منحنی‌های پیشرفت پروژه (S-Curve)

انواع + تدوین + تحلیل + نکات کلیدی

(بر اساس سندی از AACE)

ارائه دهنده:

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What we will learn?

- Purpose
- Overview
- Recommended practice
- Developing baseline S-curves
  - Common S-Curves
    - ✓ Progress S-curves
    - ✓ S-Curves with early and late dates
    - ✓ Quantity S-curve
    - ✓ Cash flow S-curves

What we will learn?

- Incorporating progress
- S-Curve analysis
  - S-Curve analysis – Applying actual data
  - S-Curve analysis – Earned value
  - S-Curve analysis – Earned schedule
  - S-Curve analysis – Early and late dates
  - S-Curve analysis – Generating a single PV curve
  - S-Curve analysis – Cautions
- Summary

Reference

Primary reference

AACE® International Recommended Practice No. 55R-09

ANALYZING S-CURVES

TCM Framework: 9.2 – Progress and Performance Measurement
10.1 – Project Performance Assessment
10.2 – Forecasting

Rev. October 5, 2021

Note: As AACE International Recommended Practices evolve over time, please refer to web.aacei.org for the latest revisions.

Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

Purpose

Purpose of S-curves

Why do we need S-curves?

Purpose of S-curves

Why do we need S-curves?

- This **recommended practice (RP)** for analyzing **S-curves** is intended to serve as a guideline, **not** to establish a standard.

- As a recommended practice of AACE International, **analyzing S-curves** provides guidelines for **stakeholders of a project** to evaluate
  1. Current status
  2. Trends

  Of a project in a **simple graphical format**.

Who develops S-curves?

Purpose of S-curves

Who develops S-curves?

- **S-curves** are often developed by
  1. Project scheduler or
  2. Cost engineer

Who develops S-curves?

Purpose of S-curves

Who develops S-curves?

- They are often
  1. Used to **indicate** costs, resource usage, or performance measures **over time** and can be applied on a **variety of project types**.
  2. Used as a project management and and/or total cost management (TCM) tool for **graphical representation** of project plan and actual data.
  3. Commonly used to **support** earned value performance assessment.

A Publication of AACE INTERNATIONAL

What are the goals of this section?

Total Cost Management Framework
An Integrated Approach to Portfolio, Program, and Project Management
Second Edition
H. Lance Stephenson, CCP FAACE, Editor

Purpose of S-curves

What are the goals of this section?

1. The RP provides descriptions of S-curves with the intent to

   improve understanding and communication among **project participants** and **stakeholders**

   when preparing and analyzing **graphics** based upon pr**oject schedule information.**

- The RP describes different types of S-curves that may be generated in a project, provided
  1. Proper information is **loaded into** the schedule
  2. Status of the **information** is maintained

     throughout the duration of the project.

What is S-curve?

Overview

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Overview

What is S-curve?

- An S-curve is a **graphical display** of cumulative costs, labor hours, progress, or other quantities

  plotted against time.

- The **term derives** from the S-like shape of the curve,

  flatter at the beginning and end and

  steeper in the middle,

  which is **typical** of most complex projects.

What should we expect from the shape?

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Overview

What should we expect from the shape?

- **Most projects** start slowly,

  ramp up to a **steady state** for a majority of the work, and

  then **slow down again** near the end

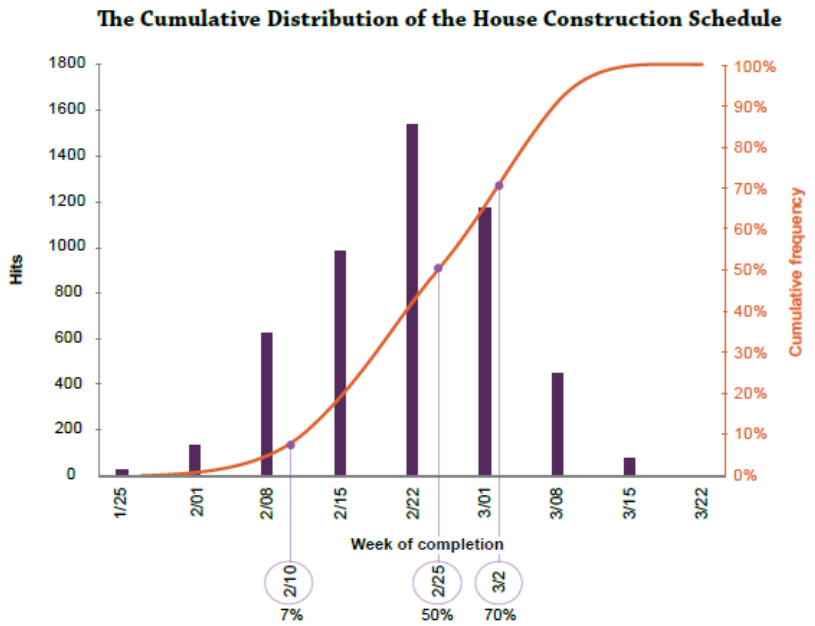
  as **productivity declines** and work **completes**.

Overview

- The term **S-curve** can also be used to indicate an **S shaped chart** resulting from a cumulative probability distribution.
- In this function, an S-curve is a tool of **quantitative risk analysis (QNRA)** which project management would use to determine the **possible dangers** of any given course of action.

- S-curves are also called
  1. Cumulative distribution charts,
  2. Velocity diagrams
  3. S-plots (SPLOTS)

What is the recommended practice?



Source: GAO. | GAO-16-89G

Recommended Practice

Recommended practice

- AACE recommends that schedulers and other project team members
  1. Develop
  2. Use

     S-curves to

     plan, monitor, analyze, forecast and control **project progress**.

- Project managers should request that project controls personnel
  1. Produce
  2. Use

     this **graphical technique** as a tool for **briefing stakeholders** on

     a) Project status

     b) Project trends

     in a quick and intuitive manner

So, how to develop baseline S-curves?

Developing Baseline S-Curves

Introduction

- Prior to developing an S-curve, a project baseline schedule needs to be developed.

- The baseline schedule should employ **best scheduling practices**
  - (i.e., documentation of scheduling basis, start, finish, no open ends, minimal constraints, a defined critical path, etc.).

What are two important requirements needed to develop baseline S-curves?

Introduction

What are two important requirements needed to develop baseline S-curves?

- The baseline schedule should also contain
  1. Cost and/or
  2. Resource

  information as required.

What S-curve is the best needed to be plotted first?

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Target S-curve

What S-curve is the best needed to be plotted first?

- The **S-curve** produced from the baseline early dates
  is often referred to as the **target S-curve**
  which reflects projected or planned progress on the project
  if all **tasks** are completed on their original early finish dates.

Why do we need target S-curve?

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Target S-curve

Why do we need target S-curve?

- This curve represents the best progress or productivity that can be **expected**.

- It is important that the cost and/or quantity information

  loaded into the **activities**

  represents the appropriate time-scaled values for **those activities**.

Could you please give me an example of why appropriate baseline schedule matters??

Appropriate baseline schedule – Example

Could you please give me an example of why appropriate baseline schedule matters??

- For example, if **electrical service equipment** will be
  a) Delivered in **one large shipment** and **then**
  b) Installed over a **three-month time period**,

  the **material cost** of the equipment will be earned when delivered,
  - So
    1. Material cost should be loaded into the delivery activity,
    2. Balance of the costs can be loaded into the installation activities

But is it appropriate to wait to receive the material to manage the cost?

You need COMMITTED COST that you learn in Financial Management Course

Loading cost

Why the method of loading costs into the schedule matters?

Loading cost

Why the method of loading costs into the schedule matters?

- When **loading costs** into activities, the activities may reflect
  1. Straight-line consumption of those costs
     - A ten-day activity with a $10,000 cost should reflect installation of $1,000 per day
  2. Front-loaded consumption profile
  3. Back-loaded consumption profile

The selected methodology of loading costs into the schedule should result in reasonable and appropriate S-curves

When to start preparing S-curves?

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Time to start

When to start preparing S-curves?

- Generating S-curves **starts** well **in advance of preparation** of the baseline schedule.
  - S-curves will be **utilized during** the
    - ✓ Schedule development process for the schedule **health check**,
    - ✓ Resource leveling,
    - ✓ Cash flow optimization
    - ✓ Etc.

What S-curves are common?

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Common S-curves

- A **variety of S-curves** exist for project control purposes, the most common being
  1. Man-hours
  2. Costs
  3. Resources

  versus time.

Common S-curves

1. **Quantity plan S-curves**

   indicating planned versus actual quantities **installed over time** (e.g., volume of concrete installed) can be used to identify and support **progress measurement**.

2. **Cost profile S-curves**

   indicating cost **over time** are often used to identify the **project's cash flow profile**.

3. **Resource profile S-curves**

   are the **outcome** of resource assignment and leveling.

What time units should be used?

Common S-curves

What time units should be used?

- The **time unit** used is typically monthly to coincide with normal monthly project status updates for most projects.

- Weekly and even daily time units **may** also be used, **depending on the circumstance** or project need.

What should be done after creating a baseline schedule?

Common S-curves – Progress S-curves

What should be done after creating a baseline schedule?

- After creating a baseline schedule,

  a baseline S-curve should be generated.

- **Baseline S-curves** provide the basis on which to compare

  project's actual status to its planned progress.

What Comparison should be used?

Common S-curves – Progress S-curves

What Comparison should be used?

- There are **two types of comparisons** that can be developed (for **simplicity's** sake Figure 1 and 2 below reference hours, but just as easily could be replaced with costs):

Common S-curves – Progress S-curves

- The two comparisons can be combined with a target or earned vs. actual comparison which can provide **insight** as to manpower and financial resources **required** to complete the project.

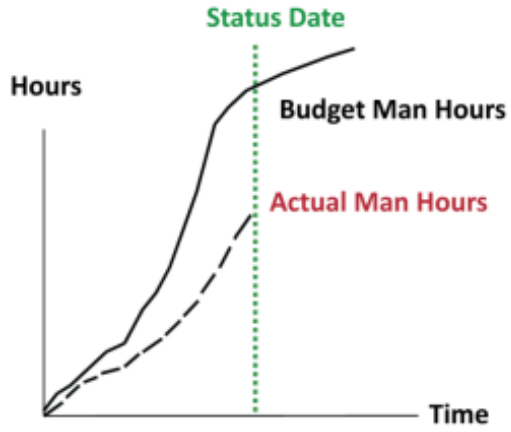


Figure 1 – Target Plan Manhours vs. Actual Manhours Expenditure

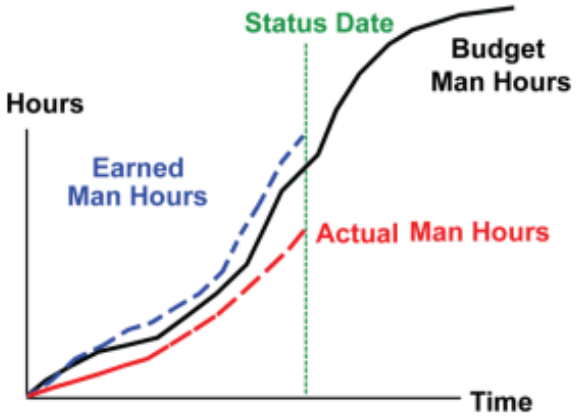


Figure 2 – Target Plan Man-Hours vs. Earned Man-Hours (Based on Plan)

How to achieve status?

Common S-curves – Progress S-curves

How to achieve status?

- Schedules with **status** applied to them are called updated schedules.

- One can produce the **same type of S-curves** as produced with the **baseline schedule** to
  1. Track **actual** progress
  2. Forecast **upcoming** progress

What to achieve from update schedules?

Common S-curves – Progress S-curves

- S-curves produced from update schedules are typically **similar**

  but different than those produced from the **baseline schedule**

  in that they also display curves derived from

  1. Earned data
  2. Actual data

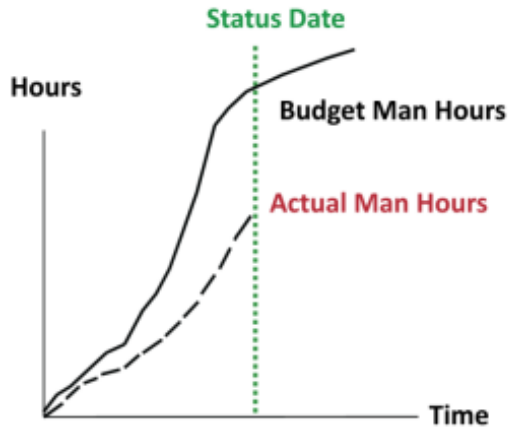


Figure 1 – Target Plan Manhours vs. Actual Manhours Expenditure

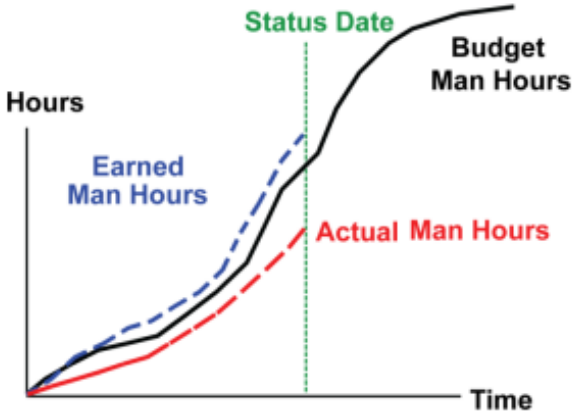
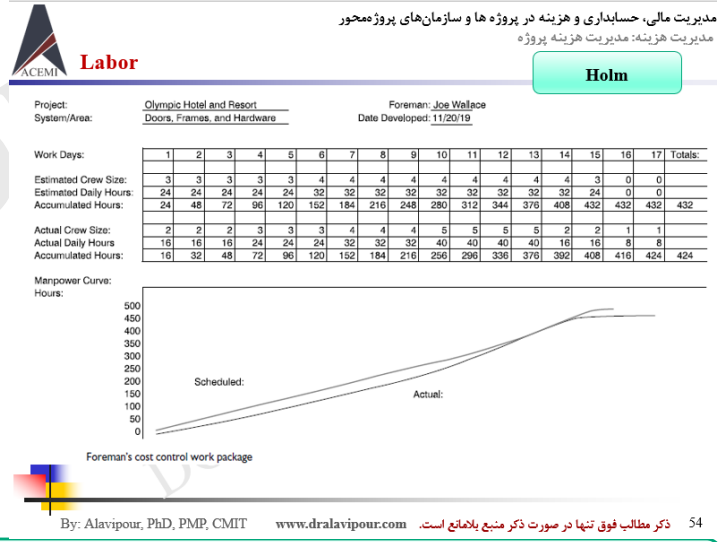


Figure 2 – Target Plan Man-Hours vs. Earned Man-Hours (Based on Plan)

Common S-curves – Progress S-curves

1. The baseline schedule provides **target progress (plan curve)**, typically in costs or man-hours.
2. The update schedule may provide **three basic metrics**:
   a) The value of the work that was **planned** to be achieved at the **time of the update**;
   b) The actual value of the **work achieved** at the **time of the update**;
   c) The earned progress that typically shows **earned costs** or **earned man-hours** at the **time of the update**.



You will learn this comprehensively in Financial Management Course!

Common S-curves – Progress S-curves

- Time-tracking system or
- Other labor reports

may generate the actual man-hours or expenditures.

Labor

Labor Time Reporting

Daily Labor Time Card

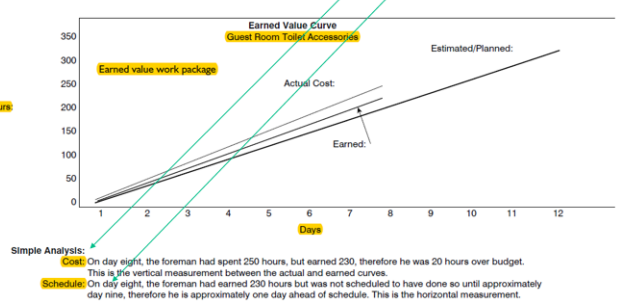
Project Highway Bridge Project No. 200808-05 Weather Cloudy-windy
Date July 20 Prepared by G.A.S.

Employee Number	Name	Craft	Time Classification	Hourly Rate	Cost Code 03157.10.3	Cost Code 03157.20.3				Total Hours	Gross Amount
132	Winnowich, N.	F	ST	34.00		8				8	$272.00
			OT								
221	Clouten, S.	C	ST	$31.00		8				8	$248.00
			OT								
248	Schluder, L.	C	ST	$31.00		8				8	$248.00
			OT								
319	Mills, R.	O	ST	$33.00		2				2	$66.00
			OT	0							
143	Gibson, E.	L	ST	$22.00		8				8	$176.00
			OT								
417	Sears, K.	L	ST	$22.00		8				8	$176.00
			OT								
176	Sibanda, M.	L	ST	$22.00	2	6				8	$176.00
			OT								
Total Hours					2	48				50	
Total Cost					$44.00	$1,318.00					$1,362.00

Highway bridge, daily labor time card

STEPS 8-11: Analyze performance – Schedule and cost performance

Work Days:	1	2	3	4	5	6	7	8	9	10	11	12	Totals
Estimated Hours/Day	16	16	24	24	30	30	30	30	30	32	32	31	
Cumulative Hours	16	32	56	80	110	140	170	200	230	262	294	325	325
Actual Hours/Day	16	24	32	32	32	34	40	40					
Cumulative Hours	16	40	72	104	136	170	210	250					250
Earned Hours/Day	16	24	30	32	32	32	32	32					
Cumulative Hours	16	40	70	102	134	166	198	230					230



Simple Analysis:
Cost: On day eight, the foreman had spent 250 hours, but earned 230, therefore he was 20 hours over budget. This is the vertical measurement between the actual and earned curves.
Schedule: On day eight, the foreman had earned 230 hours but was not scheduled to have done so until approximately day nine, therefore he is approximately one day ahead of schedule. This is the horizontal measurement.

You will learn this comprehensively in Financial Management Course!

Common S-curves – Progress S-curves

Two values are important to be extracted from update schedule!
What are they?

Common S-curves – Progress S-curves

- The **two values** that are generated in **updated schedules** are different in that

1. **Earned value:** is derived from the
   a) **Accumulation** of the percent complete of individual activities
   b) **Times** their planned quantities or costs

2. **Actual value:** is derived from either
   a) Manual entry of **actual job costs** or
   b) Calculations of the **completed activities' values**
   along with the **calculation** based on the estimates of remaining durations of those activities.

What is needed to have an accurate S-curve?

Common S-curves – Progress S-curves

- Obviously, if the **project management team** can provide actual job values or quantities to be entered into the system,

  the **actual curves** will be more accurate and valuable.

- Without actual real-time job data,

  the **software** may **default to its own algorithms** for the calculations of completion in the schedule.

You should be careful about what?

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Common S-curves – Progress S-curves

- If the remaining duration and the percent complete components of the schedule are **linked**,

  such that **one calculates from the other**,

  then the two available curves will be **identical** and offer **no separate analysis** ability.

- For this reason, it is recommended to calculate **percent complete** and **remaining duration** separately,

  allowing time and values to be represented in the curves.

When and why do we use them?

Common S-curves – Progress S-curves

When and why do we use them?

- When discussing **cost loaded schedules**,

1. **Actual cost curves**

   are generated from percent complete of activities

   hopefully based on quantities or costs

2. **Earned value curves**

   are generated from remaining duration calculations based on **time**

How the software could help?

Common S-curves – S-curves with early and late dates

How the software could help?

- **Most scheduling software** can provide the **information** that calculates the cost, hours, and/or quantity data in the schedule over the both the early dates (forward pass of the schedule) and the late dates (backward pass of the schedule).

What does early and late curves mean?

Common S-curves – S-curves with early and late dates

- The **combination** of the two graphs are sometimes referred to as banana curves.
- The two curves will typically **only intersect** at the beginning and at the end of the project.
- This information can then **easily** be put in a **graphical format** as shown in figure 3 below:

You will learn it in MSP and P6 Courses!

What does it represent?

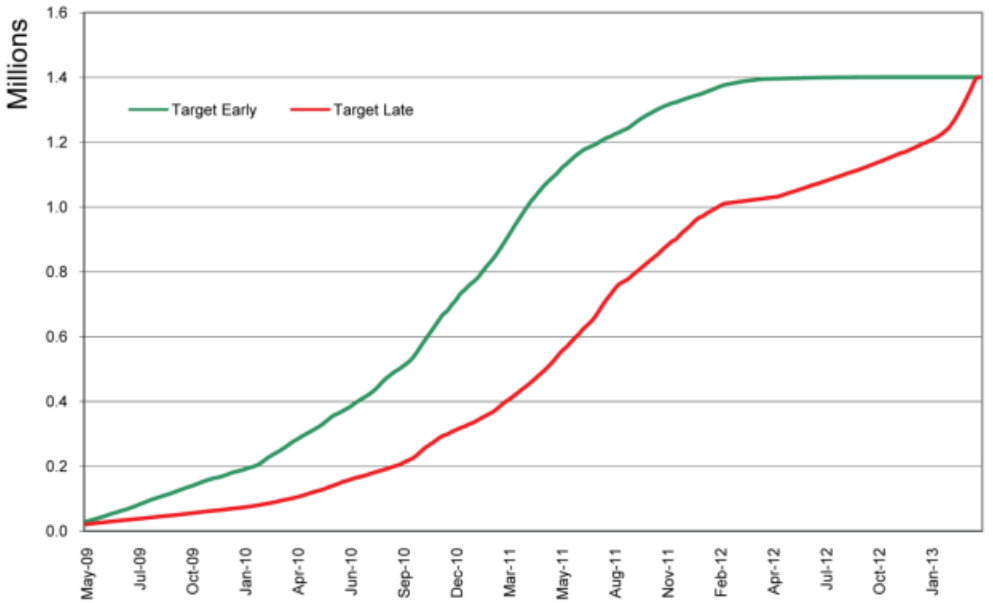

Figure 3 – Typical S-Curve with Early and Late Dates

Common S-curves – S-curves with early and late dates

- It is important to note that the lower range of the banana curve (which is the **late date curve**) is the **prediction** of progress where
  1. Every single activity is performed on the **last available day**
  2. All work is on the **critical path**
     - This means that **if a single activity** on the late date curve slips, the project slips.

When stakeholders should be concerned?

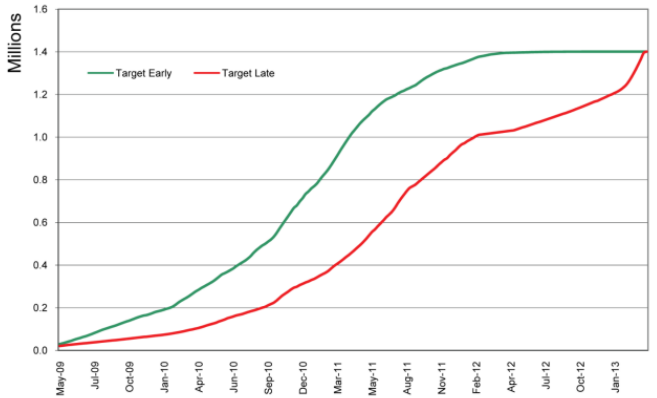

Figure 3 – Typical S-Curve with Early and Late Dates

Common S-curves – S-curves with early and late dates

- **Stakeholders** should be concerned about performance risk when a project's planned or actual curve is

  tracking close to or **below** the late date curve.

What is another useful type?

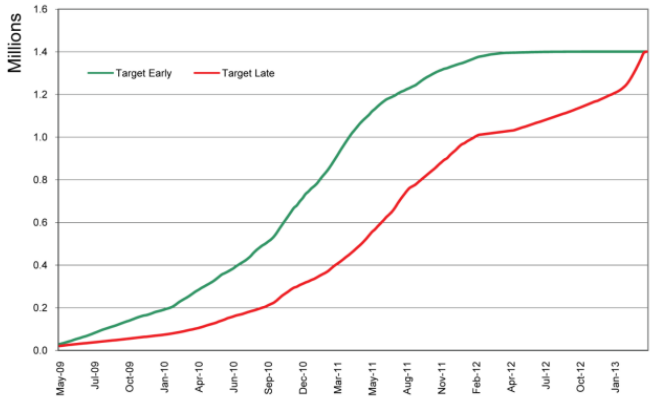

Figure 3 – Typical S-Curve with Early and Late Dates

Common S-curves – Quantity S-curve

What is another useful type?

- Another **common and useful type** of S-curve found in the manufacturing and construction industries is the

  quantity plan vs actual S-curve.

- It uses the schedule and graphs the quantity versus time.
- Here the planned quantity information is loaded into the baseline schedule which is **tracked** along with actual quantities.
- These **quantity plan S-curves** may also be used to depict
  - project growth,
  - gains/slippage,
  - progress to date, and
  - forecasts.

Let's see an example!

Common S-curves – Quantity S-curve

- For comparative purposes one could plot planned versus actual quantities (See Figure 4).

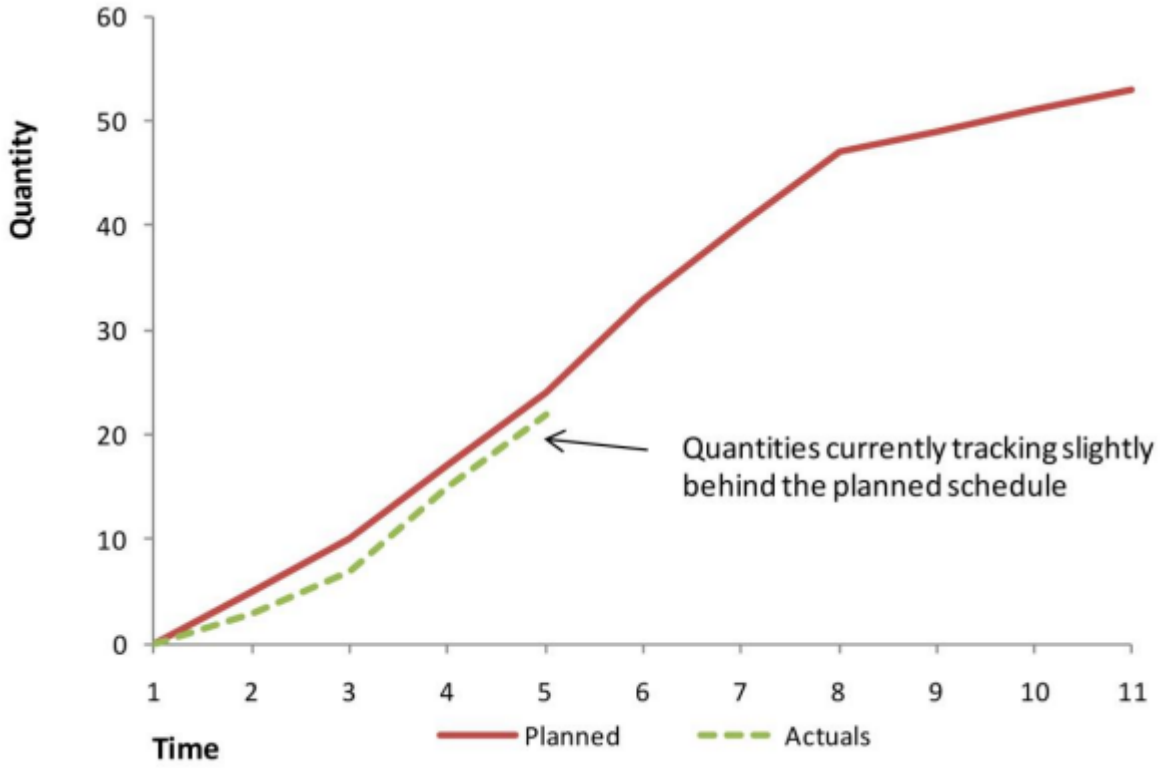

Figure 4 – Quantity Output S-Curve

What are the common types of quantity S-curves

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Common S-curves – Quantity S-curve

What are the common types of quantity S-curves

- The following is a **brief list of common types** of quantity S-curves:
  1. Engineering/design deliverables
  2. Procurement packages
  3. Resources
  4. Installed quantities

What is another useful type?

Common S-curves – Cash flow S-curves

- **Cash flow** is the inflow and outflow of funds within a project.

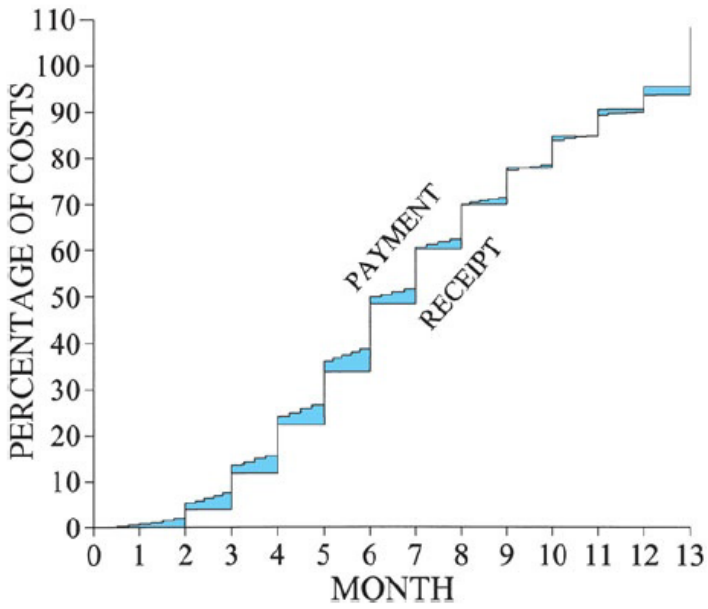
- It is a **time-based record** that may include both income and expenditures, often presented graphically.

What is the primary use?

Common S-curves – Cash flow S-curves

- One primary use of the cash flow curve is to
  1. identify the need for cash
  2. timing of the payment obligations
- It is **important to clearly understand** that without good financial health, there would not be a project.

In which contract you should be even more careful?



Cash Provided by Construction Company

Common S-curves – Cash flow S-curves

In which contract you should be even more careful?

- On a fixed price contract, stakeholders are concerned with the most complex timing considerations;

  these include

  1. Work actually performed
  2. Work earned
  3. Related expenditures
  4. Revenue payments

- Each of these may have **multiple timing considerations**.

Other contract types have some but not all of these considerations

Common S-curves – Cash flow S-curves

- Thus, in order to produce a **realistic representation of cash flow**, the **curve** must consider the **timing** of each cost element.

How to have timing of each cost element?

Common S-curves – Cash flow S-curves

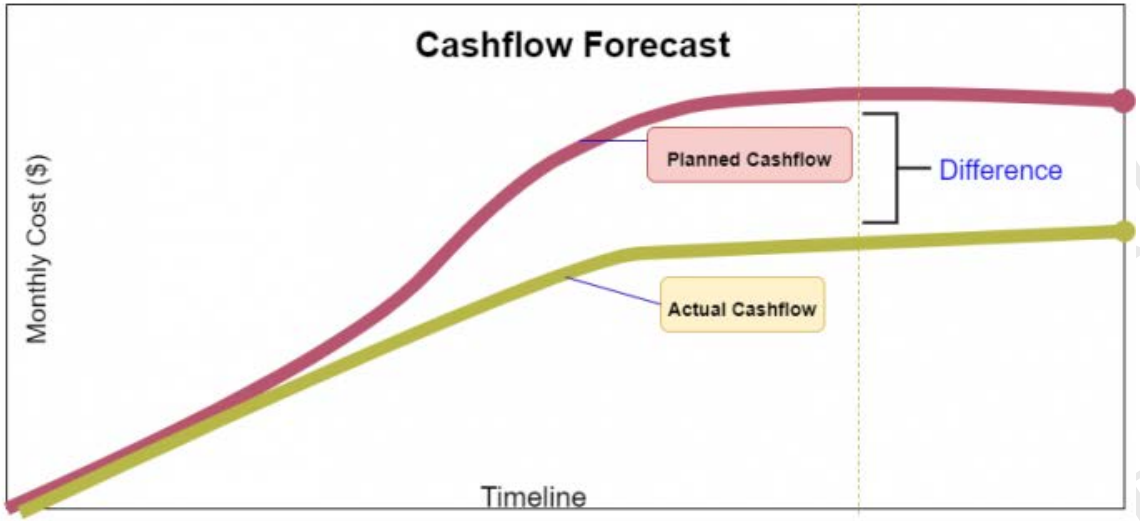
How to have timing of each cost element?

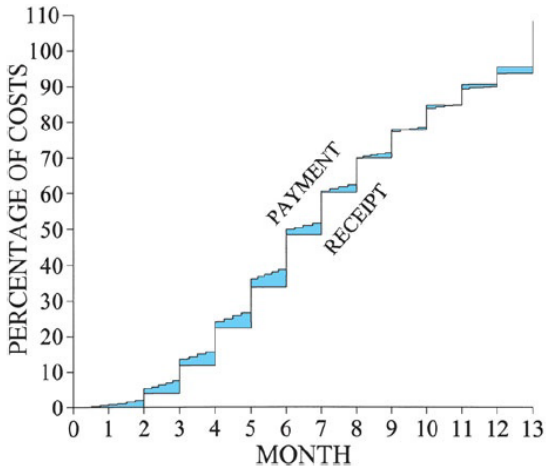
- If
  1. **Estimate** has classified cost by cost type (labor, material, equipment, subcontracts, etc.]
  2. **Costs** are loaded into schedule as resources in the same categories,

     then the **early/late curves** can be graphed by **cost type**.

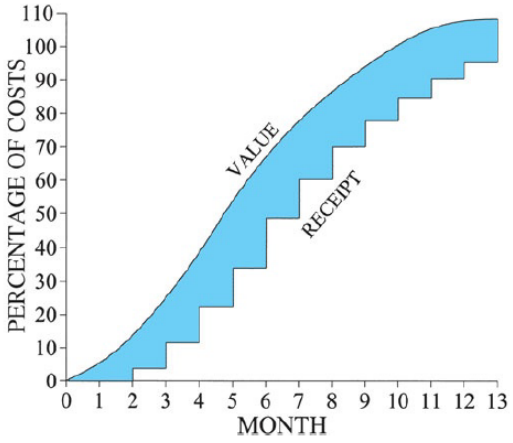
- The **S-curve on** which all these calculations are based should be a **single resource-based curve** which may be based on the **median** of the early and late curves.

Common S-curves – Cash flow S-curves





Cash Provided by Construction Company



Cash Provided by Construction Company, Labor, Suppliers, and Subcontractors

Common S-curves

What to do after baseline S-curves prepared and actual progress information obtained??

Incorporating Progress

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Overview

What to do after baseline S-curves prepared and actual progress information obtained??

- Once the
  1. **Baseline s-curves** are prepared
  2. **Actual progress** status information is obtained for the project,
     a) **Actual progress** can be incorporated
     b) **Compared** to the baseline target s-curves

Let's see an example!

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Overview

- The **addition of the actual progress S-curve** (see Figure 5) provides stakeholders with information on variances and trends.

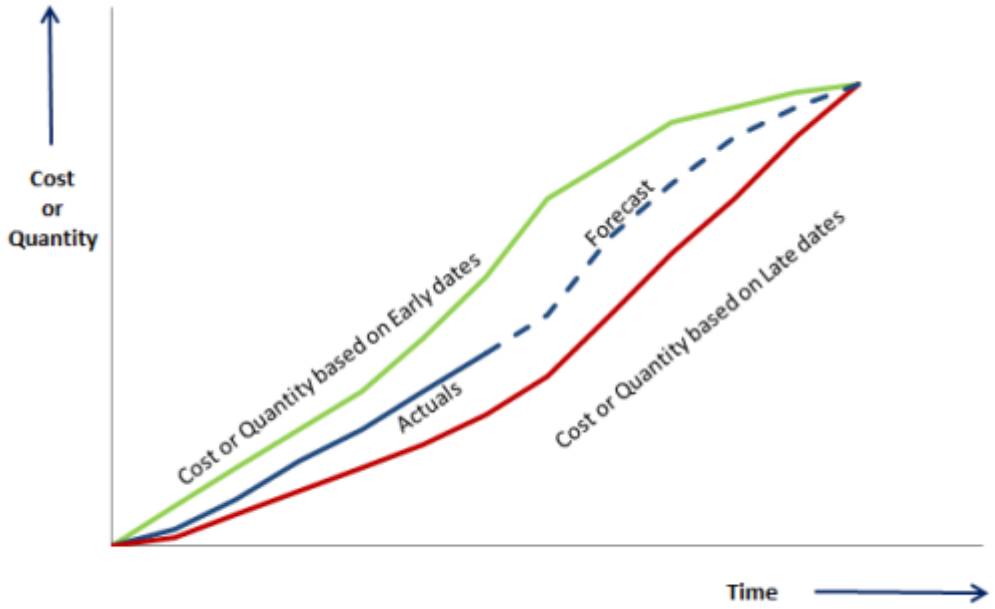


Figure 5 – Early/Late Date S-Curve with Actual Progress

How to analyze?

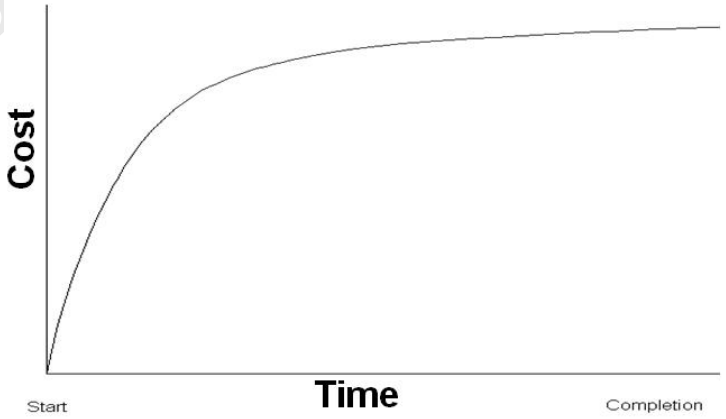
S-Curve Analysis

Introduction

- The **shape** of the S-curve may yield significant information about the **nature of the project.**
  1. Curves that start up steeply and then flatten out
  2. Curves that start out with a lower slope and then run steeply to completion

Curves that start up steeply and then flatten out

- Curves that start up steeply and then flatten out
  1. May indicate **application** of a front-loading methodology
  2. Could also reflect **projects** that require little or no planning time, such as **repair of disaster damage**
  3. It could indicate a **schedule** that has been accelerated at the outset



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Curves that start out with a lower slope and then run steeply to completion

- Curves that start out with a lower slope and then run steeply to completion
  - could indicate a large planning or design time in the **beginning** and a reduced construction time.

Review of S-curves to ensure that the shape and slope of the curves is reasonable and justified is an important element of effective project planning and control.

What are the impacts of labor and material on S-curves?

Labor and material impacts on S-curves

What are the impacts of labor and material on S-curves?

- For **labor**, S-Curves may be back-loaded,
  initially relatively flat, and
  increasingly steep towards the **end** of the project
  before flattening at final ramp-down of labor resources.

- Projects where the **costs** are **mostly** installed materials and labor tend to show a **more linear distribution** of costs over time.

- Mobilization costs will generally show **more frontloading** of the **curve**.

Methods of analyzing s-curves

How many methods are there for analyzing S-curves?

Introduction

- There are **several methods** of analyzing the S-curve.

- The methods discussed in this RP are:
  1. Applying actual data
  2. Applying earned value
  3. Applying earned schedule
  4. Applying common shapes of early and late dates to the s-curve

*The analysis method used may depend on the **complexity of the project** and **contractual requirements.***

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Applying actual data

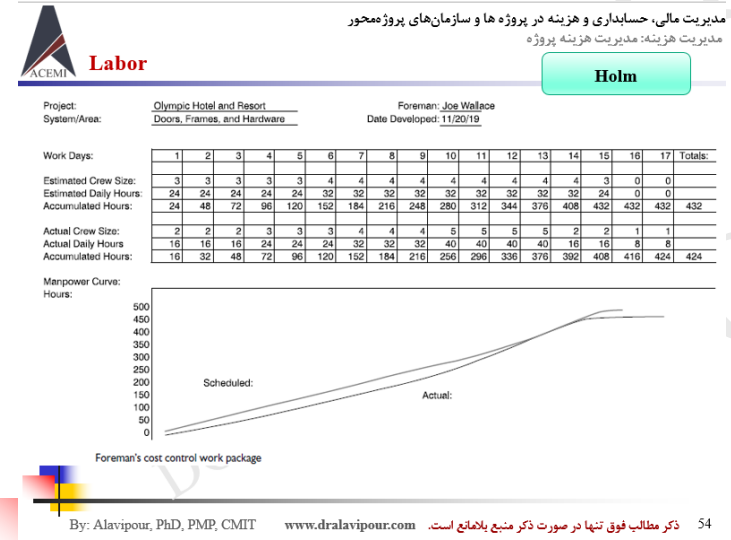
- The **easiest S-curve analysis method** to use is to compare
  1. Actual data
  2. Planned s-curve

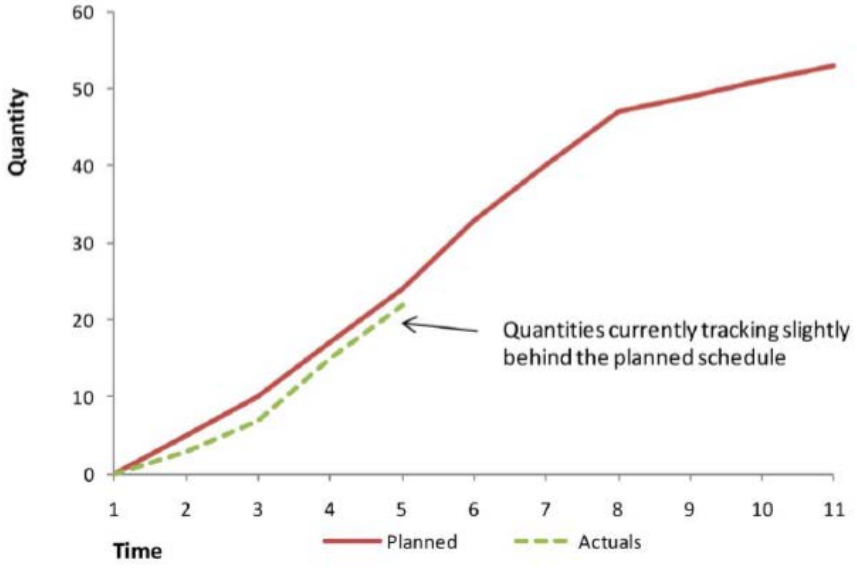
- This provides an **easily understood view** of project status.

- Below are **two examples** of actual data applied to S-curves along with a brief analysis for the curve.

Applying actual data

- This **S-curve suggests** that since the actual data is below the planned value, the actual progress is **less than the planned progress**.
- Conversely, **if the actual data** line is above the planned line, the graphic would indicate the **actual progress** is greater than the planned progress.



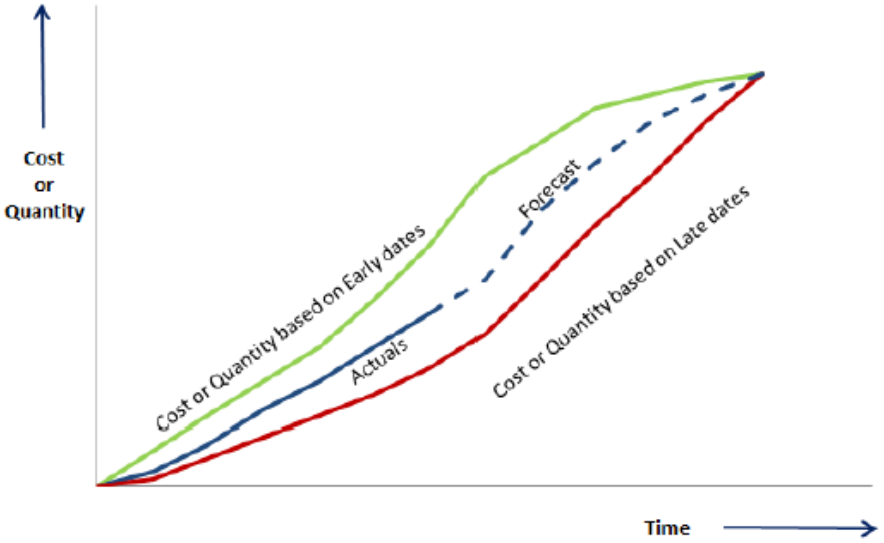


Applying actual data

- In this example, the **actual data** is plotted along with the **early** and **late** date information from the schedule.
- The analysis of this graph indicates that as long as
  1. Actual data falls between the early and late dates
  2. Forecasted completion is on or before the end date

  the project is in **good standing**.

Is there a guarantee for project success?



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Applying actual data

Is there a guarantee for project success?

- This plot does **not guarantee** project success;

  it **only** indicates that the actual work appears to be within planned boundaries.

- Again, note that the **closer that actual** data conforms to the late dates,

  the **higher the risk** of project delay,

  especially if there are resource limitations in the schedule.

*This project should be analyzed carefully for the **resource requirements** and **critical path** to complete the project.*

Let's see earned value approach!

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Earned value

- **Another common** approach is to analyze the S-curve of a project based on earned value.
- Earned value management is a method of **integrating** scope, schedule, and cost performance data

  with objective technical measures to provide management with

  timely and accurate status, performance and forecast data from which they may make **informed project decisions**.

For additional information see Financial Management course!

Earned value

- Below are **two examples** of applying actual and earned data to S-curves along with a brief analysis of the curve

Earned value

- In **Figure 6**, the planned line is the **baseline** against which **actual performance** is analyzed.
- The figure shows that the **project currently** anticipates
  1. An early finish
  2. With additional costs or quantities from the performance baseline

- This information should be **evaluated** with the project **stakeholders** to determine **if this is** the best course for the project.

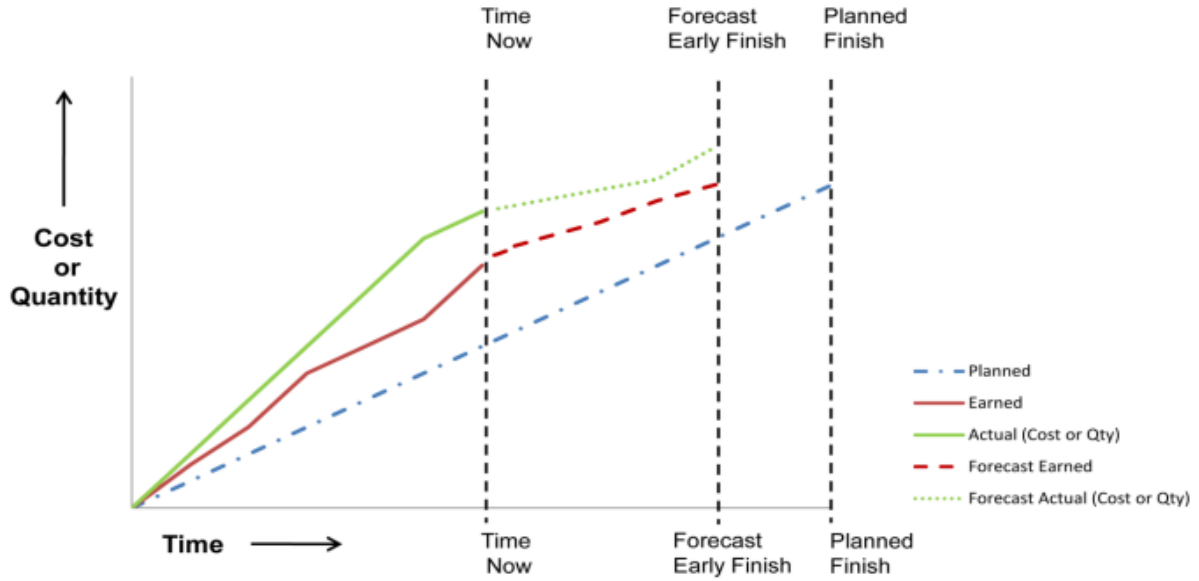

Figure 6 – Earned Value S-Curve

Earned value

- **Figure 7** depicts a hypothetical situation where a known **problem** and its **projected impact** are being considered.

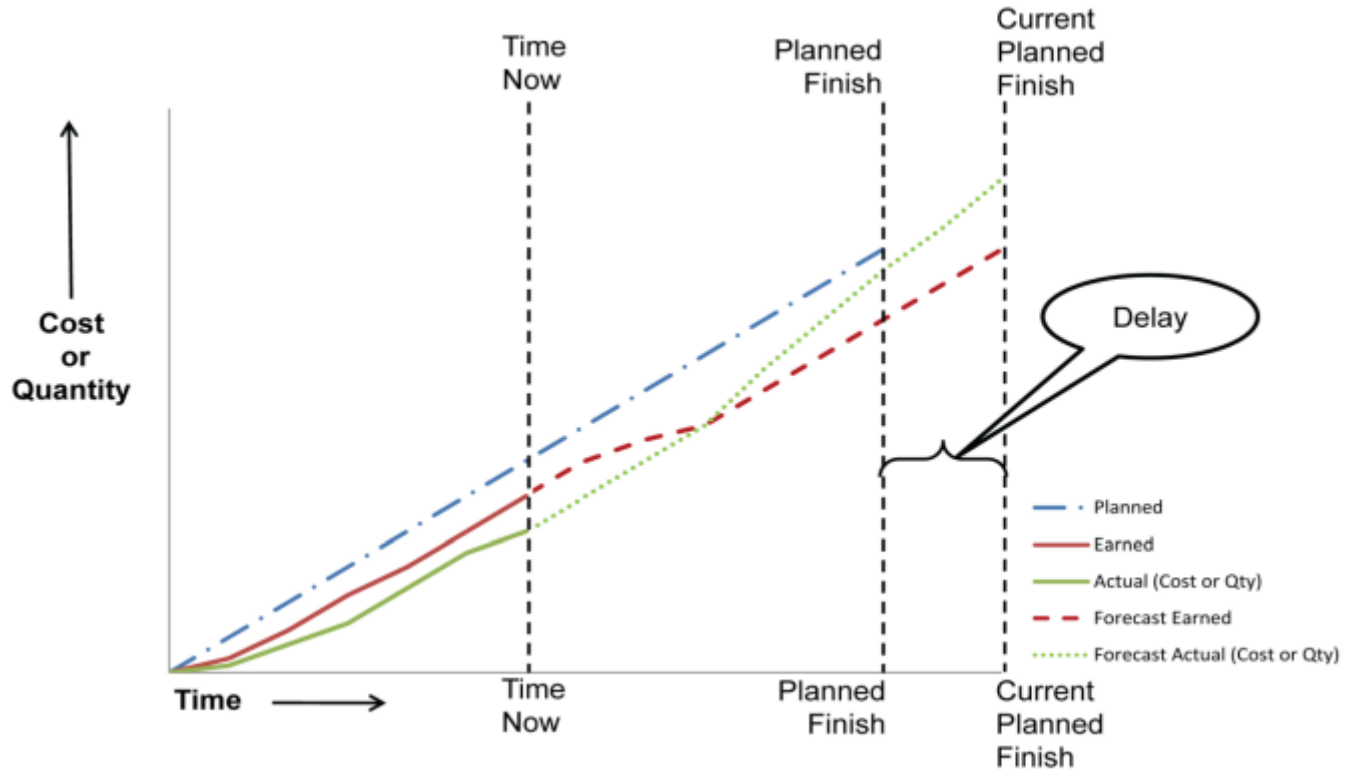

Figure 7 – Earned Value S-Curve

What should we do with this?

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Earned value

1. The **reason(s)** for the delay and forecast overrun should be brought to the **project stakeholders** to determine the **best course of action**.
2. In order for the project to regain lost time and finish on time, it will be necessary for the performance to be **improved enough** to allow the S-curve to change slope and meet the completion milestone.
3. This can be **plotted and used** to determine progress necessary to complete on time.
4. As a follow-on analysis, the **S-curve** for subsequent recovery schedules can be **reviewed** to see **whether the curves are sufficient**.

Could the analysis be improved even more?

Earned value

- It is also possible to **segregate** individual trades and graph their earned value curves.

These can be **very useful** in analyzing the

1. Performance of those trades
2. Predicting the impact of the **trade's performance** on the project.

Earned value

- The terms shown in **Figures 8 and 9** are defined in Recommended Practice 10S-90, Cost Engineering Terminology.

Earned value

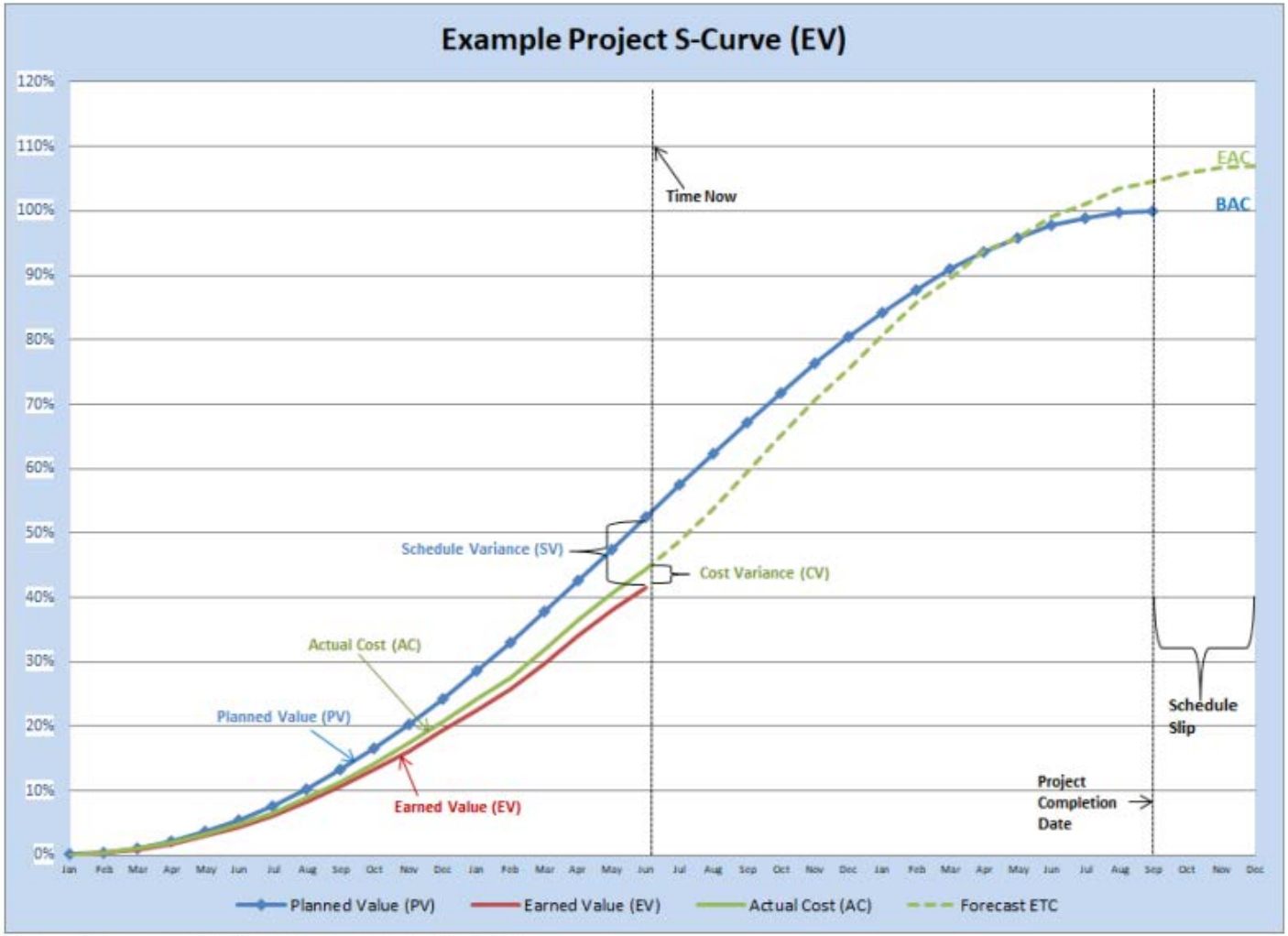

Figure 8 – Earned Value S-Curve Basic Analysis

Earned schedule

- **Earned Schedule (ES)** is a method of using readily available time-based elements of **earned value** to

  calculate schedule performance and variances (in terms of duration or time), and to **forecast schedule completion**.

- The **concept** of Earned Schedule is one where earned value is **converted into** the schedule variance (in time) along the **projected baseline progress curve**.
- The **comparison** of the earned progress date and the status date will reveal how many days the project is **behind or ahead**.
- ES uses analytical equations to forecast the project end date.

Earned schedule

- ES terminology is **very similar to** that of **EV**.
- ES term is appended by the **suffix (t)**.
- Table 1, below, **compares typical earned value** terms with comparable earned schedule terms.

Application	Earned Value Management Term	Comparable Earned Schedule Term
Budget	Budget at Completion (BAC)	Planned Duration (PD)
Status	Earned Value (EV)	Earned Schedule (ES)
	Actual Cost (AC)	Actual Time (AT)
	Schedule Variance (SV)	Schedule Variance (time) $SV_{(t)}$
Remaining Work	Budgeted Cost for Work Remaining (BCWR)	Planned Duration for Work Remaining (PDWR)
	Estimate to Complete (ETC)	Estimate to Complete (time) $ETC_{(t)}$
Forecasting	Variance at Completion (VAC)	Variance at Completion (time) $VAC_{(t)}$
	Estimate at Completion (EAC)	Estimate at Completion (time) $EAC_{(t)}$
	Independent Estimate at Completion (IEAC)	Independent Estimate at Completion (time) $IEAC_{(t)}$

Table 1 – Earned Value Terminology vs. Earned Schedule Terminology

Earned schedule

- Figure 9, below, shows both standard **EV** terms and **ES** terms.

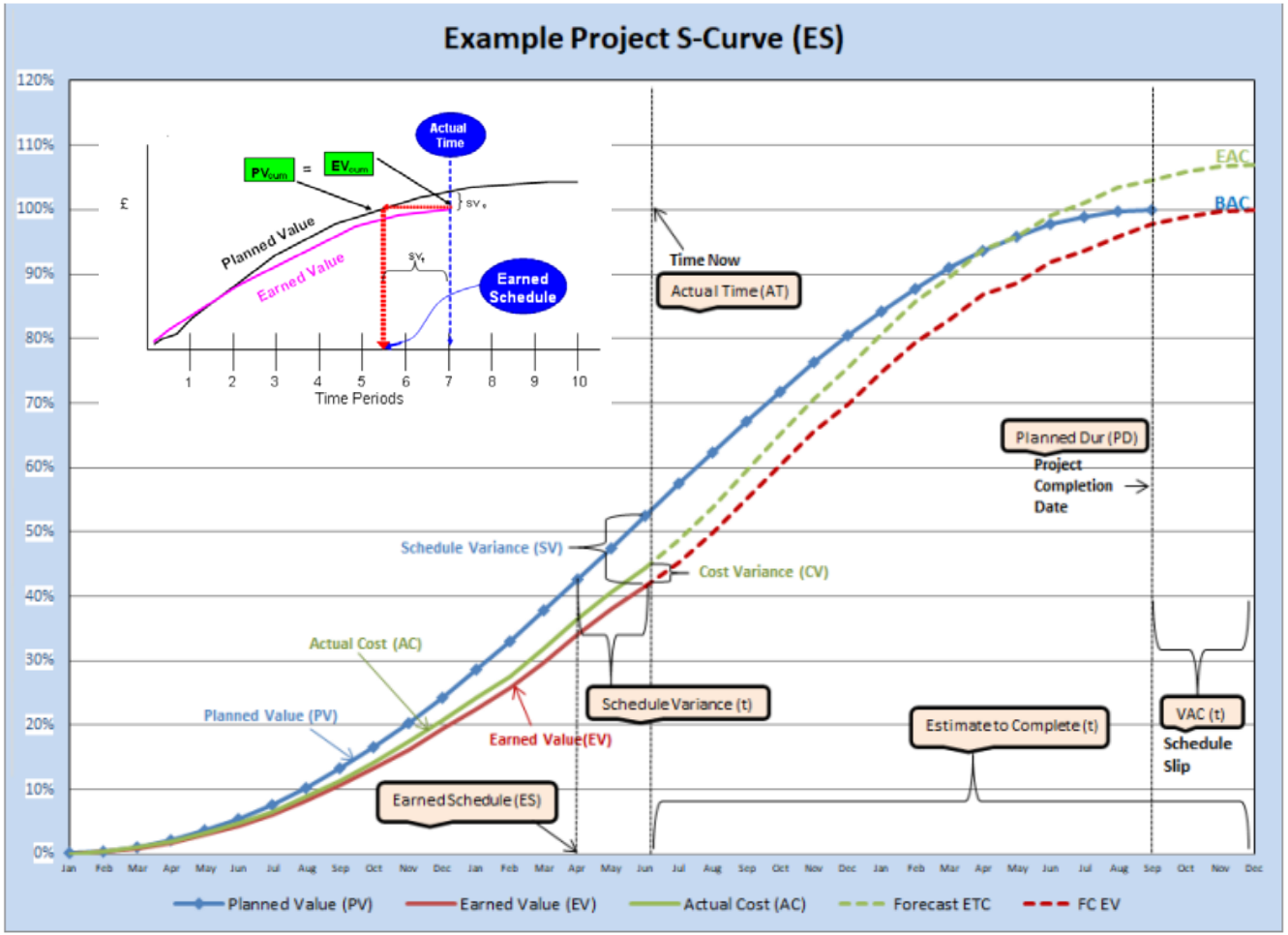

Figure 9 – Earned Schedule S-Curve

Earned schedule

You completely learn this in these courses

https://dralavipour.com/general-course/financial3

https://dralavipour.com/video-course/web23

Early and late dates

Let’s talk about banana curve!

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Early and late dates

- There are **many shapes** that banana curves may take; three examples are provided below.
  - **While any of these** shapes may be acceptable depending on the project, the **use of historical S-curves** from **similar projects** can help **validate the S-curve shape.**
    - ✓ *For example, a **resource-leveled schedule** tends to produce a **more linear S-curve** than a schedule without resource leveling.*
    - ✓ *Also, S-curves with **steps and sudden angulation** may be an indication of **poor planning***

Let's see what these curves indicate!

Early and late dates

- The S-curves may indicate that there are **excessive float** values on the activities at the end of the project schedule.
- This could result from the **logic ties** (particularly at the back end of the project) and these activities may require some analysis.
- The **early date target line reaches completion** well before the late finish date target line.

- **This banana curve** may indicate that the **project scope** is **not required** to finish anywhere near this early.

So, what does that mean?

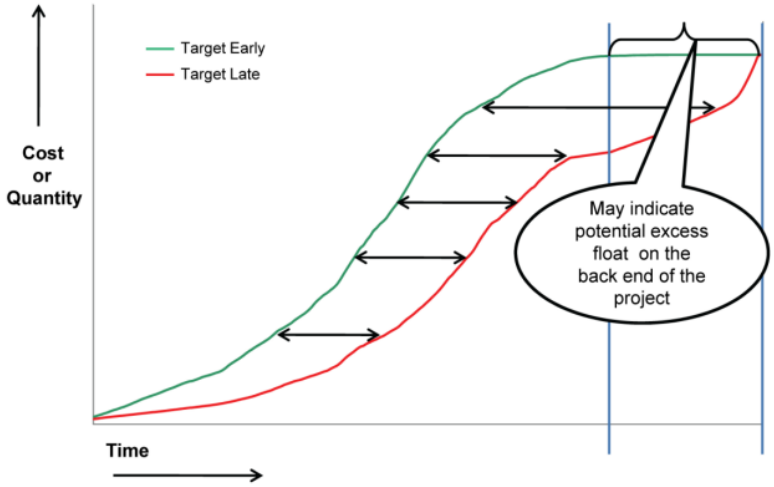

Figure 10 – Example A

Early and late dates

- So, **one may look** at the underlying logic and **ask the question**, *"Can this work be allowed to occur this soon as the result of the **early completion of this scope**?"*

Let's see another one!

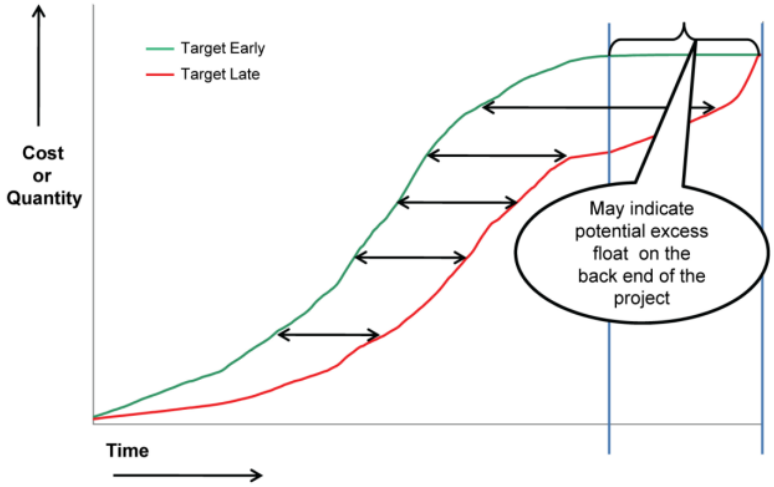

Figure 10 – Example A

Early and late dates

- The S-curves shown in Example B is another indicator of **potential problems**, usually caused by **excessive float** linked into a common successor.
- The effect is a reasonable early target curve but a bloated late target curve, possibly **due to** having a detailed engineering schedule but an under-developed construction schedule.

- Also, there are **two key points** of analysis from the S-curves in Example B that may need further examination.

What are they?

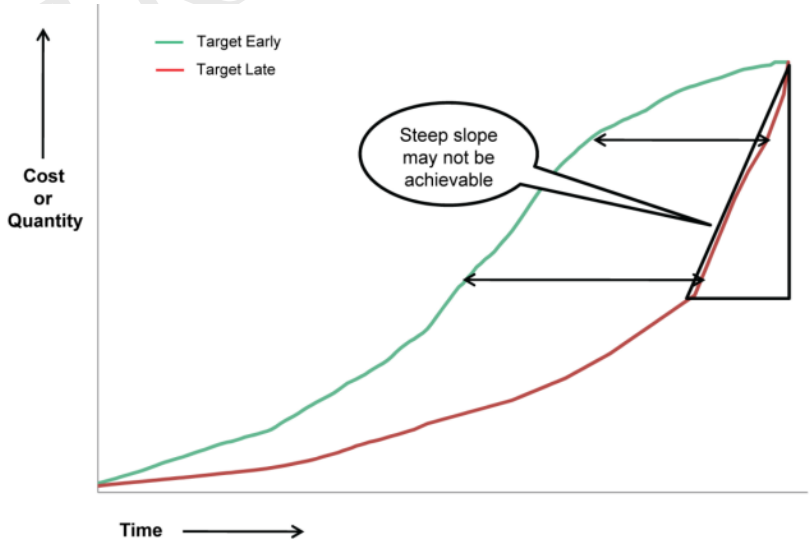

Figure 11 – Example B

Early and late dates

1. First, there is **potentially some excessive float** in the schedule which may contribute to the **shape of the S-curve.**
2. Second, and **more importantly**, this may indicate that the late activities have **not been properly resource leveled**,

   resulting in the **late curve schedule** activities sliding to the far right.

- The **project** will then have
  1. Have too much work stacked up at the **end of the schedule**
  2. May become impossible to complete from a **resource perspective**.

These types of banana curves at the project summary level may indicate that the schedule is not yet logically complete

Let's see another one!

Early and late dates

- The **banana S-curve** in Example C tells us that the schedule is very tight (**little activity float**).
- This may **not be reasonable** unless it is being caused by
  1. Excessive use of contingency or
  2. A limited number of parallel activities

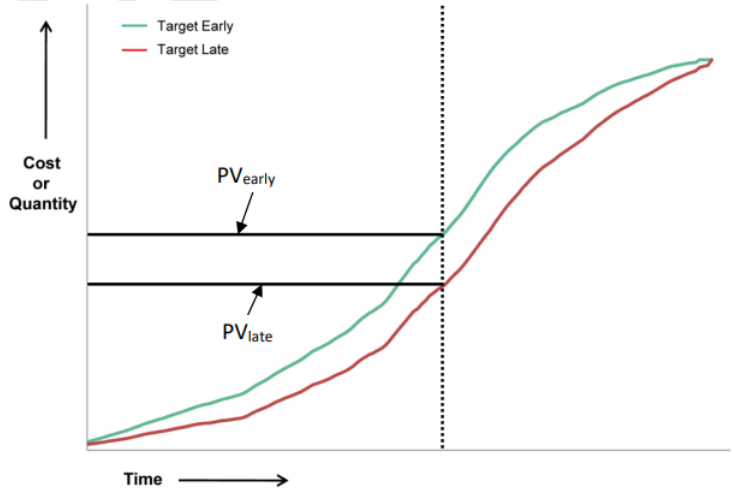

Figure 12 – Example C

But we need a single curve! What should be done?

Generating a single PV curve

- The **planned (PV) line** for earned value analysis requires a **single curve**;

  the analyst must therefore determine a method for generating a single performance measurement baseline curve, (the PV curve), **from the early/late data available**.

- The analyst **must exercise a degree** of judgement in selecting a single curve when there are two data values available at any given point in time, the early planned value **(PVearly)** from the target early curve, and the late planned value **(PVlate)** from the target late curve in Figure 12.

Let's see what happens when we choose each one!

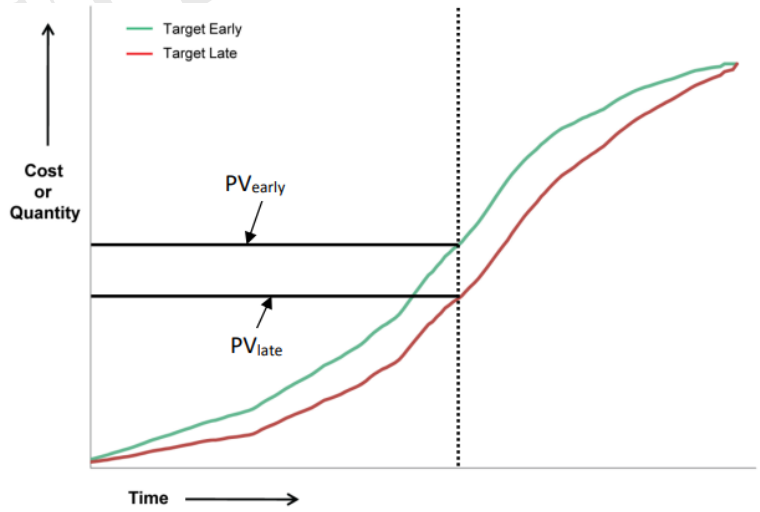

Figure 12 – Example C

Generating a single PV curve

- Possible options are:

1. **Generate the PV curve from the early date values.**
   - In this case, the calculated SPI will likely **never be reported above 1.0** since **exceeding the early dates** *"is seldom achieved."*
   - The project would be considered **behind schedule (SPI < 1.0)** **even when** it is within its planned boundaries.

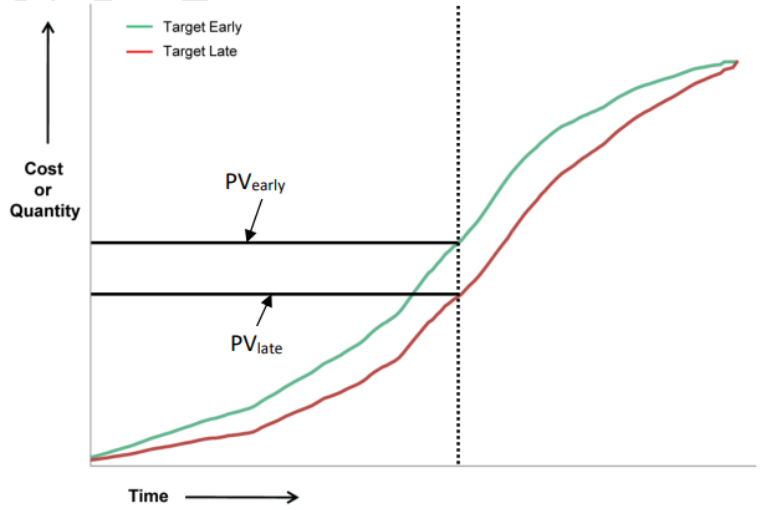

Figure 12 – Example C

Generating a single PV curve

- Possible options are:

2. **Generate the PV curve from the late date values.**
   - This **eliminates** the **distorting aspect** of float
   - This **establishes** a "*no later than*" curve for the project.
   - In this case, any SPI calculated **less than 1.0** would indicate that the project is behind its late dates and therefore likely to slip past its planned completion.
   - An **SPI reported below 1.0** would require immediate management attention and possible **action**.

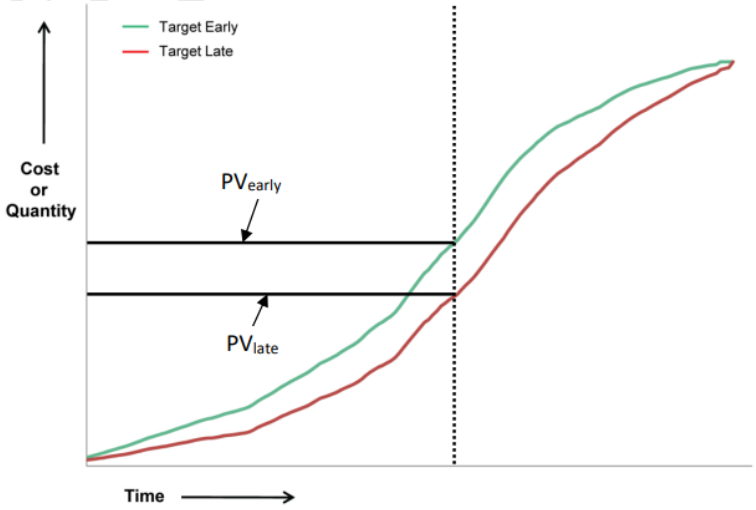

Figure 12 – Example C

Generating a single PV curve

- Possible options are:

3. Generate the PV curve from an average of the early and late values.

- This is a *"middle of the road"* approach where the PV curve would be the **midpoint** of the early/late envelope.
- SPI results could **range above and below 1.0** but would require additional confirmation (as shown on Figure 6) that the **actual progress falls somewhere** between the early and late values.

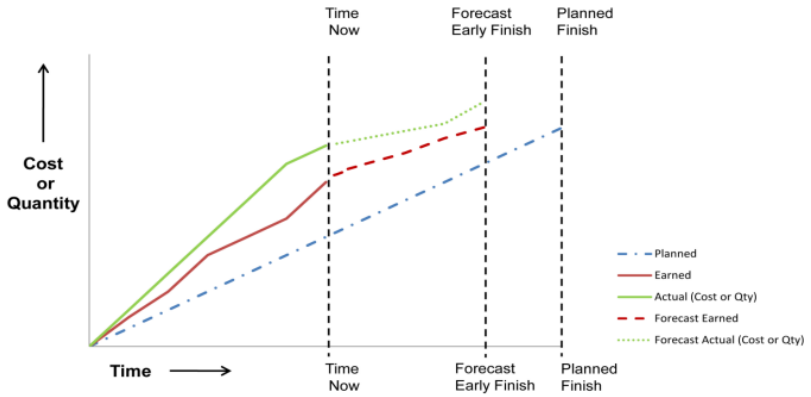

Figure 6 – Earned Value S-Curve

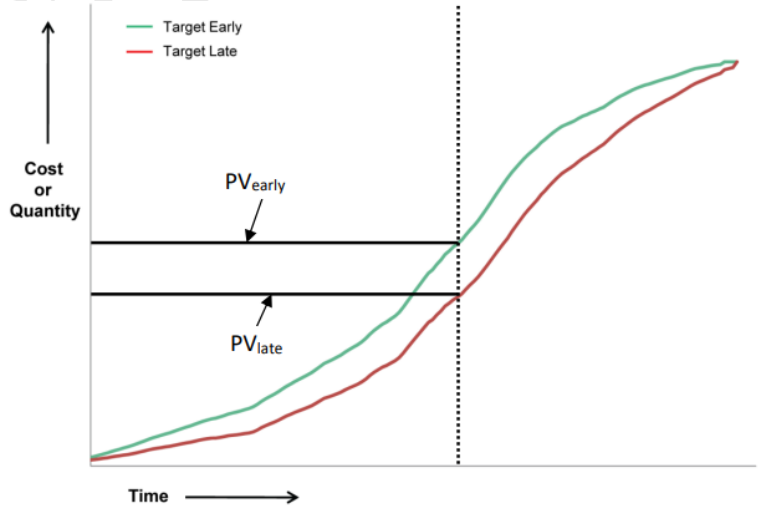

Figure 12 – Example C

Generating a single PV curve

- Possible options are:

4. **Generate the PV curve from a weighted calculation of the early and late values.**
   - This is a subset of **midpoint approach** which could be used based on either
     1. Contractual terms or
     2. Project team discretion

What if we have higher gaps between TE and TL?

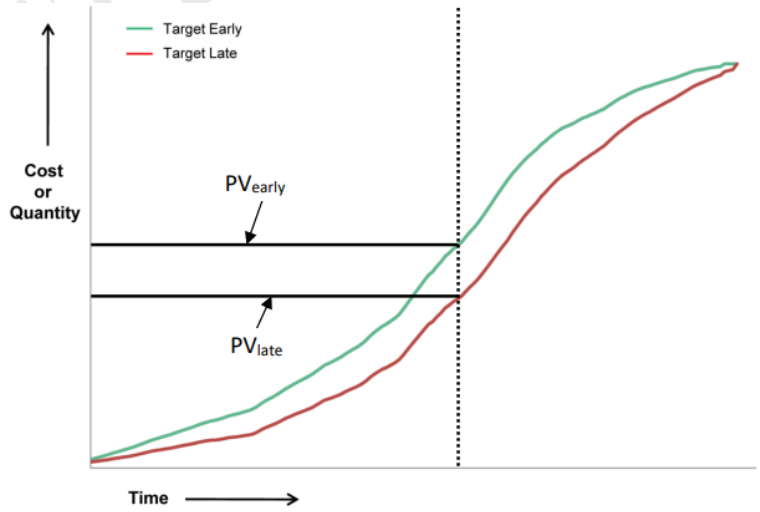

Figure 12 – Example C

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Generating a single PV curve

- The **gap** between early and late curves represents the **float** and can be an indication of the **health of the schedule**.
  - Schedules with high float activities, long duration activities and/or missing logics/activities may result in a **vertically wider banana curve.**
    - ✓ This **becomes more important** when a **single PV curve** is **not generated** based **on early dates**.

What care should be taken here?

Generating a single PV curve

- In these cases, it is important **to ensure** there are adequate activities and logic built into the schedule

  so the **gap between early and late curves** is within project management **tolerance for delay.**

What additional analysis needed other than analyzing S-curves?

Generating a single PV curve

What additional analysis needed other than analyzing S-curves?

- There are two additional methods to further analyze S-curves.
  1. First, is to consider **what percentage of activities** in a schedule should have varying degrees of criticality (this will vary from industry to industry and project to project).
  2. The second is to **review historical curves** to see how close similar projects' S-curves compare.

Be cautious about…

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Cautions

- It is possible for **S-curve information** to be misleading instead of instructive.
  1. For example, if the project is tracking costs and has **pre-ordered several high-cost items**,

     then the **cost S-curve** may indicate **excellent progress**

     regardless of the **current status** of the critical work.
  2. As another example, **poor productivity** will also show a high-cost S-curve while **schedule progress** will be **lower than expected**.

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Cautions

- **Progress S-curves** indicate **cumulative progress** of all work, not just critical work.

- The project may **be behind** due to over-emphasis on **non-critical work** at the expense of the critical work and still show excellent S-curve progress.

- The **S-curve by itself without** any other project information (project status narrative, detail schedule analysis, etc.)

  may provide a **false view** of the project.

- **Used in conjunction** with other sound project controls practices,

  S-curves can provide project stakeholders quick and meaningful indications of the **overall progress** of the project.

Summary

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Summary

- There are **several different methods** to generate and analyze an S-curve for a project.
  1. Complexity of the project,
  2. Project contract structure,
  3. Value of the project

  are **just a few factors** in determining the best type of S-curve to be utilized on a particular project.

The S-curve together with a CPM schedule

are tools that **may be used by stakeholders** to

1. Status,
2. Evaluate, and
3. Forecast the project.

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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