurements result in two variance values, schedule variance and cost variance.
- The following Figure is a graphical representation of the three measurements
- The figure shows a single activity that has a five-day duration and a budget of $500. The budget is prorated over the five days at an average daily value of $100.

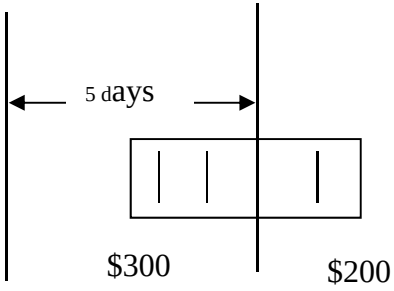
Cost Schedule Control

BCWS



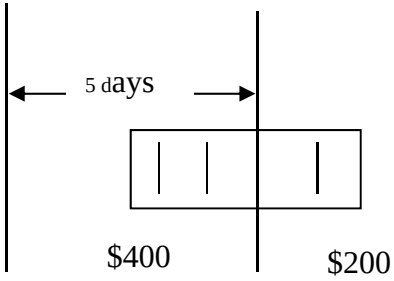
Scheduled/
Budgeted to do work over 5 days
in a 5-day window
BCWS=$500

BCWP



Schedule slippage permits only
3 days/$300 work to be
performed
BCWP=$300
Schedule variance=($200)

ACWP



Actual cost of work performed-$400
ACWP=$400
Actual cost variance=($100)

Cost Schedule Control

- The **left panel** of the above Figure shows an initial (baseline) schedule with the activity starting on the first day of the week (Monday) and finishing at the end of the week (Friday). The budgeted $500 value of the work is planned to be accomplished all within that week. This is the budgeted cost of work scheduled (BCWS).
- The **center panel** shows the actual work that was done. Work did not begin until the third day of the week. Using an average daily budget of $100 we see that we were able to complete only $300 of the scheduled work. This is the budgeted cost of work performed (BCWP).
- The **rightmost panel** shows the actual schedule as in the center panel, but now we see the actual dollars that were spent to accomplish the three days work is $400. This $400 is the actual cost of work performed (ACWP).

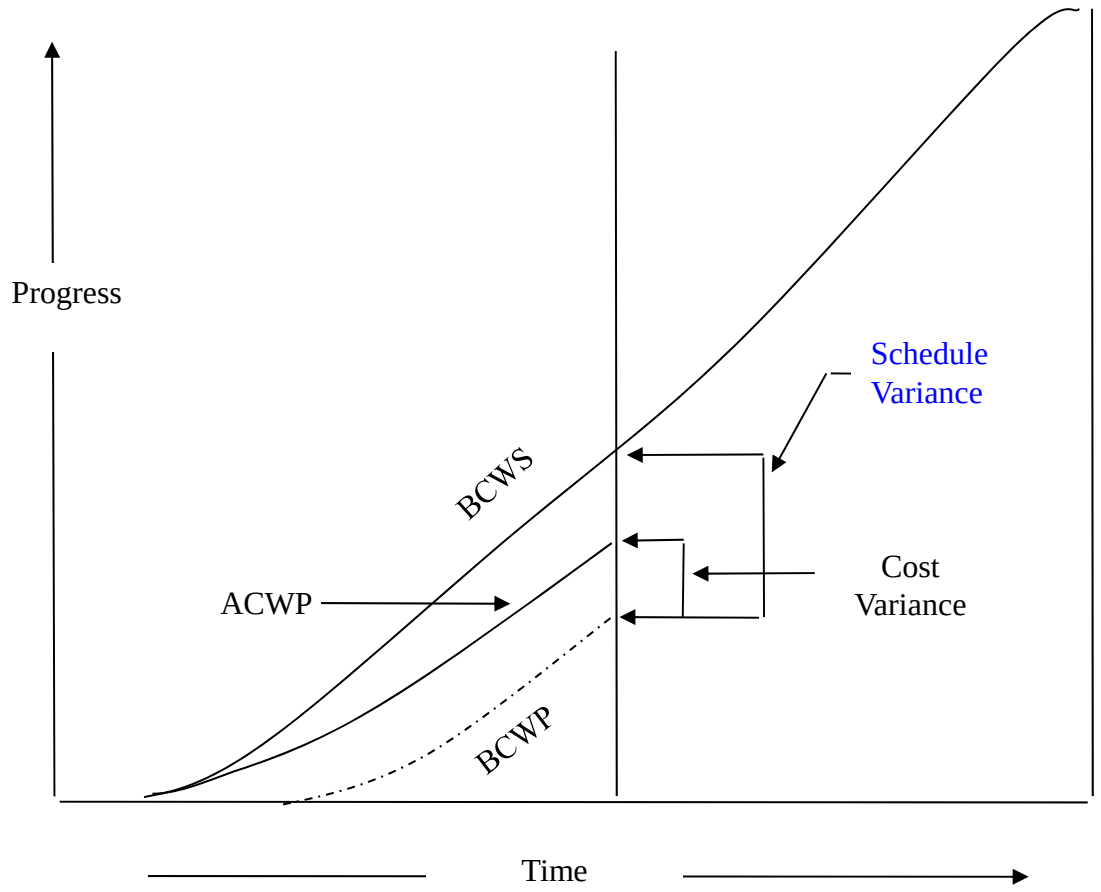
Cost Schedule Control

- The BCWS, BCWP, and ACWP are used to compute and track two variances.
  - The first is schedule variance (SV). SV is the difference between what was done and was planned to be done, expressed in dollars or person hours / day equivalents.
  - The second is cost variance (CV). CV is the difference between the BCWP and the ACWP, which is $100 in this example. That is, we overspent by $100 (ACWP-BCWP) the cost of the work completed.

Cost Schedule Control

- Generally, it will be misleading just when we find the actual cost is below the baseline to conclude that the project is on a healthy track.
- The more reliable conclusion will be inferred by comparing both budget variance and schedule variance, as shown in the following Figure.
- In the following figure, by Comparing the BCWP curve with the BCWS curve you see that you have under spent because all of the work that was scheduled has not been completed.
- And Comparing the BCWP curve to the ACWP curve also indicates that you overspent for the work that was done.
- Clearly, management would have been misled by the previous **Figure A**.

Cost Schedule Control



Cost Schedule Control

- The CSC can also be used to predict the future status of a project.
- From the previous figure, By cutting the BCWS curve at the height from the horizontal axis, which has been achieved by the BCWP, and then pasting this curve on to the end of the BCWP curve, you can extrapolate the completion of the project. Note that this is based on using the original estimates for the remaining work to be completed. And doing the same for the ACWP.

Cost Schedule Control

- The three basic indicators yield one additional level of analysis for us.
- Schedule performance index (SPI) and Cost performance index (CPI) are a further refinement. They are computed as follows:
  - SPI = BCWP / BCWS
  - CPI = BCWP / ACWP

Cost Schedule Control

- **Schedule performance index**. The schedule performance index (SPI) is a measure of how close the project is to performing work as it was actually scheduled.
- If we are ahead of schedule, BCWP will be greater than BCWS, and therefore the SPI will be greater than 1. On the other hand, an SPI below 1 would indicate that the work performed was less than the work scheduled.

Cost Schedule Control

- **Cost performance index**. The cost performance index (CPI) is a measure of how close the project is to spending on the work performed to what was planned to have been spent. If you are spending less on the work performed than was budgeted, the CPI will be greater than 1. if not, and you are spending more than was budgeted for the work performed, then the CPI will be less than 1.

- Some managers may prefer this type of analysis. Any value less than 1 is undesirable; any value over 1 is good.

Using the WBS to Report Project Status

- Because the Work Breakdown Structure (WBS) shows the hierarchical structure of the work to be done, it can be used for status reporting, too.
- Each activity box can be shaded to reflect completion percentages. As lower-level activities are completed, the summary activities above them can be shaded to represent percent complete data.
- Senior managers will appreciate knowing that major parts of the project are complete. Unfortunately, the WBS does not contain scheduling or sequencing information.

Level of Detail

- How much detail and and what is the frequency of reporting in project status reports?
- The more you report, the more likely that others will micro-manage your project.
- Let’s go over the reporting requirements at the activity manager, project manager, and senior manager levels.

Level of Detail

- **Activity Manager:** The activity manager needs the most detailed information available, since the activity manager is directly responsible for getting the work done. He is a type of person that will micro-manage the activities he will be interested to know what happened, what was scheduled to happen, who did what (or didn't do what), why it happened as it did, what problems have arisen, what solutions are within reach, and what changes need to be made.

Level of Detail

- **Project Manager :** The project manager is mainly concerned with the status of all activities open for work during the report period; it is important to remember that there are reports for the project manager and reports from the project manager to senior management.
- **Senior Management:** Report project status to senior management in some graphical form, Gantt chart. Reports at the activity level will be appropriate but for large projects milestone-level reports are more effective.

Project Status Review Meetings

While the format of the status review meetings should be flexible, as project needs dictate, certain items are part of every status meeting, here is a general description for the agenda:

1. The project champion reports changes that may impact the future of the project.
2. The customer reports reports changes that may impact the future of the project.
3. The project manager reports on the overall health of the project and the impact of earlier problems, changes, and corrective actions as they impact at the project level.
4. Activity managers report on the health of activities open or scheduled for work since the last status meeting.
5. The project manager reviews the status of open problems from the last status meeting.
6. Activity managers of future activities report on any changes since the last meeting that might impact project status.
7. Attendees identify new problems and assign responsibility for their resolution
8. The project champion, customer, or project manager, offers closing comments.
9. The project manager announces the time and place of the next meetings.

Change Control

- A good project management methodology shall have a change management process in place.
- Two documents are part of every good change management process:
    1. project change request
    2. project impact statement.

Change Control

- **Project change request**:
  - Every change requested by the customer must be documented.
  - That document might be as simple as a memo but it might also follow a format provided by the project team.
  - In any case, it is the start of another round of establishing Conditions of Satisfaction.
  - Only when the request is clearly understood can the project team evaluate the impact of the change and determine whether the change can accommodated.

Change Control

- **Project impact statement**:
  - The response to a change request is a document called a project impact statement.
  - It is a response that identifies the alternative courses of action that the project manager is willing to consider.
  - The requestor is then charged with choosing the best alternative.
  - The project impact statement describes the feasible alternatives that the project manager was able to identify, the positive and negative aspects of each, and perhaps a recommendation as to which alternative might be best. The requester will decide on the final decision.

Change Control

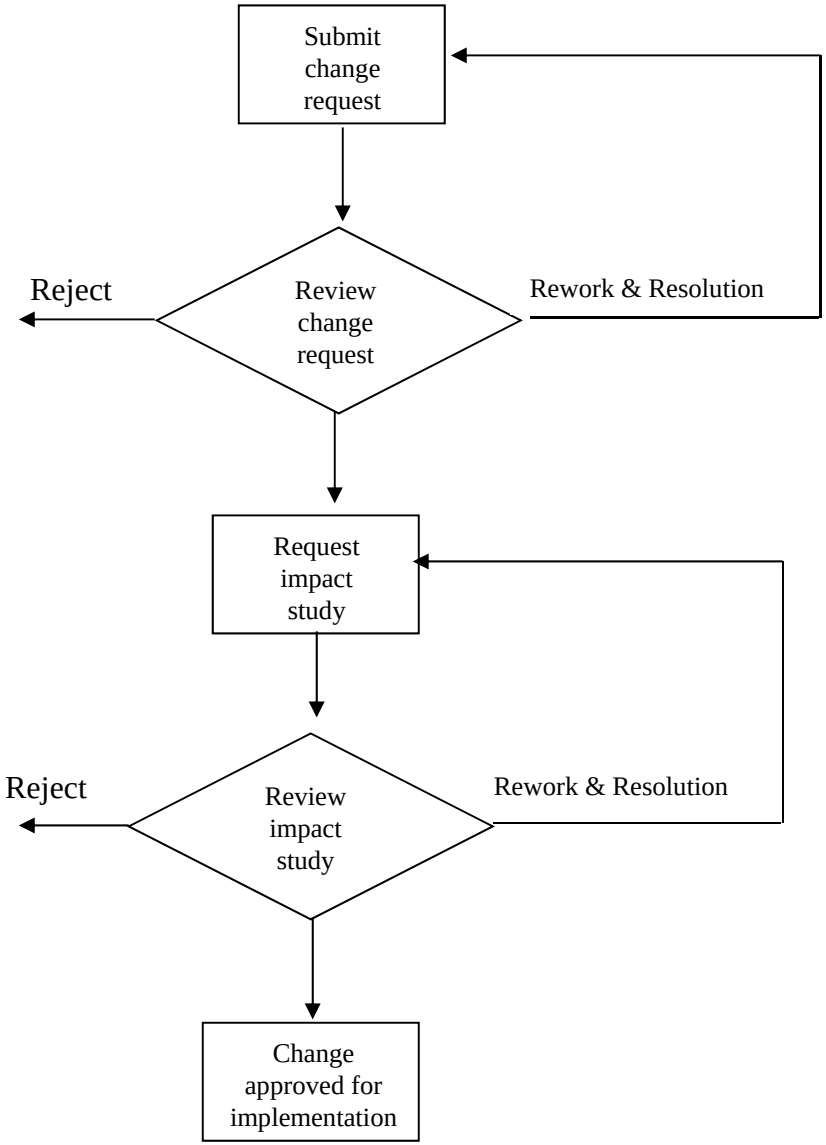
- Six possible outcomes can result from a change request:
  1. It can be accommodated within the project resources and timelines.
  2. It can be accommodated but will require an extension of the deliverable schedule.
  3. It can be accommodated within the current deliverable schedule but additional resources will be needed.
  4. It can be accommodated but additional resource and an extension of the deliverable schedule will be required.
  5. It can be accommodated with a multiple release strategy and prioritizing of the deliverable across the release dates.
  6. It cannot be accommodated without a significant change to the project.

Change Control

- An integral part of change control processes is the documentation. Every change request shall follow the procedure listed in the following flowchart.

- And the change request is submitted by the customer using the form shown in the following figure and forwarded to managers charged with reviewing such requests.

Change Control Process



Change Request Form

Project Name
Change Requested By
Date Change Requested
Description of Change
Business Justification
Action
Approved by Date

Software Quality Control
and
Software Quality Assurance

SQC & SQA

Software Quality Control

Is about the Software Product

Software Quality Assurance

Is about the Process that governs the delivery and development of the software product

Software Quality Control

Theory-W : Win-Win

- **Theory-W moves the productivity equation outside of the internal organization**
- **What makes a "win" for key stakeholders**
- **Basic Steps:**
  1. **Establish a set of win-win preconditions**
     - **Understand how people want to win**
  2. **Structure a win-win software process**
     - **Establish a realistic process plan and keep people involved**
  3. **Structure a win-win software product**
     - **Match product to users and maintainers win conditions**

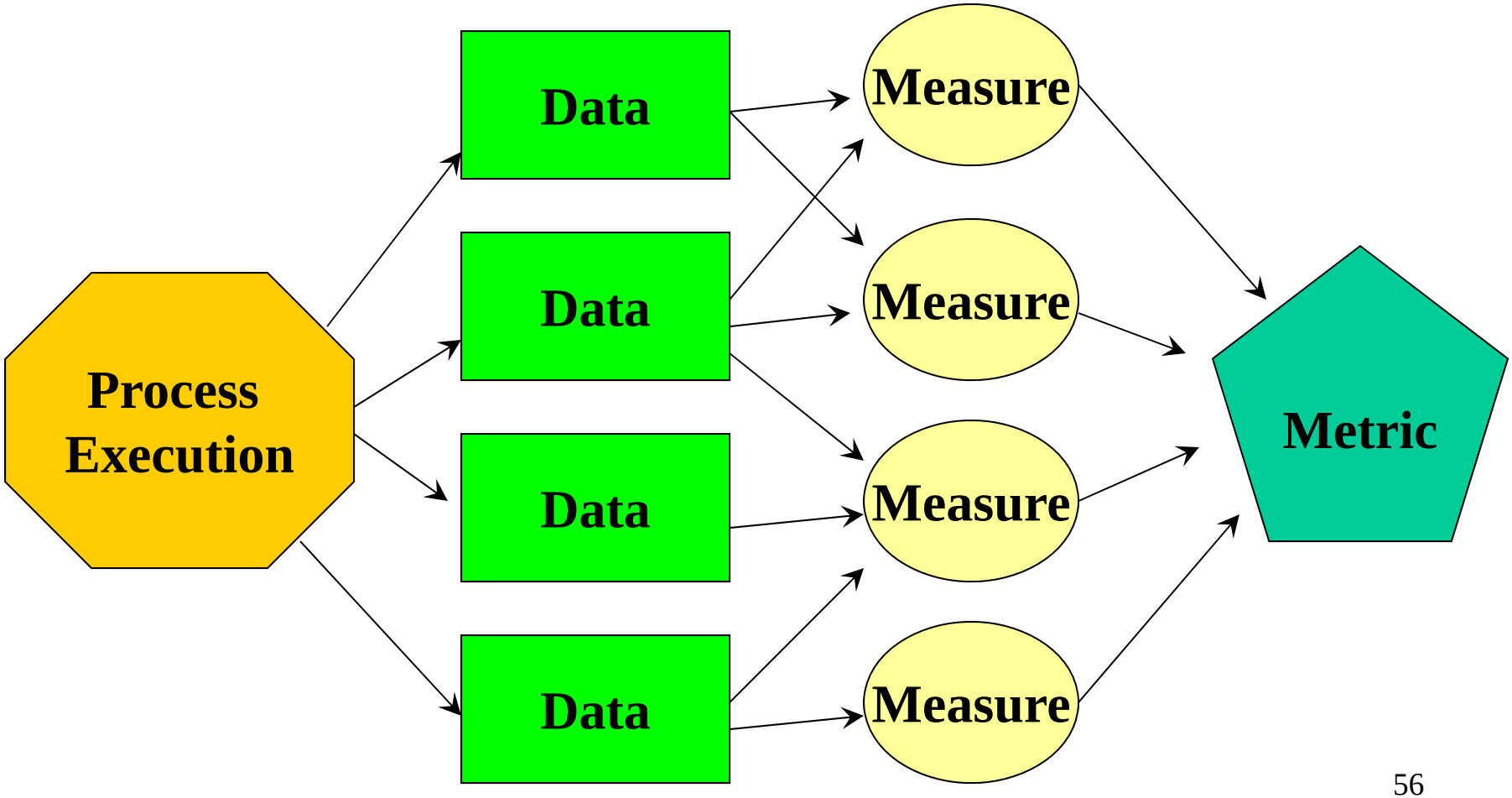
Software Quality Control

Software Measurement

- ***Metric*** ***is*** **a measure or combination of measures that provides insight into a software issue or concept. Every metric should have a purpose**
- ***Measure*** **is quantifying an attribute of a process or product; i.e. result of counting**
- ***Data*** **is the raw number**

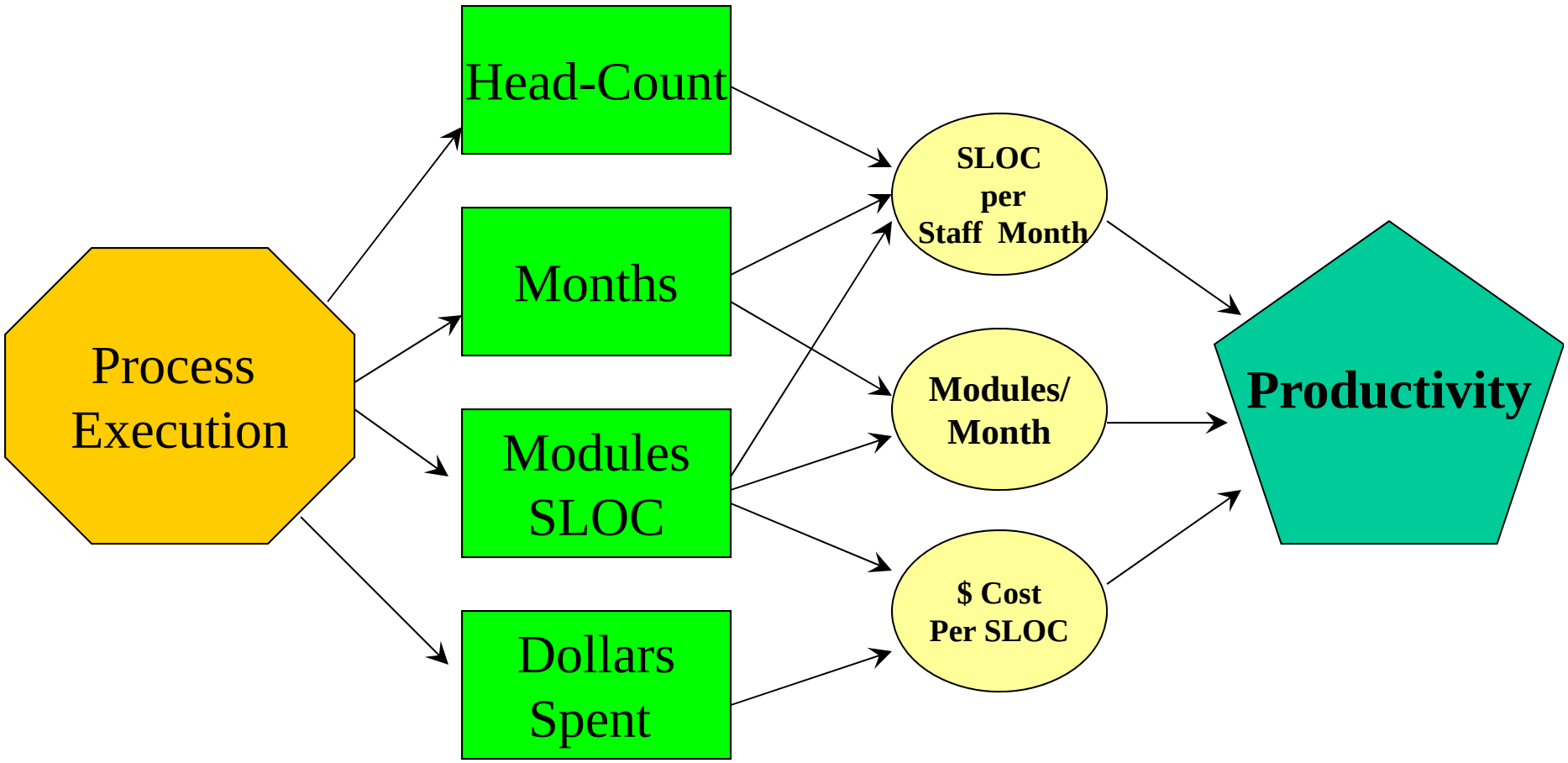
Software Quality Control

Software Measurement



Software Quality Control

Software Measurement



Software Quality Control

What is Quality?

Quality is the degree of excellence

Software Quality Control

What is Software Quality?

- Ease of Use
- conformance to requirements and specifications
- High Availability 99.999%
- Low number of defects found by the customer

From Customer Perspective

External Quality

Software Quality Control

What is Software Quality?

- Reusability
- Flexibility
- Extensibility
- Readability
- Maintainability

From Technical Perspective

Internal Quality

Software Quality Control

Why software quality may fall?

Not Following the process is the root cause of the problem

Software Quality Control

What else?

Testing wasn't based on the RSD

Software Quality Control

Trends and Directions …

- **Implicit dependency between the cost and quality**
- **In the marketplace, higher quality means more profit**
- **Higher quality means lower maintenance cost**
- **Poor quality means loss of customers**

Software Quality Control

What is the cost for software quality control?

- **Clearly NOT free**
- **Budget: May add up to the final cost of the software product**
- **Schedule: May add up to the final delivery date of the project**

Software Quality Control

What we gain from controlling the software quality?

- **All the external and internal quality properties of the software system**
- **Defected software products wouldn't be delivered to customers**
- **Avoiding penalty for defects discovered by customers**

Software Quality Control

How to control the software quality?

- **Follow the SW development process**
- **Compliance with ISO standards**
- **Testing**
  - **White-box : code inspections based on requirements and design documents**
  - **Black-box : behavioral testing based on requirements**

Software Quality Control

Measuring software testing :

- How many requirements tested
- How many test cases passed/failed
- Do fixes inject more defects
- Tester productivity: number of tests executed per day

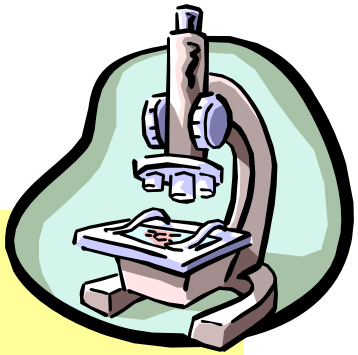
Software Quality Control

Improving software testing :

- **Always based on the requirement and specification document**
- **Automation for test case generation and execution**
- **Fault=Defect=Bug are results from misunderstanding of the requirements by the developer and system engineer**

Software Quality Assurance

What does it mean?



- **Provide a more effective quality control mechanism**
- **SQA is meant to assure that quality is achieved as intended and planned**
- **Look into the SWD process and improve that process**

Software Quality Assurance

How it is achieved?

- **Ensure SW project participants comply with the process**
- **Participate as moderator in design and code inspections**
- **Audit development groups to comply with the ISO standards**

Software Quality Assurance

You can read more into the SQA term

- **SW Product**
  - **SWD compliant with the SWD process**
  - **SWD conforms to RSD**
- **SWD Process**
  - **Periodically evaluate the process**
  - **Process improvement and Tailoring**
  - **Removal of process defects**
  - **Conforms to standards**

Software Quality Assurance

How to tailor and improve the process?

- **Periodically gather and monitor statistics about:**
  - **Requirements Review**
  - **Design Review**
  - **Code inspections**
  - **Test plans**
- **See whether what have been gathered did meet the objectives**

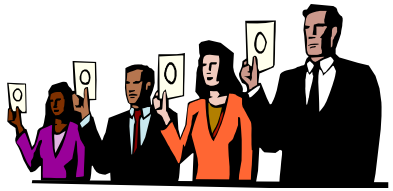
Software Quality Assurance

SQA cost may fall into one of the following:

- **Proactive measures:**
  - **Training, Predictive Metrics, Process improvement**
- **Reactive measures:**
  - **Design and Code inspections**
  - **Testing**

Software Quality Assurance

- Monitor and loop back defects in the following phases:



  - **Requirements Review**
  - **Analysis and Design**
  - **Implementation**
  - **Testing**

For the above phases, **peer reviews** are the basis for quality guarantees

Software Quality Assurance

During the requirement review phase:

- **Review requirements for:**
  - **Doability**
  - **testability**
  - **correctness**

Software Quality Assurance

During the Analysis/Design phase:

- **Review A/D document for**
  - **Design covers the requirements**
  - **Design can be implemented**
  - **Design correctness and validation**
  - **Design based on formal model**

Software Quality Assurance

During the Implementation phase:

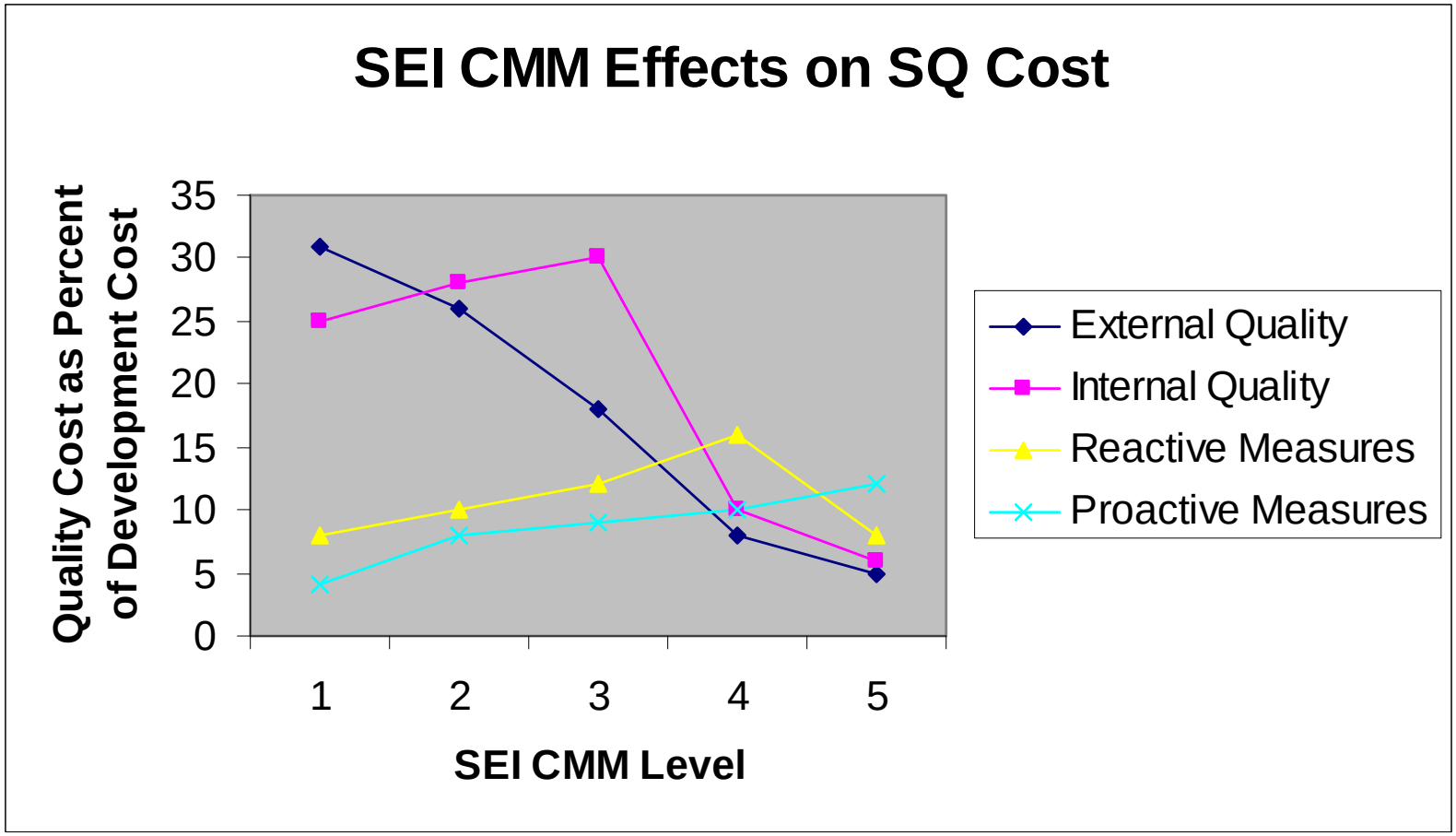
- **Have a code inspection meeting to:**
  - **Ensure that implementation is based on the A/D document**
  - **Code is healthy "Fat-Free"**
  - **Discover logical errors**
  - **Requirements are covered**
  - **Implementation driven by CASE tools**

Software Quality Assurance

During the Testing phase:

- **During this phase**
  - **Write test plans**
  - **Test against requirements**
  - **Test results saved in a common repository**
  - **Ideally, this testing shall be a black-box testing**
  - **Test cases generated from models**

SEI CMM Maturity effects on SQ Cost



SQA Planning

- A software project has a document called *Software Quality Assurance Plan* (SQAP)
- The intent of this document is to document tasks to be executed, standards of verification and validation, procedures and organizational structure

The Mythical Man-Month [Brooks]

Cost

- Number of people involved in the project
- Amount of time spent on the project

Progress

- Output of people involved in the project
- Decreased by communication among them

Man-Month expresses cost

Man-Month doesn't express progress

Balancing the Software Quality

- **To reach the aspiration goals of software quality, we have to balance the 3 P's**
  - People
    - Value people
  - Process
    - Practice it, Improve it, and Level 1-5 on the SEI-CMM maturity scale
  - Product
    - Customer satisfaction and reusability

Theory of Constraints

- **Triple Constraint vs. Quadruple Constrain**
  - Triple Constraint
    - Quality
    - Budget
    - Schedule
  - Quadruple Constraint
    - Risk
    - Quality
    - Budget
    - Schedule

Theory of Constraints

- **But monitoring Risk is done along three dimensions**
  - Quality
  - Budget
  - Schedule

- **Formal Monitoring documents:**
  - Test results
  - Cost reports
  - Project schedule

Theory of Constraints

- **Quadruple Constraint**
  - Needed when addressing planning issues
- **Triple Constraint**
  - Needed to monitor the software project

Theory of Constraints

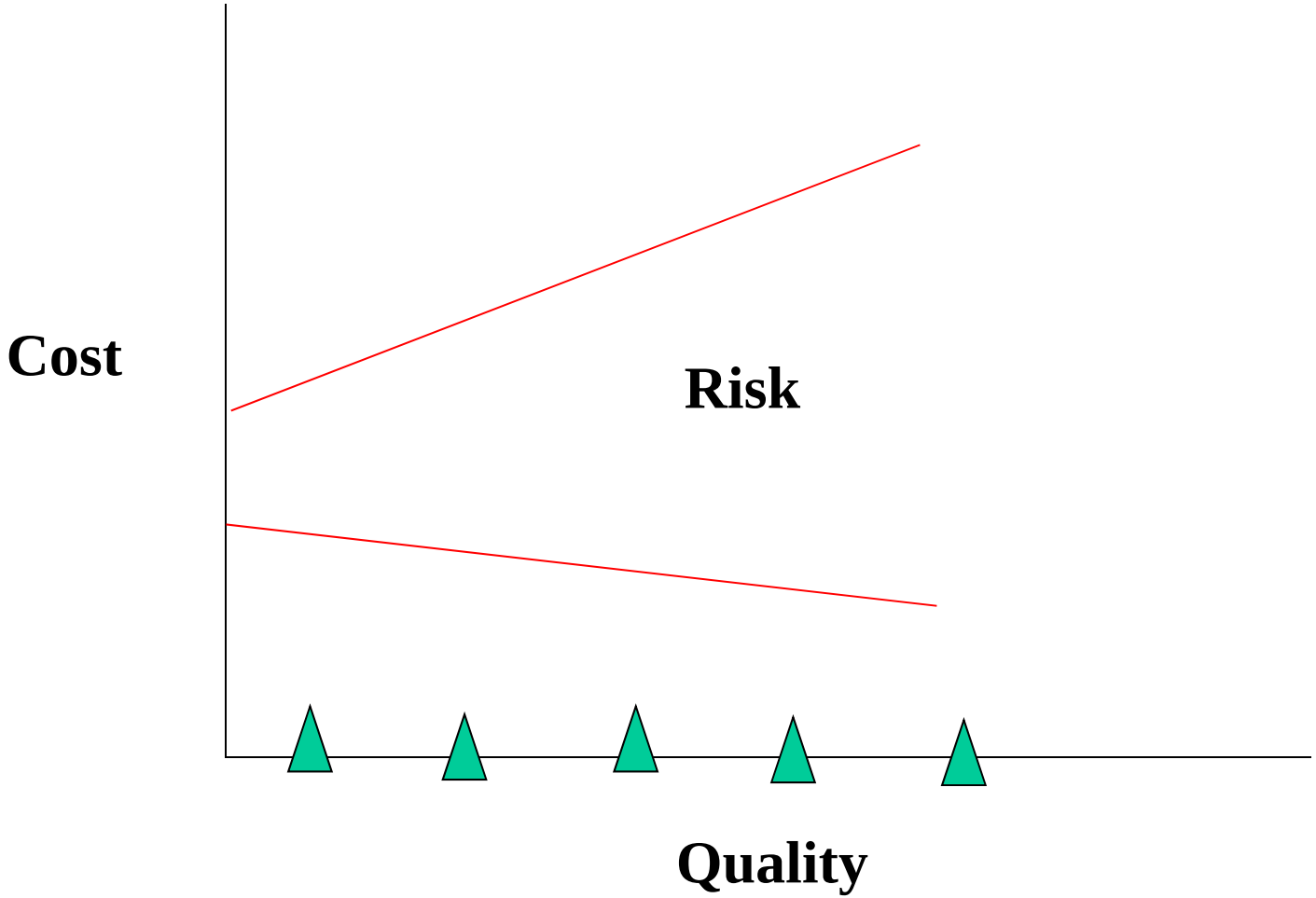
- **Within the context of Quadruple Constraint**
  - **Quality is measured in milestone achievements; sometime referred to as quality gates.**

Theory of Constraints

- **What the Quadruple Constraint can tell us?**
  - A particular software project may have an increasing risk as cost increases and risk decreases as schedule lengthens
  - However, another project may have exactly the opposite situation.

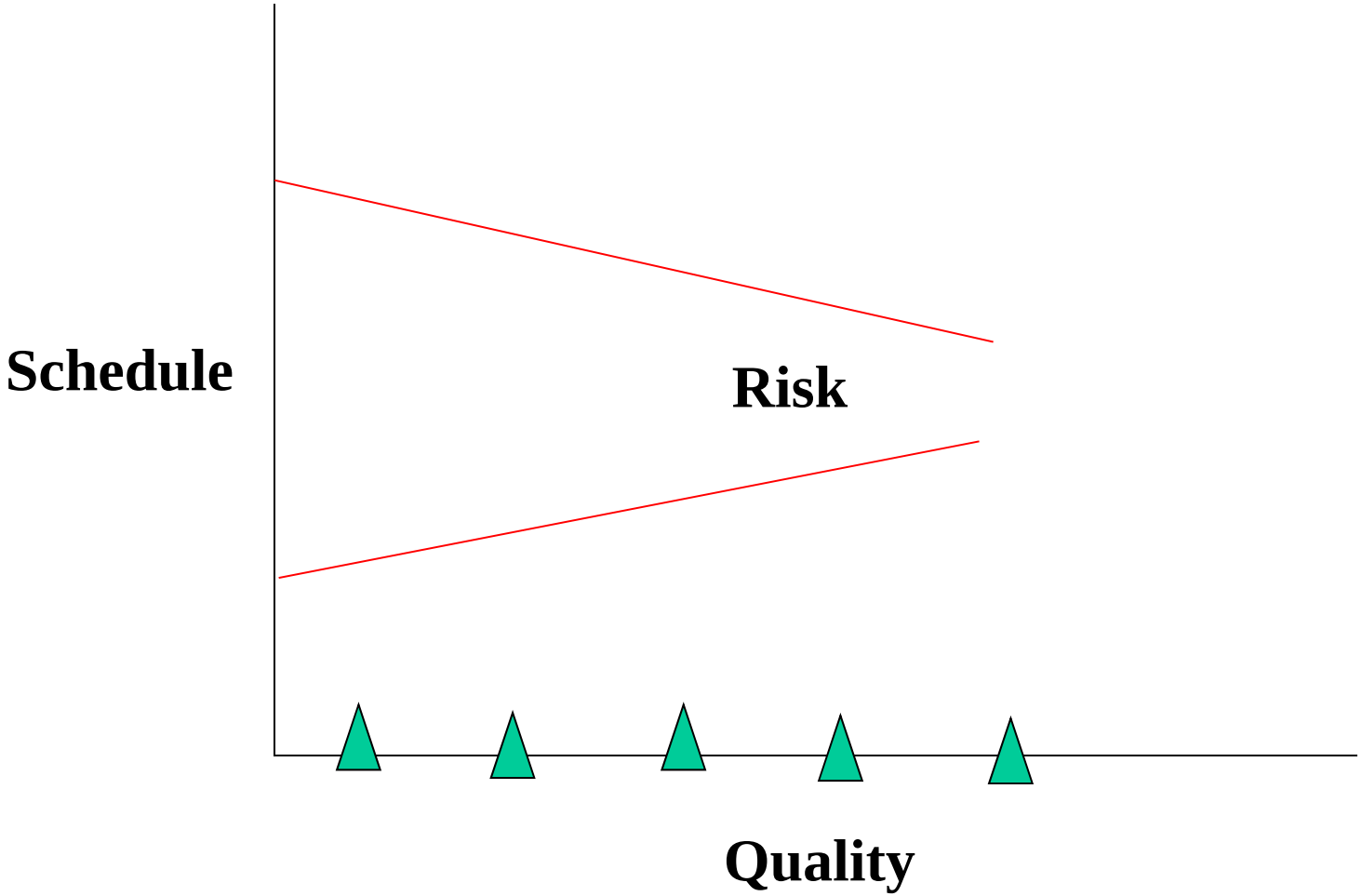
Theory of Constraints

- **(a) Risk with Cost vs. Quality**



Theory of Constraints

- **(b) Risk with Schedule vs. Quality**



Theory of Constraints

Satisfying the Quadruple Constraint is very difficult because:

- The events that naturally occur during the project lifetime conspire to:
  - Lower performance
  - Drag project behind schedule which may make it
    - » Exceed budget
    - » Raise the risk of failure

Theory of Constraints

As a project manager,

you must stay alert to the problems and strive constantly to satisfy the Quadruple Constraint