



فرآیند یکپارچه برنامه ریزی، زمانبندی و کنترل پروژه

بخش اول:
مقدمه: معرفی دوره آموزشی

ارائه دهندگان:

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فرآیند یکپارچه برنامه ریزی، زمانبندی، ارزیابی و کنترل پروژه

برنامه ریزی و زمانبندی پروژه یکی از مهمترین موارد در موفقیت پروژه ها تلقی گردیده که آموزش آن باید در ۳ مرحله فرآیندی صورت پذیرد. مرحله اول یادگیری مفاهیم برنامه ریزی و زمانبندی و نحوه ارزیابی برنامه زمانبندی (Schedule Constructability Analysis) و کنترل پروژه میباشد. مرحله دوم یادگیری نرم افزارهایی است که میتوانند این مفاهیم را پیاده سازی نمایند و مرحله سوم یادگیری فرآیندی است که بتواند کل این ساختار را در تمامی طول چرخه حیات پروژه، از مرحله قبل از طراحی (Pre-design) تا مرحله پس از ساخت (Post-Construction) توسط مدیر پروژه پیاده سازی نماید. البته ما کل این مراحل را در ساختار آموزش کاملاً استاندارد تدوین نموده و به آموزش آنها خواهیم پرداخت.

این دوره جامع، مرحله اول یعنی فرآیند برنامه ریزی، زمانبندی، ارزیابی و کنترل پروژه را در ۳ بخش اصلی به شما آموزش خواهد داد. بخش اول، آموزش مفاهیم پایه و مقدمات بوده و بخش دوم استاندارد اجرایی برای پیاده سازی و اجرای این فرآیند را به صورت علمی و بین المللی به شما آموزش خواهد داد. اما در بخش سوم، این فرآیند و نحوه پیاده سازی آن را در کشورمان ایران آموزش میدهیم تا بتوانید در یک ساختار جامع تمامی این مبانی را یاد بگیرید.

آنچه خواهید آموخت

در این دوره جامع علاوه بر اینکه فرآیند برنامه ریزی، زمانبندی، ارزیابی برنامه زمانبندی و کنترل پروژه را بر اساس ساختار بین المللی، اصولی و به صورت علمی می آموزید، اصول برنامه ریزی و کنترل پروژه های مهندسی در ایران را نیز فرا خواهید گرفت.

ارائه گواهینامه حضور بر اساس حضور بیش از ۶۰ درصد در دوره
و گواهینامه حرفه ای بر اساس قبولی در آزمون برای هر دوره

مهارت‌های سخت (Hard Skills) - سطح کارشناسی و اجرایی

سطح ۵	سطح ۴	سطح ۳	سطح ۲	سطح ۱	دپارتمان
	استاندارد مدیریت ساخت CMAA	متدولوژی Prince2	راهنمای PMBOK		مدیریت پروژه
	تامین مالی پروژه			مدیریت مالی و هزینه پروژه ارزیابی اقتصادی پروژه	مدیریت مالی و هزینه
				برنامه ریزی و کنترل پروژه نرم افزار MSP نرم افزار Primavera	مدیریت برنامه ریزی و زمان بندی
		مدیریت کیفیت پروژه			مدیریت کیفیت
اجرای پروژه به روش CM			مدیریت ادعاء و اختلافات	آنالیز تاخیرات پروژه	مدیریت قرارداد
		مدیریت ایمنی پروژه			مدیریت ایمنی
مدیریت طرح		مدیریت چابک Agile	مدیریت پروژه به روش Lean دفتر مدیریت پروژه PMO		مدیریت طرح و برنامه
		مدیریت پایداری پروژه			مدیریت پایداری
			مدیریت ریسک پروژه		مدیریت ریسک
			نرم افزار Power BI	مدیریت اسناد و مدارک پروژه	مدیریت اطلاعات
	مدیریت BIM در پروژه		نرم افزارهای BIM		مدلسازی اطلاعات ساختمان (BIM)

فرآیند یکپارچه برنامه ریزی، زمانبندی، ارزیابی و کنترل پروژه

مهم ترین سرفصلها

۱. مقدمه

- ✓ مفاهیم برنامه ریزی، زمانبندی، ارزیابی و کنترل پروژه
- ✓ نکات کلیدی از نگاه قراردادی

۲. استاندارد اجرایی

- ✓ شناسایی و تعریف همه فعالیتها
- ✓ اولویت بندی و تعریف روابط بین همه فعالیتها
- ✓ تعریف، تخصیص و تسطیح منابع فعالیتها
- ✓ تعیین زمان برای همه فعالیتها
- ✓ بررسی و تایید برنامه زمانبندی از منظر افقی و عمودی
- ✓ بررسی و تایید مسیر بحرانی
- ✓ اطمینان از مناسب بودن شناوریهای تخصیص یافته
- ✓ آنالیز ریسک و ساخت پذیری برنامه زمانبندی (Schedule Constructability and Risk Analysis)
- ✓ حفظ و نگهداری Baseline Schedule در طول پروژه
- ✓ به روزرسانی Actual Progress

۳. برنامه ریزی، زمانبندی و کنترل پروژه در ایران

- ✓ اصول برنامه ریزی مجدد (Replan)، زمانبندی مجدد (Reschedule) و برنامه ریزی جبرانی (Catch up plan)
- ✓ اصول برنامه ریزی مهندسی پروژه و تعریف MDR
- ✓ دسته بندی و کلاس بندی مدارک مهندسی
- ✓ فاز بندی طراحی پروژه
- ✓ آشنایی با مراحل تولید مدارک مهندسی
- ✓ دیسیپلینها و انواع مدارک مهندسی
- ✓ Work Step های محاسبه پیشرفت مهندسی
- ✓ به روزرسانی برنامه فاز مهندسی پروژه
- ✓ اصول برنامه ریزی تدارکات پروژه
- ✓ آشنایی با مراحل خرید کالا و تهیه گزارش وضعیت کالا (PSR)
- ✓ آشنایی با مراحل قبل از قرارداد خرید کالا (RCI) و بعد از قرارداد (MCI)
- ✓ آشنایی با اصطلاحات بین المللی بازرگانی Incoterms

ارائه گواهینامه حضور بر اساس حضور بیش از ۶۰ درصد در دوره

مهارت‌های سخت (Hard Skills) - سطح ارشد و استراتژی

سطح ۵	سطح ۴	سطح ۳	سطح ۲	سطح ۱	دپارتمان
		منشور اخلاق در مدیریت پروژه			مدیریت پروژه
			استراتژی مدیریت هزینه و مهندسی ارزش		مدیریت مالی و هزینه
			استراتژی مدیریت برنامه ریزی و زمانبندی		مدیریت برنامه ریزی و زمان بندی
	استراتژی مدیریت کیفیت				مدیریت کیفیت
		استراتژی مدیریت قرارداد		اصول مدیریت ساخت	مدیریت قرارداد
	استراتژی مدیریت ایمنی				مدیریت ایمنی
استراتژی مدیریت طرح و برنامه					مدیریت طرح و برنامه
	استراتژی مدیریت پایداری				مدیریت پایداری
		استراتژی مدیریت ریسک			مدیریت ریسک
		استراتژی مدیریت اطلاعات			مدیریت اطلاعات
استراتژی مدیریت BIM					مدلسازی اطلاعات ساختمان (BIM)

References Used in This Course

Primary references

- ❑ “Best practices for project schedules” published by **U.S. Government Accountability Office (GAO)** that is assisting the Congress in 2015 used in this course.
- ❑ “DCMA (Defense Contract Management Agency) 14-Point schedule assessment set of criteria” was formed in 2005 and firstly was used by **US Department of Defense**.
- ❑ “Planning & Scheduling Excellence Guide (PASEG)” published by **National Defense Industrial Association (NDIA)** in 2019.
- ❑ “Construction Planning and Scheduling” **book** published by **Hinze** in 2013 used in this course.
- ❑ “Construction scheduling: preparation, liability, and claims” **book** published by **Wickwire** in 2003 used in this course.

Other references

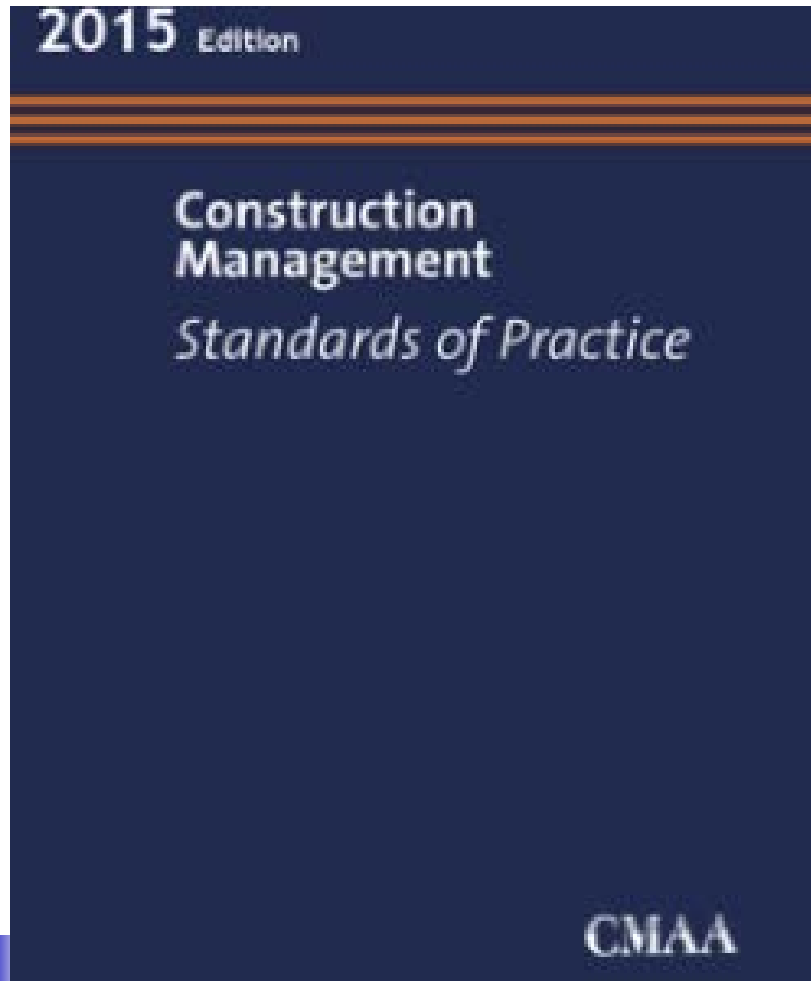
- ❑ **SCL Delay and Disruption Protocol**, 2nd edition, 2017
- ❑ **CAE 471 handbook (the handbook of IIT university)** that is about “**Construction Planning and Scheduling**” used in this course.
- ❑ “**The Associated General Contractors of America: Construction Planning and Scheduling**” published by **Glavinich, The University of Kansas** in 2004.
- ❑ “**CMAA Webinars**” used in this course.
- ❑ “**PMBOK**” published by **PMI** in 2017 used in this section.
- ❑ “**Practice Standard for WBS**” published by **PMI** in 2006 used in this section.

Updated references in 1401

- ❑ Project control for engineering (P 6-1), **Construction Industry Institute (CII)**, 1986
- ❑ Project control for construction (RS 6-5), **Construction Industry Institute (CII)**, 2012
- ❑ CPM Scheduling for Construction (Best Practices and Guidelines) published by **Carson et al., PMI** in 2014.

References Used in Advanced Course

Primary References



Other References

- ❑ **Construction Project Mangement (A practical guide for building and electrical contractors):** Eddy M. Rojas, University of Washington, 2009
- ❑ **Urban Construction Project Management:** Lambeck and Eschemuller, McGraw Hill Construction, 2009
- ❑ **Advanced Scheduling Handbook for Project Managers:** Averous and Linares, 2015
- ❑ **A Guide to Managing Programs Using Predictive Measures:** National Defense Industrial Association (NDIA), 2017
- ❑ **Construction planning, programming and control:** Cooke and Williams, 2009



اعتبار تا ساعت ۲۳ پنجشنبه ۱ اردیبهشت

Other References

Discount code:

scheduling1401

☐ You can find this course on ACEMI Webiste:

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



موسسه مهندسی
و مدیریت ساخت علوی پور
(ACEMI)

دوره آموزشی استراتژی برنامه ریزی و کنترل پروژه در طول چرخه حیات پروژه

مدرس: دکتر سید محمدرضا علوی پور
تعداد ویدئوها: ۱۲
مدت زمان کل آموزش: ۱۶ ساعت



فرآیند یکپارچه برنامه ریزی، زمانبندی و کنترل پروژه

بخش دوم:

مقدمه: مفاهیم برنامه ریزی، زمانبندی، ارزیابی و کنترل پروژه

ارائه دهندگان:

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What we will learn?

- ☐ Planning and scheduling
 - ❖ Concepts and terminology
 - ❖ Types of schedule during the life cycle of the project
- ☐ Schedule and records in contract
- ☐ Elements missing in the contract and need more consideration (general recommendation)
- ☐ Key activities & considerations for project schedule specification
- ☐ Project realities and effective solution

Planning and Scheduling

(Concepts and Terminology)

What is planning and scheduling?

- ❑ **Significantly** different
- ❑ **Scheduling** can **never** be performed **effectively without planning**
- ❑ **Construction planning and scheduling** should address:
 - ❖ What?
 - ❖ Where?
 - ❖ How?
 - ❖ Who?
 - ❖ When?

What is planning and scheduling?

- ❑ The **planning** portion of a construction project relates to:
 - ❖ Developing the **logic** of **how** a project will be **constructed**

- ❑ **Scheduling** consists of:
 - ❖ **Integrating** that **plan** with a **calendar** or a **specific time frame**.

Purposes and importance of project planning and scheduling

- ☐ **Increase** profit by **reducing** costs
- ☐ **Maintain** deadline
- ☐ **Construction work** fits on the operation
- ☐ **Cooperation**: Deliveries, shutdown, responsibilities of owner, suppliers, GCs, SCs, etc.
- ☐ **Monitoring**: Status of the project (time, cost, quality, etc.)
- ☐ **Control**: Control problems and make correction is needed
- ☐ **Changes**: mistakes by parties or additional task
- ☐ **Damages**: what happened? Claims?

Why do we need a schedule for changes?

What is planning and how to do that?

❑ **Planning** is about:

1. What?

- ❖ What tasks and activities?

2. Where?

- ❖ Where your building, project site, storage, prefab, suppliers, and etc. located?

3. How?

- ❖ Methods?
 - ❖ Build in the site? Or prefab? Or combination of both? Or etc.
 - ❖ If there are experienced contractors, rely on them.

4. Who?

- ❖ Stakeholders, owner, designers, engineers, GC, SCs, suppliers, local agencies, and all people who are part of the projects.

What is planning and how to do that?

- ❑ Process **begins** in the **pre-construction phase** of a project.
- ❑ Designated person must **define the details** of **how** to build the project.
- ❑ Formal planning, done correctly, involves **five steps** or phases:
 1. Planning the planning phase
 2. Gathering information
 3. Preparing the preplan
 4. Disseminating the pertinent information in the plan to all affected parties
 5. Evaluating the results of the planning efforts and its consequences.

*The **majority** of the work associated with defining **how** the project effort will proceed is properly **called “planning”** rather than **“scheduling.”***

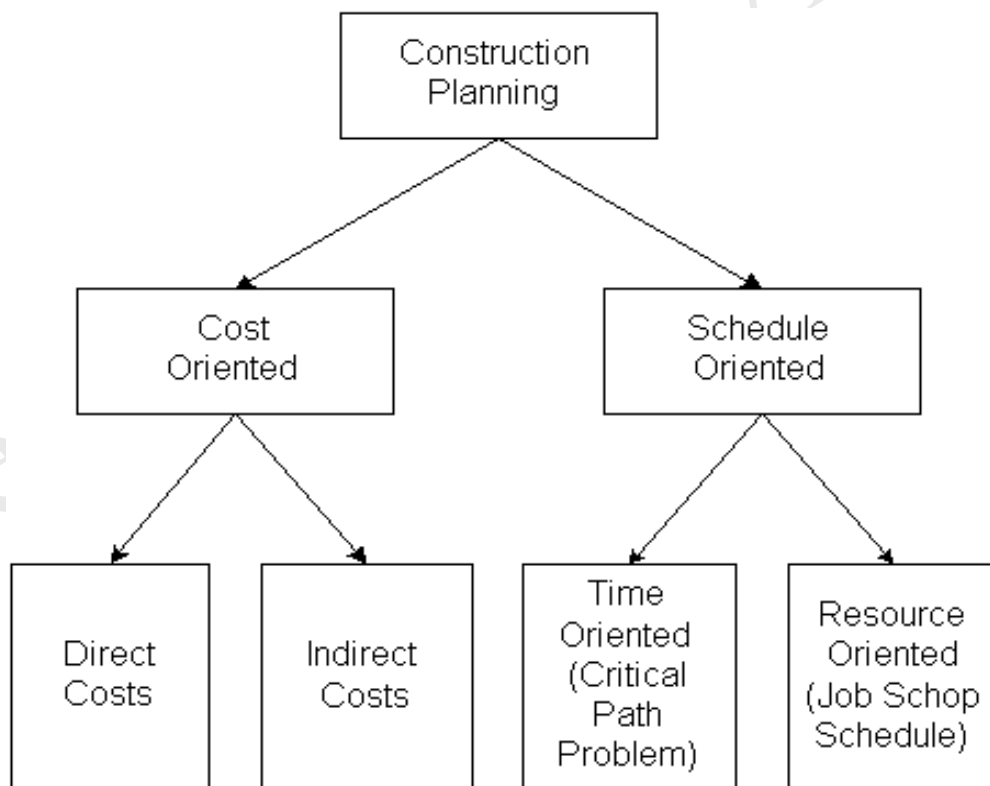
What is planning and how to do that?

- ❑ Project planning is a process within **program management**.

*Project planning is the basis for controlling and managing project performance, including managing the **relationship** between cost and time.*

What is planning and how to do that?

- ☐ Which **one is more critical?** **Cost** or **Time** or **Resource**
- ☐ Construction planning is **not restricted** to the period of **“construction.”**
- ☐ It should be an **essential activity** during the **“design.”**



What is scheduling and how to do that?

- ☐ **Scheduling** is about when
- ☐ **Scheduling** is a timetable of **activities**
- ☐ A project **schedule** is a written or graphical representation of the Contractor's plan
- ☐ A project **schedule** emphasizes the elements of duration
- ☐ A project schedule should define specific time periods

What is scheduling and how to do that?

❑ Scheduling **consists** of:

1. Determining the **duration needed** for

✓ **Each** of the planned **tasks**

✓ The **overall length** of the project schedule

2. Determining the **time** each of the planned tasks should be **started**

3. **Finalizing** the **sequence** and **logic**

Risks of scheduling

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Risks of Requiring a Schedule

- Approved/accepted schedule takes on a "legal status"
- Owner agrees to schedule that can be later used as the basis of a claim

Risks of Not Requiring a Schedule

- Unable to effectively measure the progress of work
- Unable to confirm the work is properly coordinated
- Unable to verify timing for performing its own responsibilities required to complete the work

Risks of not requiring schedules far outweigh risks of requiring, reviewing & accepting schedules

Give me an example of why?

Risks of scheduling

Time and money can be easily lost through poor project planning and scheduling of on-site labor, materials, and equipment.

HOW ABOUT CLAIMS?

For example, a **lack of coordination** in ensuring that materials and equipment are delivered to the site on time can be **devastating** to the project.

WHY?

Resulting in delays and lost productivity.

So, how important is that from the **contract perspective**?

Is it always good to **deliver** materials and equipment early?

Risks of scheduling

Materials and equipment delivered **too early** can be as devastating as those delivered too late.

WHY?

Resulting in **additional costs** associated with on-site or remote storage, double handling, and possibly interest and insurance.

This is exactly what **LEAN CONSTRUCTION** talks about!

- ❑ Planning and scheduling are **continual processes** throughout the **life of a project**.
- ❑ Planning and scheduling may be done in **stages throughout the project** as stakeholders learn more details.
 - ❖ This approach to planning, known as **rolling wave planning**.
- ❑ Scheduling involves the **management and control of the schedule** over the project's **life cycle**.
- ❑ Work and strategies for executing the work must be **planned first** before activities can be **scheduled**.

The integrated master schedule (IMS)

- ❑ An **Integrated Master Schedule (IMS)** is a **network of tasks** linked from **program start** through **program finish**.
- ❑ The IMS is the **foundation** of the **performance measurement baseline (PMB)** used to track progress, forecasts, and changes throughout program execution.
- ❑ The IMS enables the **Critical Path Method** that is used to identify **the program critical path**, as well as **driving paths** to major interim events or deliverables.
- ❑ It **begins** with the **Integrated Master Plan (IMP)**, which details the **contractual deliverables** and the **Statement of Work/Objectives (SOW/SOO)**.

All of this is enveloped by the hierarchy of the Work Breakdown Structure (WBS).

The integrated master schedule (IMS)

❑ IMS integrates:

1. **Planned work**
2. **Resources** necessary to accomplish that work
3. **Associated budget**,

*IMS should be the central point of **program management**.*

❑ An **IMS** **connects** all the scheduled work of the **owner** and the **contractor** in a network, or collection of logically **linked sequences of activities**.

❑ The **IMS** must be a **complete** and **dynamic** network.

The integrated master schedule (IMS)

- ❑ In this course, a “**program**” **encompasses** an **entire program** from beginning to end, including all **owner** and **contractor** effort.
- ❑ An **IMS** may be made up of **several** or **several hundred individual schedules** that represent portions of effort within a **program**.

Why and how is this important?

- ❑ These **individual schedules** are “**projects**” within the larger program.
 - ❖ *For example, a **program IMS** may consist of*
 1. ***Individual project schedules** for the **prime contractor**,*
 2. ***Owner program management office**,*
 3. ***Owner testing laboratory**.*

Rolling wave planning

❑ Near-term effort will be planned in **greater detail** than long-term effort.

1. Near-term effort:

- ❖ Represented as **detailed work packages**.
- ❖ It depends on the project's **size, phase, scope, risk, and complexity**.
 - ✓ *For example, some schedules may be planned in detail for only 2 or 3 months.*
- ❖ **Recommendation**:
 - ❖ **GAO Best practice**: 6 to 9 months from the current date.
 - ❖ **SCL Protocol**: 6 to 18 months from the current date.
 - ❖ **CMAA guideline**: 3 to 9 months from the current date.
- ❖ **Detailed activities** represent tasks that are typically **4 to 8 weeks long**.
 - ❖ **SCL Protocol**: No activity or lag should **exceed 28 days** in duration

Rolling wave planning

2. Long-term effort:

❖ Represented as planning packages.

✓ Planning packages:

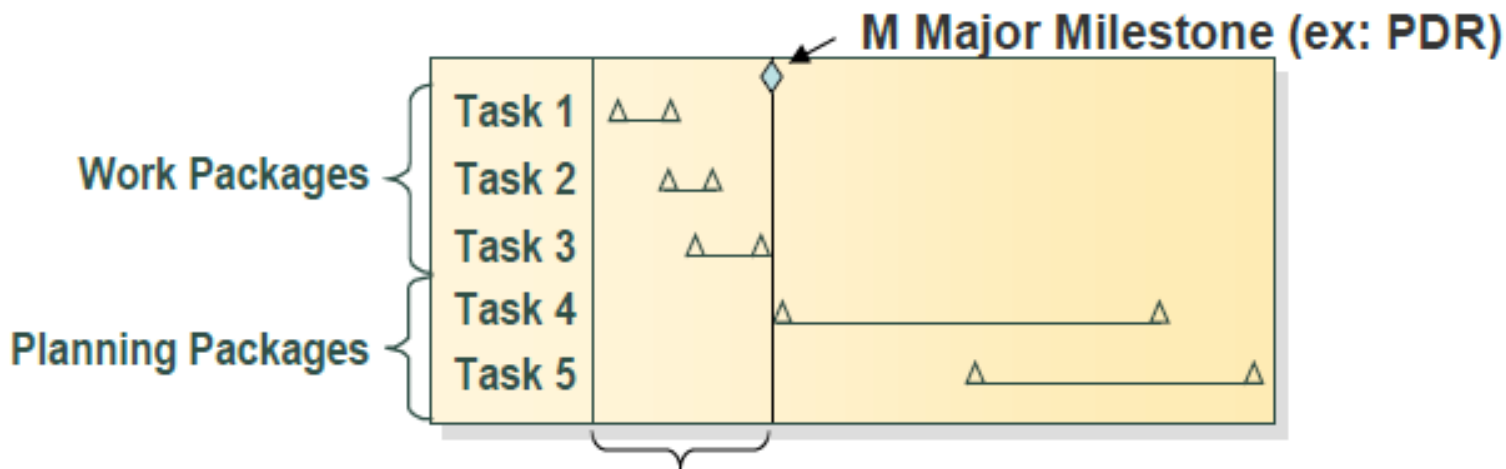
❖ Summarizing work in the **distant future**.

❖ Planned at **higher level** such that a **single activity** may represent **several months of effort** accomplished by a resource group or even a future contract or phase.

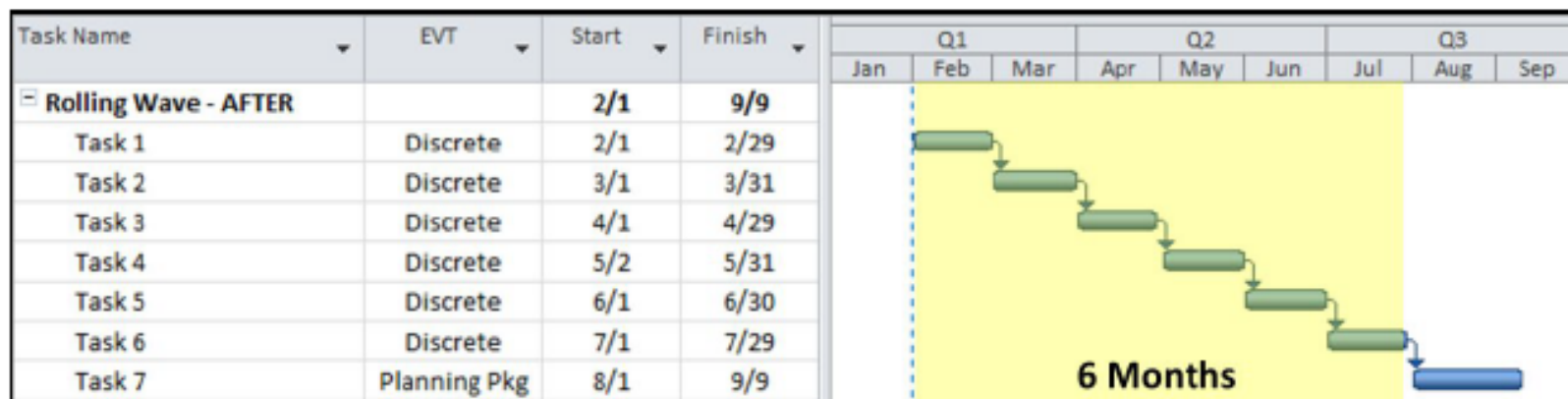
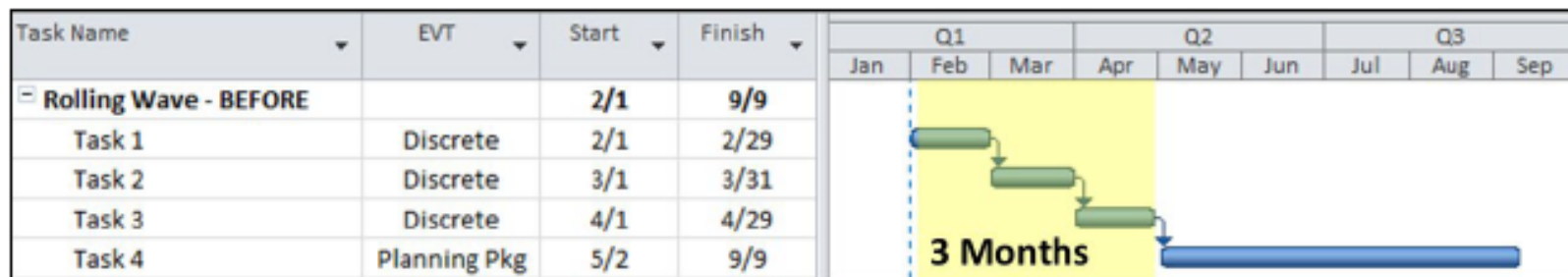
❖ As time passes, planning packages broken into **detailed work packages**.

❖ When “rolling wave” programming is used, an **activity limitation of 28 days** for maximum duration is not necessary for the later summarized activities.

*This **incremental conversion** of work from planning packages to work packages known as “rolling wave” planning*



Rolling wave planning



Rolling wave planning – Best practice

- ❑ If portions of far-term effort are **well defined**, they should be **included** in the IMS **as soon as possible**.
- ❑ Each planning package **must** still be traceable to **WBS elements** within the IMS.
- ❑ Planning packages should be **logically linked** within the **schedule** to:
 1. Create a **complete picture** of the project from **start to finish**
 2. Allow the **monitoring** of a **project's critical path**
- ❑ Planning packages that are on or **near the critical path** or that carry **significant risk** should be broken into smaller activities.

Rolling wave planning – Best practice

Read this article

<https://dralavipour.com/blog/view/Plan-schedule-control>

Planning and Scheduling

(Types of Schedule During the Life Cycle of the Project)

Types of schedule

1. Pre-design Schedule

- ❖ Prepared by **CM** to manage **“Pre-Design Process”**

2. Design Schedule

- ❖ Prepared by **CM** to manage **“Design Process”**

3. Pre-bid construction Schedule (or Engineer’s Schedule)

- ❖ Prepared by **CM/Designer** to **evaluate “Construction Schedule”** provided by **GC**
- ❖ Prepared by **CM/Designer** for **estimating** general **“time”** and **“budget”**

4. Bid Schedule

- ❖ Prepared by **CM/Designer** to manage **“Bidding Process”**

5. Contractor construction Schedule

- ❖ Prepared by **GC** or sometimes **CM/Designer** to **control** and **manage “Construction Project”**

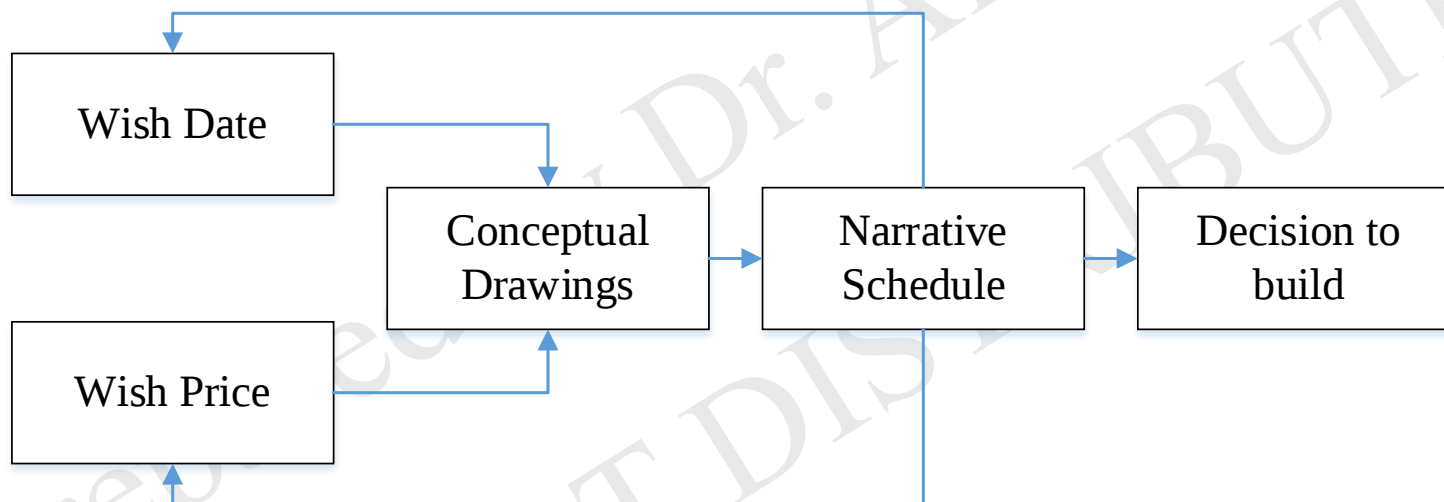
6. Occupancy Schedule

- ❖ Prepared by **CM/Designer** to bridge the gap between **construction and operations**

7. Forensic Schedule

- ❖ Prepared by **CM/Designer** to analyze **delays “After-the-Fact”**

❑ Decision to build



Pre-design phase – Narrative schedule

❑ Usually **Narrative Schedule** is used in **pre-design phase**.

❖ A **narrative description** usually **consists of**:

1. Contractor plans to work across the Project
2. Contractor's planned construction sequence
3. Number of crews
4. How long it believes the work will take.

➡ The **degree of detail** varies from **Project to Project**, but **most** narrative schedules range between **one paragraph** and **two pages**.

➡ **When** a narrative schedule is **requested**, the level of detail is required.



Pre-design phase

❑ Narrative Schedule

RE: Bridge Project
Narrative Schedule

Dear Engineer,

The bridge construction project consists of two abutments (Abutment #1 and Abutment #2), three pile-supported piers (labeled Pier #1, Pier #2, and Pier #3 from west to east), and four spans with steel girders and concrete decking (labeled Span 1, Span 2, Span 3, and Span 4 from west to east).

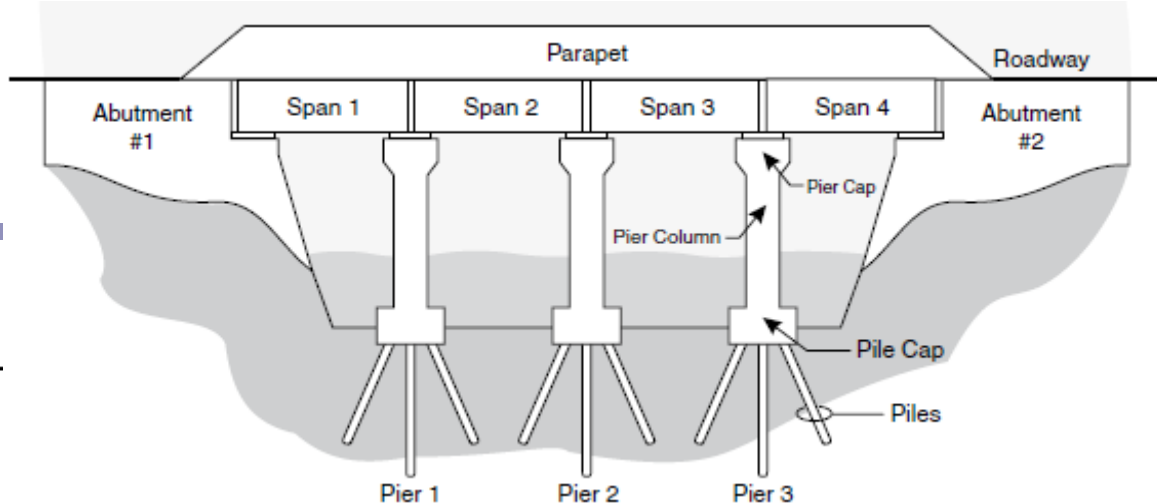
I will mobilize to the site on April 1, 2008, and plan to construct this bridge by moving from west to east. I plan to construct the bridge abutments and piers concurrently. One crew will construct Abutment #1 and then Abutment #2 and at the same time Piers #1 through #3 will be constructed starting at Pier #1 through Pier #3. The construction of the spans will follow the installation of the piers.

I expect the construction of each abutment to take approximately 6 weeks and the construction of each pier to take approximately 8 weeks. I expect that all of the abutments and piers will be in place and ready to accept the steel girders for the spans by the end of July.

From the end of July until the middle of October, I plan to erect the steel for the four spans, form and pour the decks, and form and pour the parapets and sidewalks. After completing any punchlist work, I plan to open the bridge to traffic on October 20, 2008.

Please feel free to contact me with any questions.

Sincerely,
Bob Smith
Project Manager



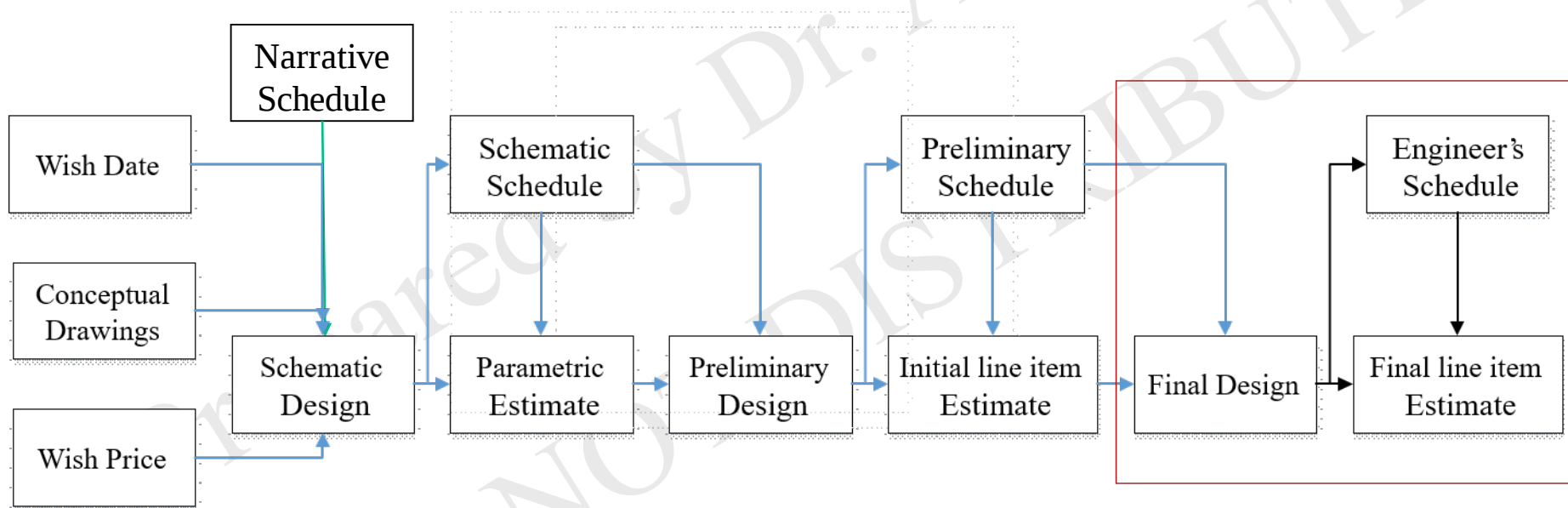


Pre-design phase – Narrative schedule samples

- ☐ See File #1
- ☐ See File #2
- ☐ See File #3

Prepared by Dr. Alavipour
DO NOT DISTRIBUTE

- ❑ In **Preliminary Schedule**: only (1) **General time frame** and (2) **General budget**
- ❑ In an **Engineer's Schedule**:
 1. It can be the **detailed schedule** with logic, time frame, resources, and budget
 2. It can be only the **Gantt Chart**



Design phase

❑ Why Schedule is needed for estimating?

- ❖ **Project overhead** (travel, storage fees, testing and inspection, etc.)
- ❖ **Time available** for **resources**
- ❖ **Weather** to be anticipated. This offers a basis for decisions regarding:
 - ❖ Equipment and labor **productivity**,
 - ❖ **Cold weather** operations,
 - ❖ Need for **multiple shifts overtime**, and
 - ❖ Etc.

❑ How to do it?

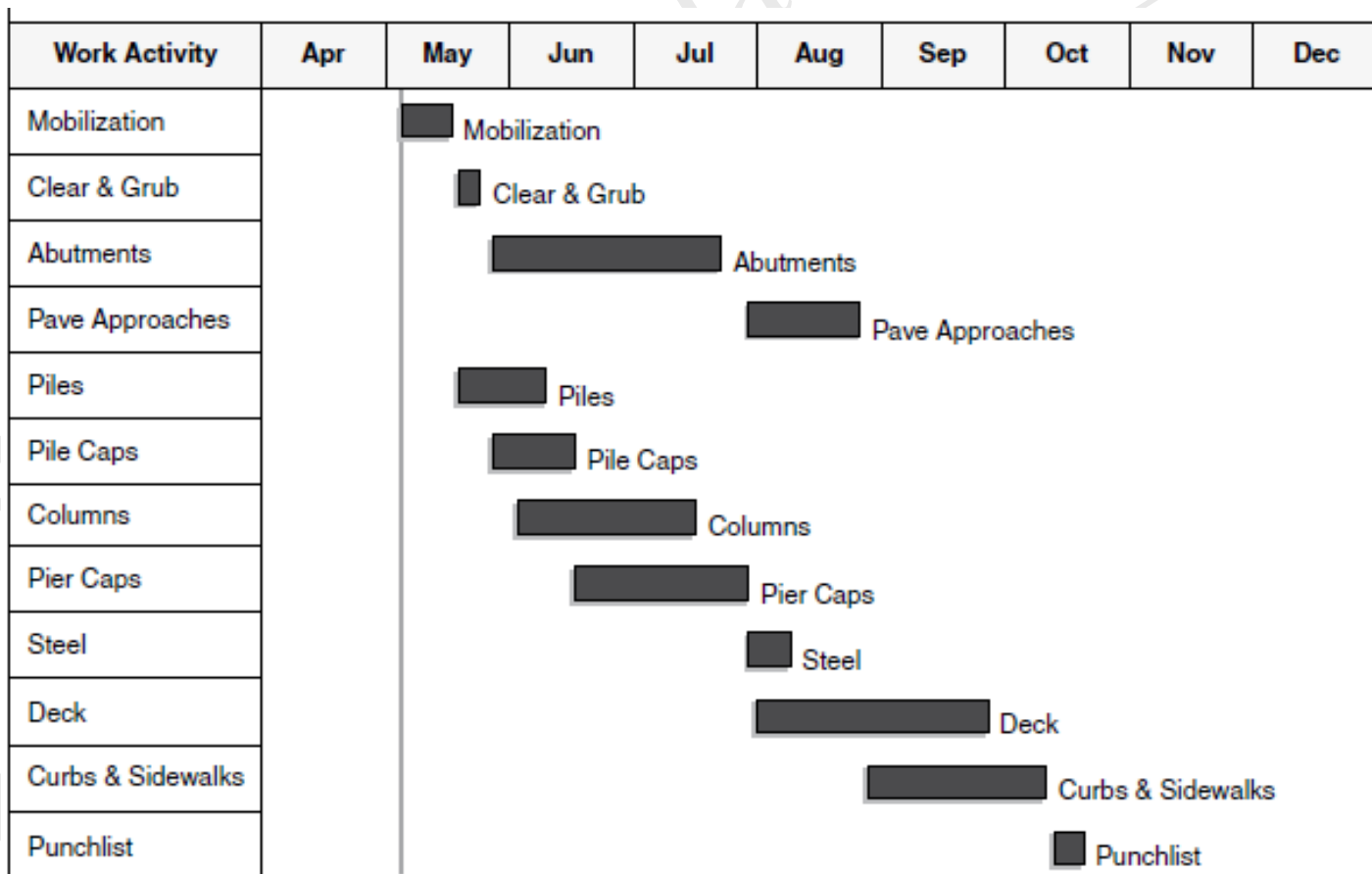
1. **Divide** the project into **major segments**
2. **Estimate** the **time** for each of these **segments**
3. Establish the **sequence**
4. The result is a **Gantt chart** that shows the **start** and **finish dates** for the overall project and the **approximate calendar times**.

Planning and Scheduling

(Types of Schedule During the Life Cycle of the Project)

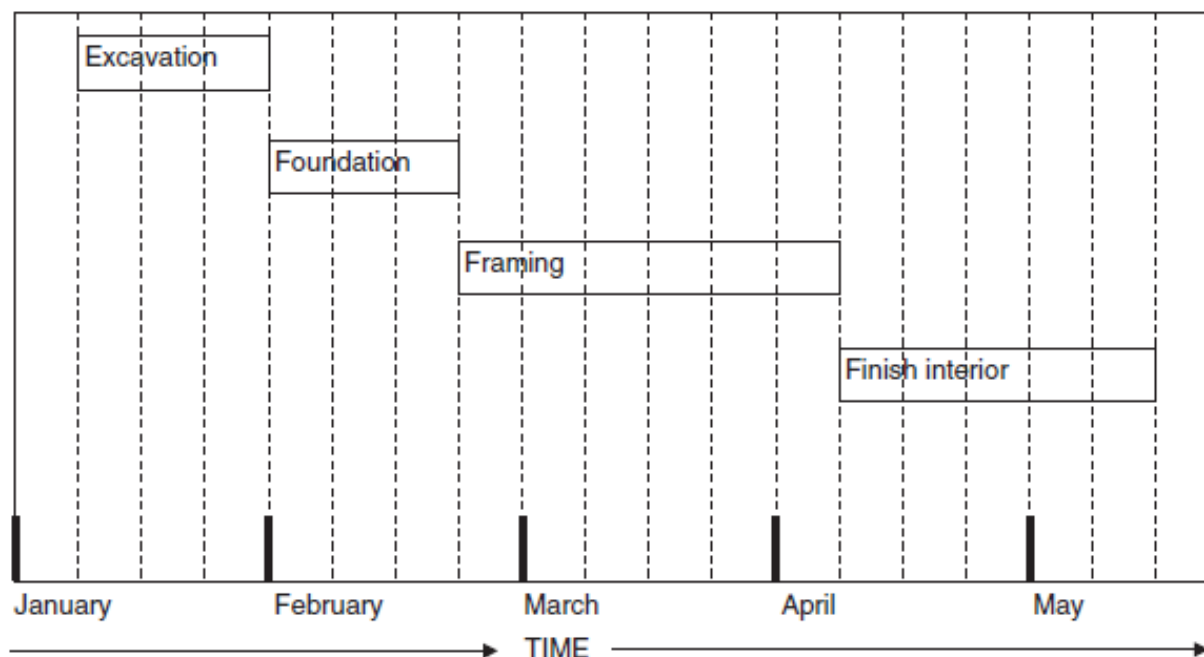
Design phase – Gantt Chart

- ❑ **Gantt chart**, also called a **bar chart schedule**
- ❑ **Visually** depicts the Project's **major work activities** in relation to **time**.
- ❑ **Simple** and **straightforward**, showing the **duration, timing, and sequence** of the work activities



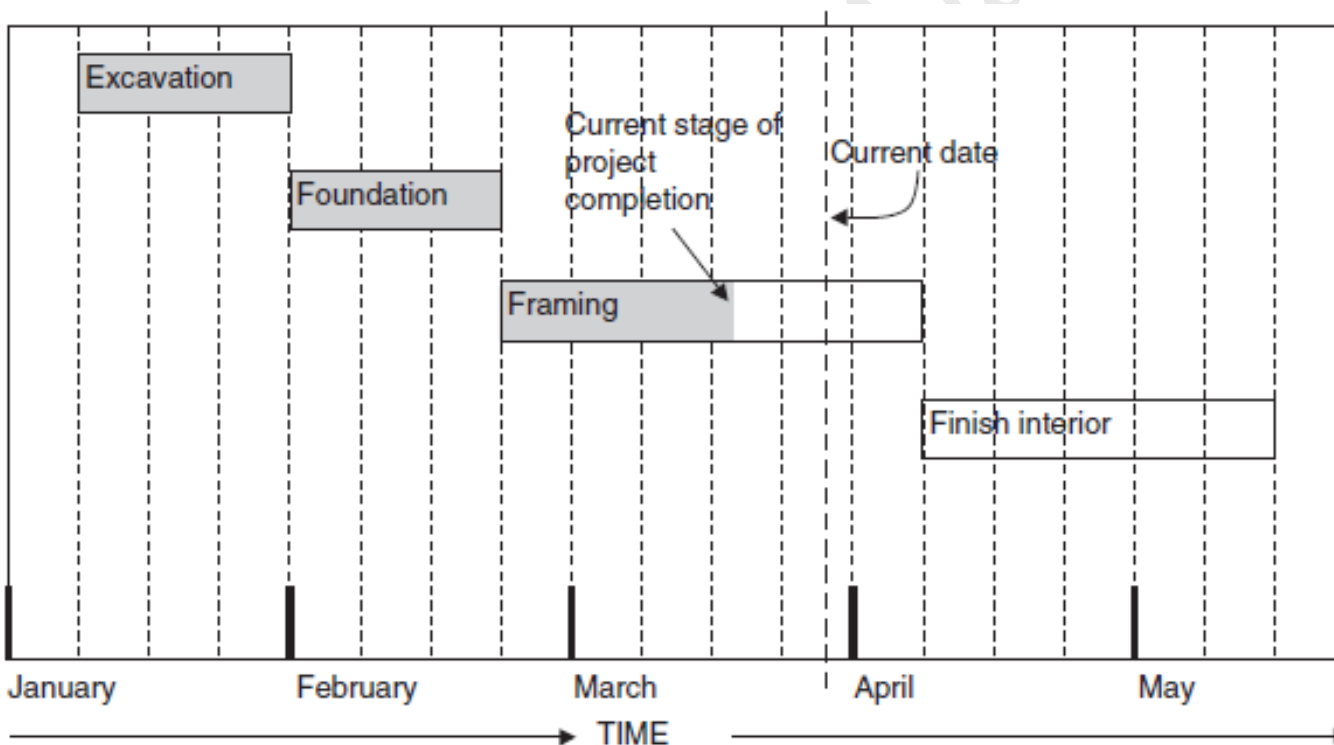
Design phase – Basic Gantt Chart

□ Bar Chart showing general construction work tasks.



Design phase – Basic Gantt Chart

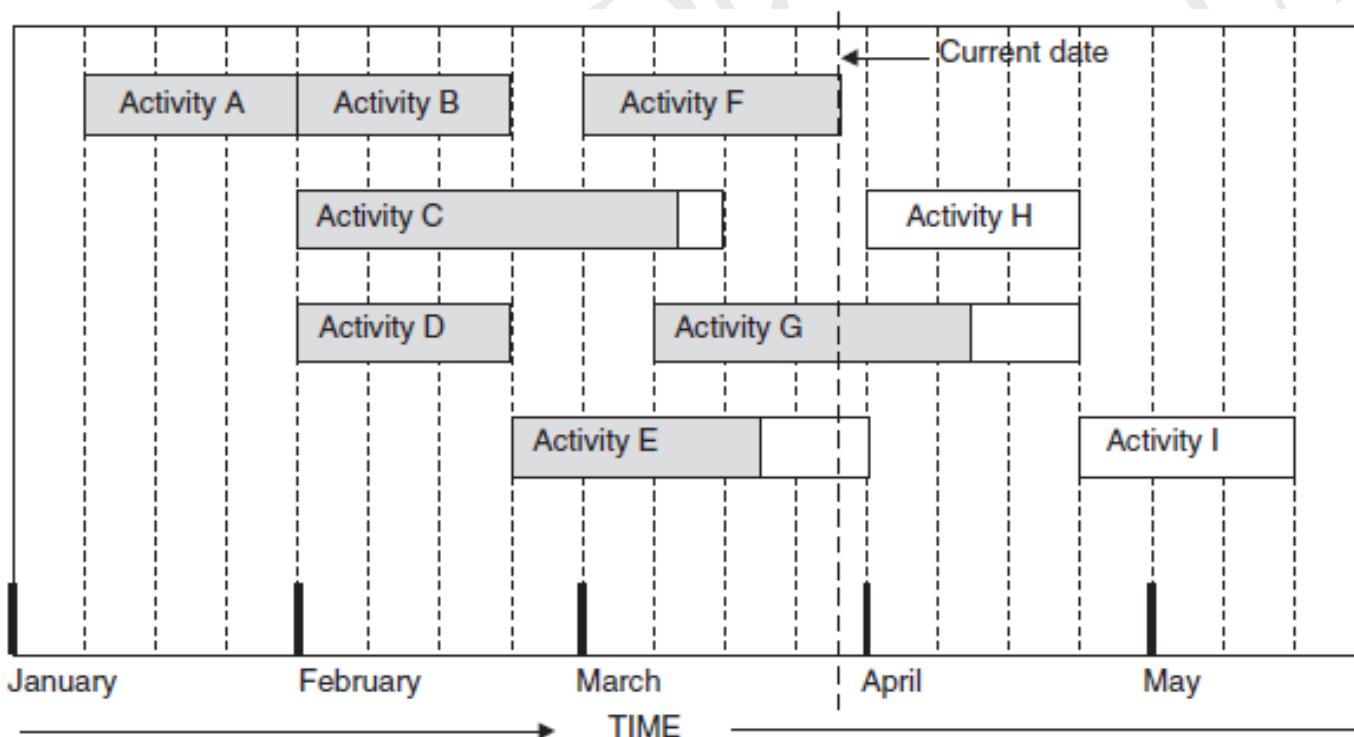
❑ Bar Chart showing scheduled versus actual performance.



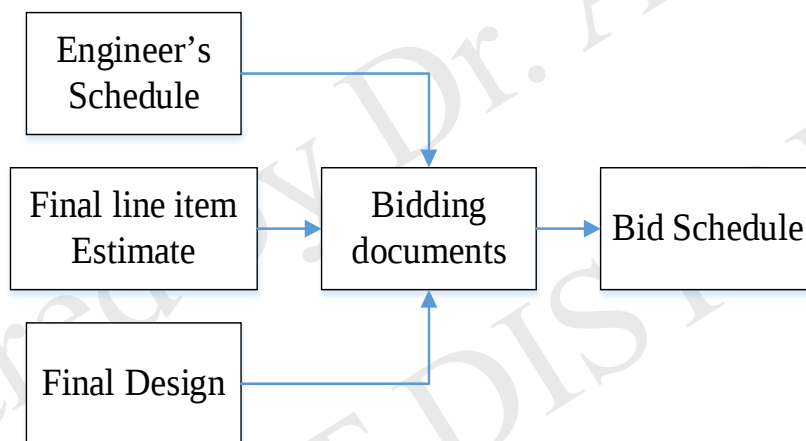
Design phase – Disadvantages of Gantt Chart

❑ Bar chart showing general construction work tasks.

- ❖ The **failure** to show the **interrelationships** between activities is a **major shortcoming of bar charts**, **mandating** that **more sophisticated scheduling techniques** be utilized on **complex projects**.



❑ Bidding documents usually prepared by CM or A/E:





Bidding phase – Bid schedule

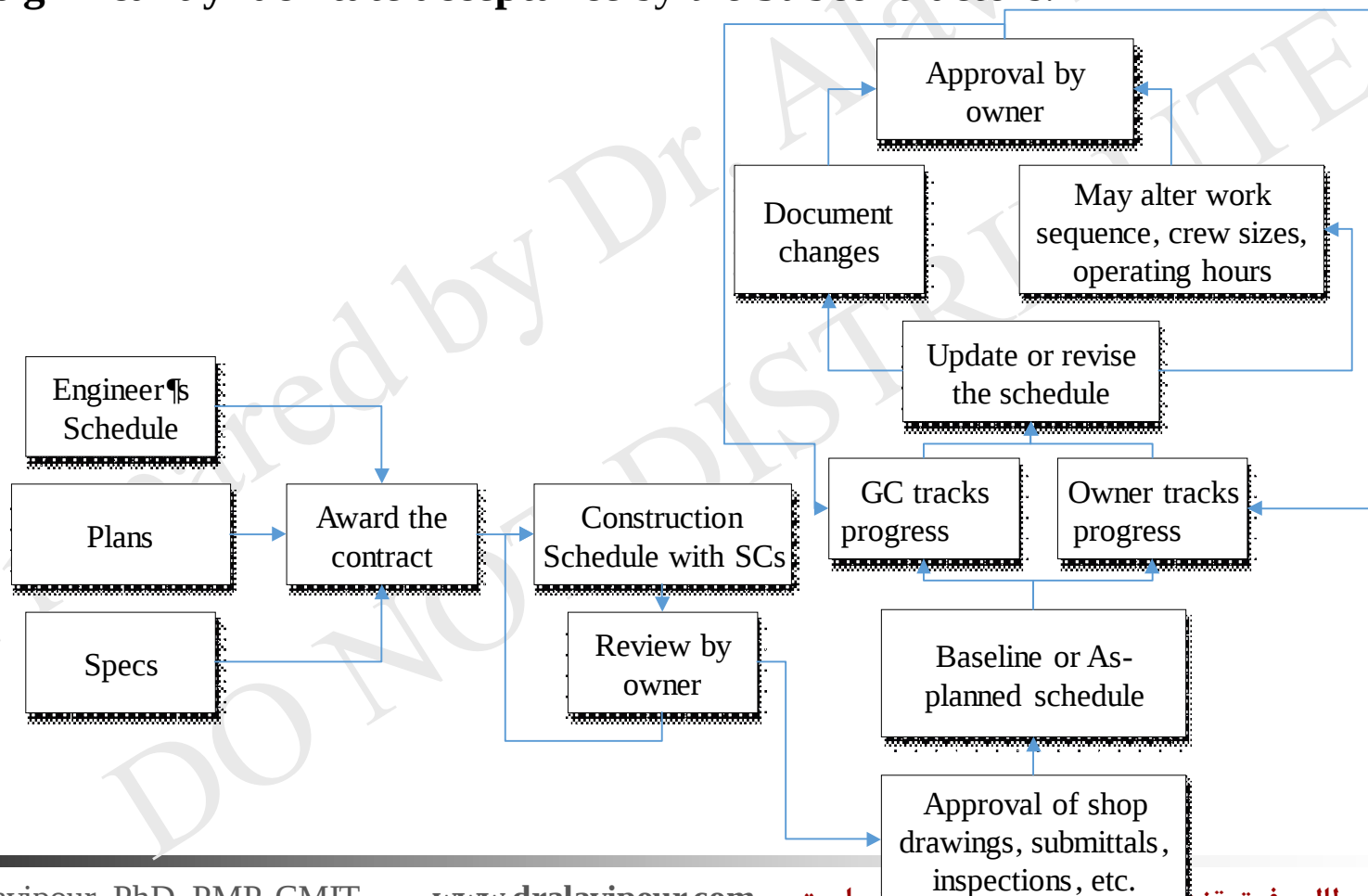
Bid Schedule

HVAC/Plumbing Bids

<u>Project</u>	<u>Bid Date</u>	<u>Time</u>
Cahaba Heights Athletic Fields	5/29/2019	11:00
UAB Quarterback Tower AHU's & RAF's Replacement	5/30/2019	2:00
Lynn Fanning Elementary School Dining Addition	5/30/2019	2:00
UA Event Management Center	5/31/2019	2:00
HPD Law Enforcement Training Facility Phase #2	6/4/2019	2:00
BHM Airport Aircraft Rescue Firefighting Station	6/5/2019	2:00
Crestwood Medical NICU & Administration Renovation	6/5/2019	3:00
Rudd Middle School	6/6/2019	2:00
UAB Off Site Renovations	6/6/2019	2:00
Marshall Space Center - Revitalize Building 4619 Mech Sys.	6/10/2019	11:00

****Projects listed in RED are projects we are bidding as a PRIME/GENERAL CONTRACTOR.****

- ❑ The **development** of the **construction plan** should include the GC and SCs.
- ❑ **Involving the Subcontractors** in the development of the **construction plan/schedule**, will **significantly facilitate acceptance** by the **Subcontractors**.



Construction phase

- ❑ After the receipt of the Notice of Award, the **superintendent** (or other designated person) must **define the details of how to build the project**.
- ❑ In this **planning phase**, **communications** take place between different parties that have already given some thought to the plan, including the estimator(s), contract administrator, architect/engineer, CM, etc.

Construction phase – How to select scheduling methods?

❑ Which **methods** for **Construction** Schedule?

- ❖ Gantt Chart
- ❖ Linear Schedule (LOB or LSM)
- ❖ Critical Path Method (CPM)
- ❖ Critical Chain Method (CCM)

Construction phase – Linear schedule

❑ Line of Balance scheduling (LOB) or Linear Schedule Method (LSM)

❑ **Most effectively** used for **repetitive** or **linear projects** in **nature** such as:

❖ Highway construction, pipeline construction, power line construction, tunneling, communications, railways, road construction, high-rise building, and etc.

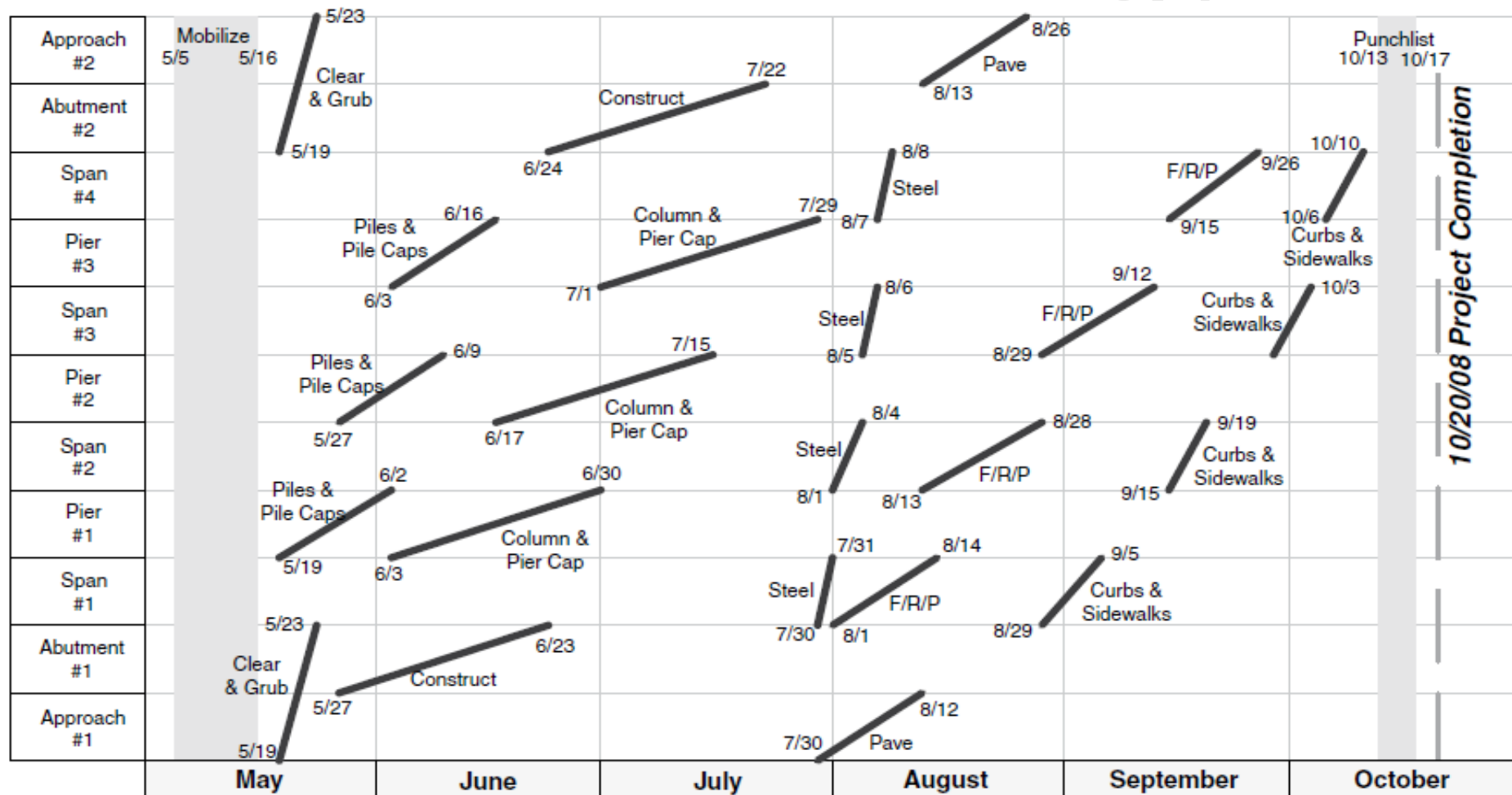
➡ EXAMPLES:

❑ **Installation** of a **pipeline** in which **every 100 meter** are considered to be **repeated**.

❑ A **track** of **50 homes** under construction

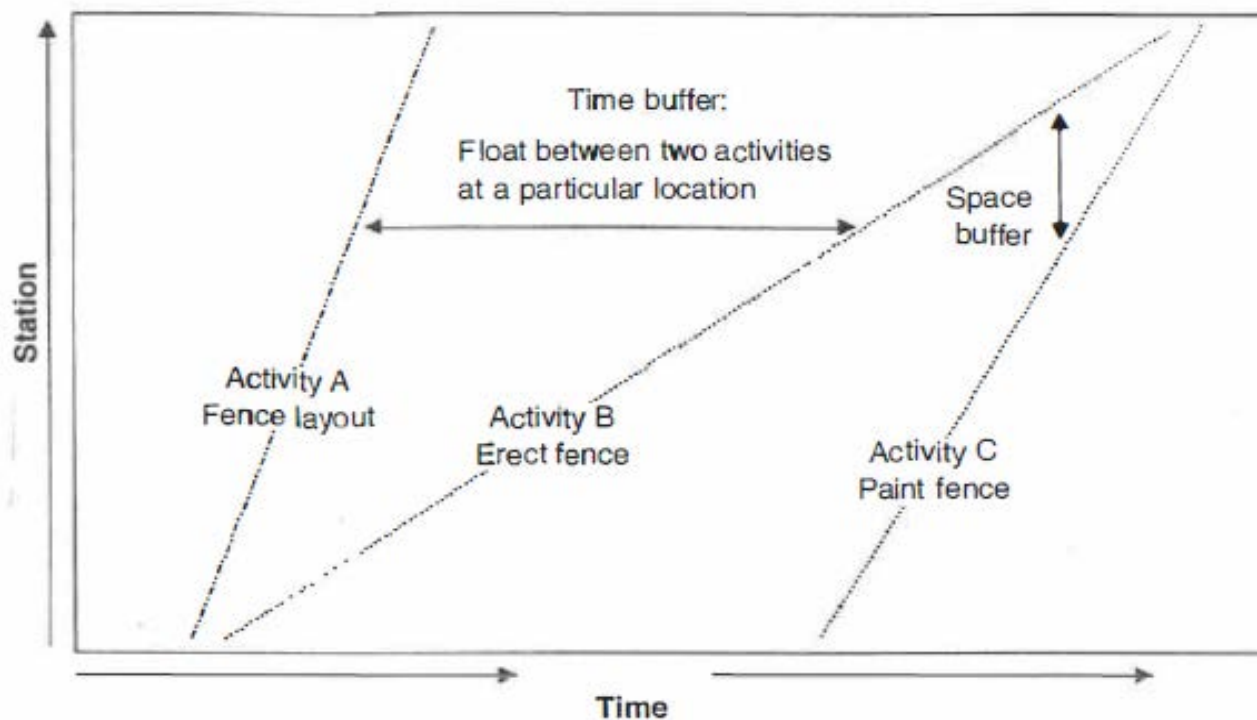
❑ On **high-rise structures**, the repetition **might** be on **floor-by-floor** basis.

Construction phase – Linear schedule

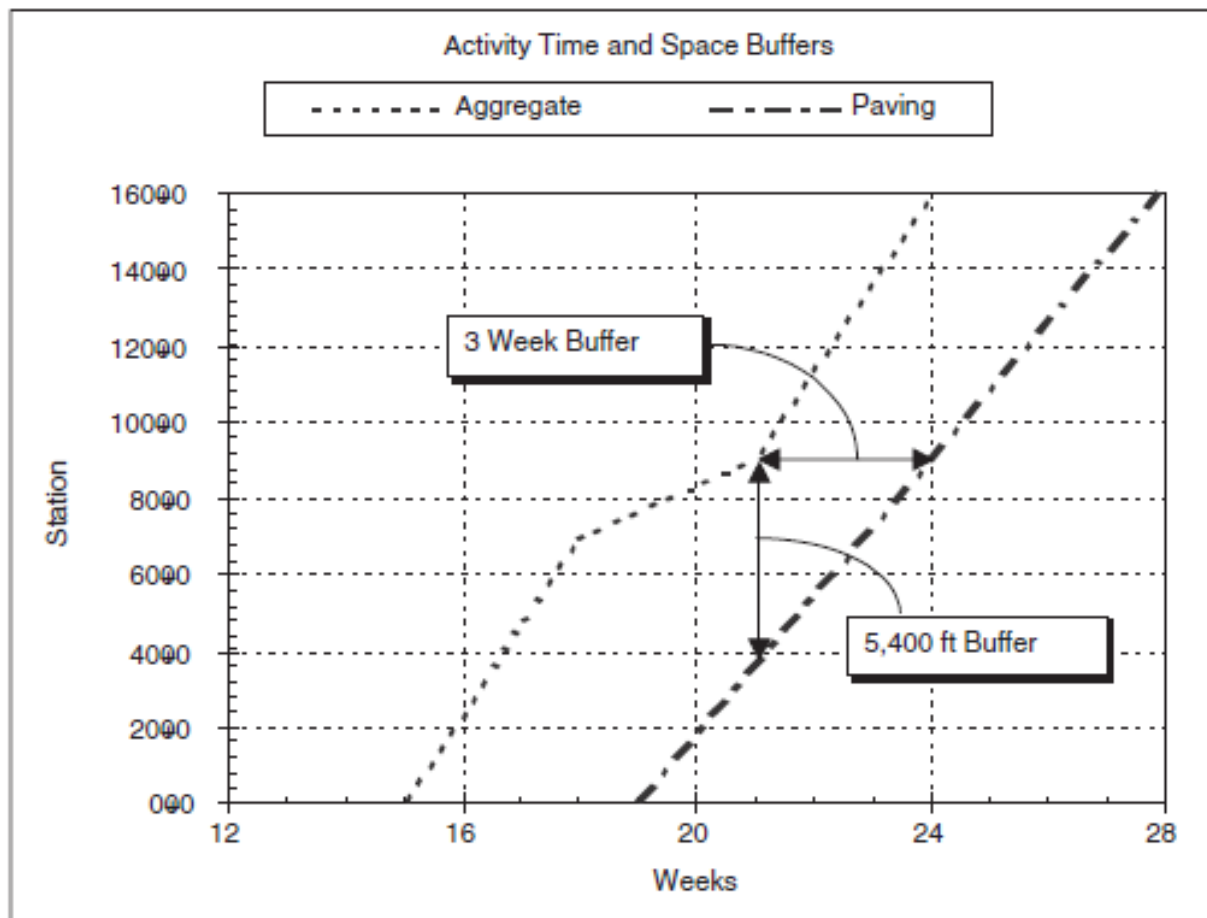


Construction phase – Advantages of linear schedule

- ❑ Is the linear schedule **deterministic** or **probabilistic**?
 - ❖ At **first glance**, the linear schedule would appear to be **deterministic**; however, **time buffer** that exists between activities reveals that it too is a reflection of the **probabilistic approach**.
- ❑ **Time buffer** is an acknowledgment that the **timing of the occurrence** of activities **cannot** be scheduled with **pinpoint accuracy**.



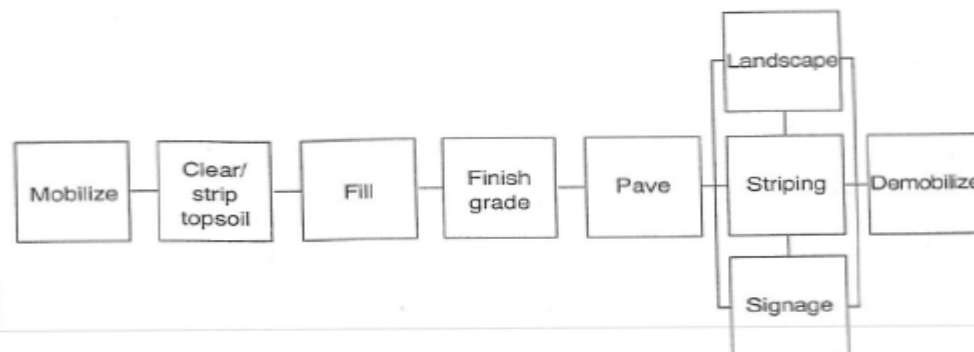
Construction phase – Advantages of linear schedule



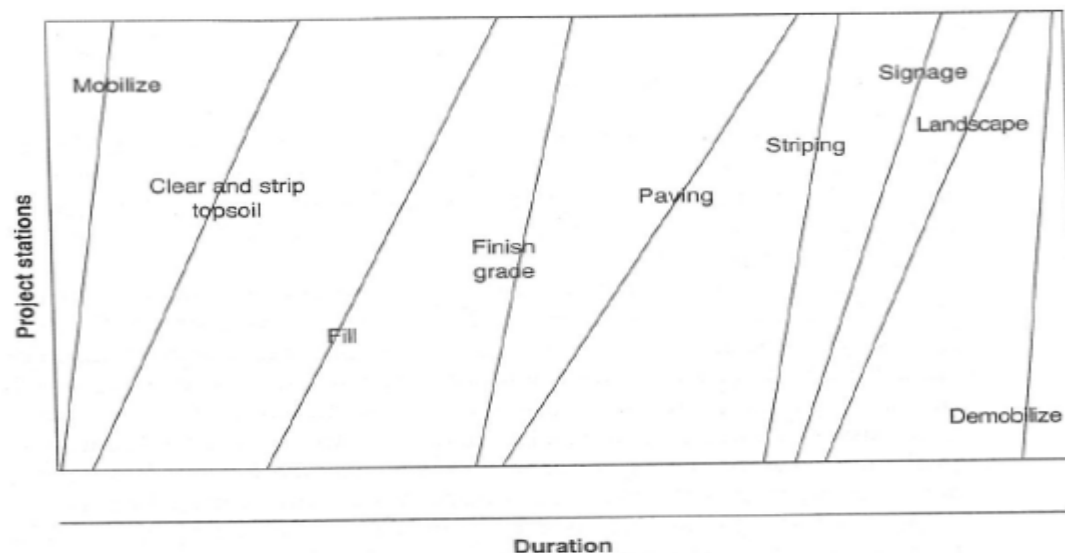
Activity Time and Space Buffers.

Construction phase – Advantages of linear schedule

- ❑ Linear schedule is a **more accurate portrayal**.
- ❑ For example, there will be a point in the schedule as the
 - ❖ **Last portion of the fill** work is being done
 - ❖ **Finishing grading** is well **underway**, and
 - ❖ **Paving** work will have **started**



(a) Example of a precedence diagram for a road construction project



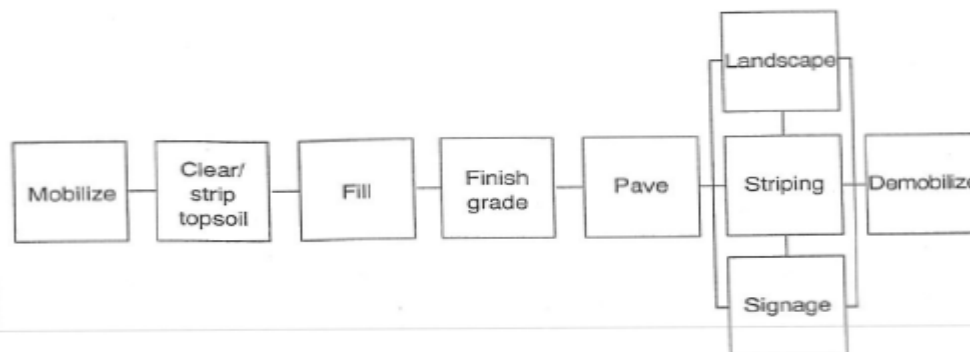
(b) Example of a linear schedule for a road construction project

Example to Compare Precedence Schedules with Linear Schedules

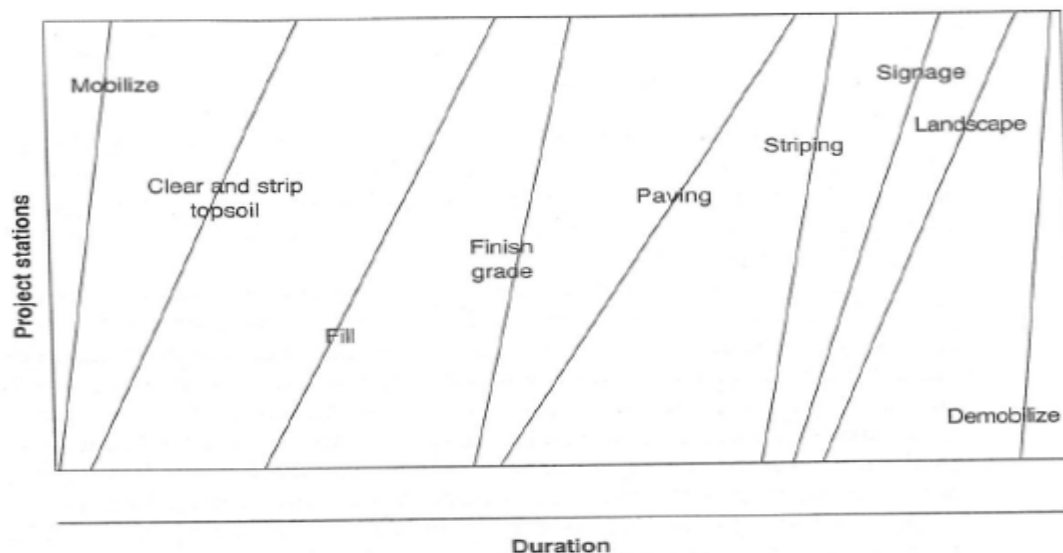
Construction phase – Advantages of linear schedule

❑ No need to think in terms of an **early-start** schedule or **late start** schedule.

❖ More related to the **expected schedule**



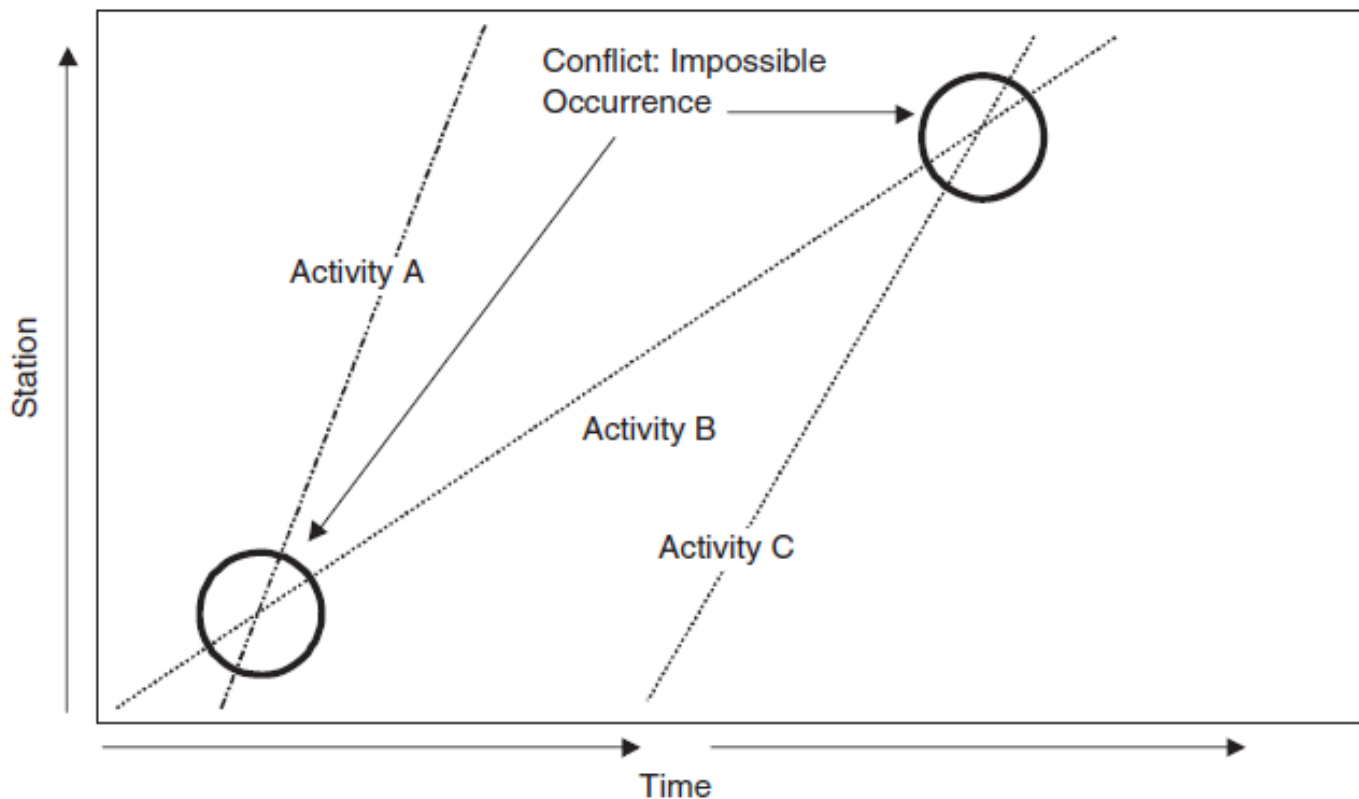
(a) Example of a precedence diagram for a road construction project



(b) Example of a linear schedule for a road construction project

Example to Compare Precedence Schedules with Linear Schedules

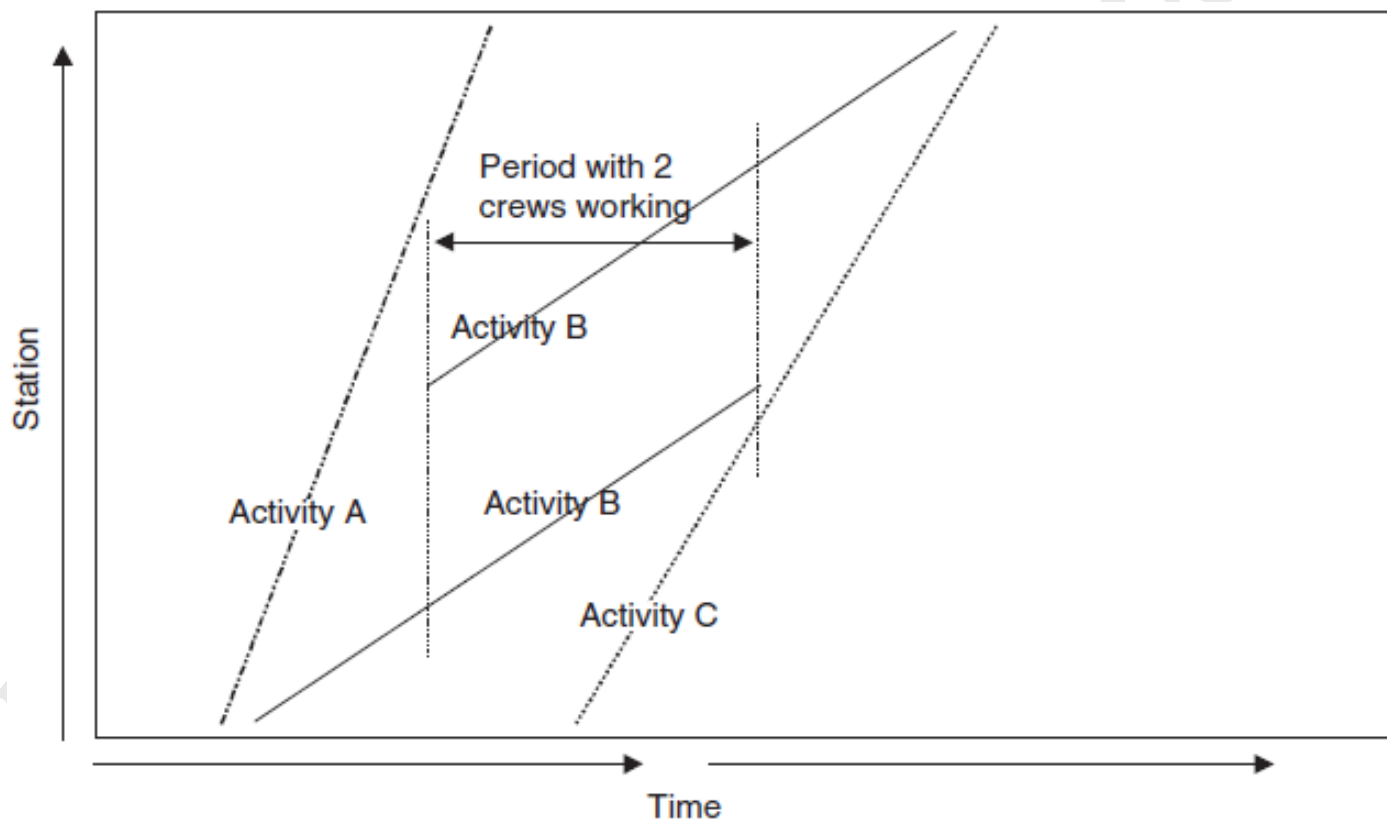
Construction phase – Advantages of linear schedule



Linear Schedule Showing Conflict that Must Be Resolved.

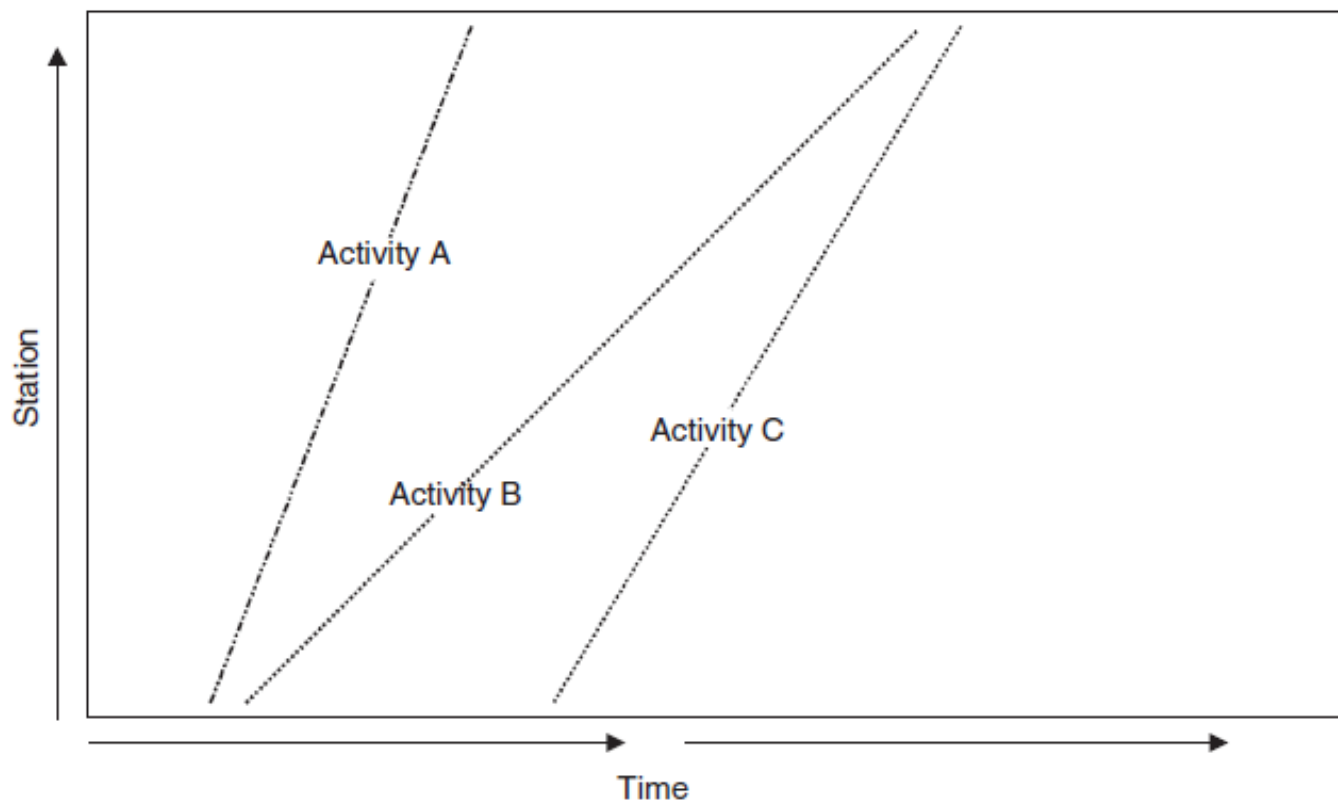
How?

Construction phase – Advantages of linear schedule



Linear Schedule Showing Project Compression by Adding a Second Crew.

Construction phase – Advantages of linear schedule



Linear Schedule with Project Compression by Accelerating One Activity.

Construction phase – Advantages of linear schedule

❑ **Main advantage** over other techniques: **track** planned and actual **production rates**

❖ Productivity is related to **location (e.g., stations/day)** rather than a resource quantity (e.g., cubic meter/hour).

❖ However, **productivity** is **not realistic** because activities are characterized by **straight line**. Productivity **changes over time** and is **not linear**.

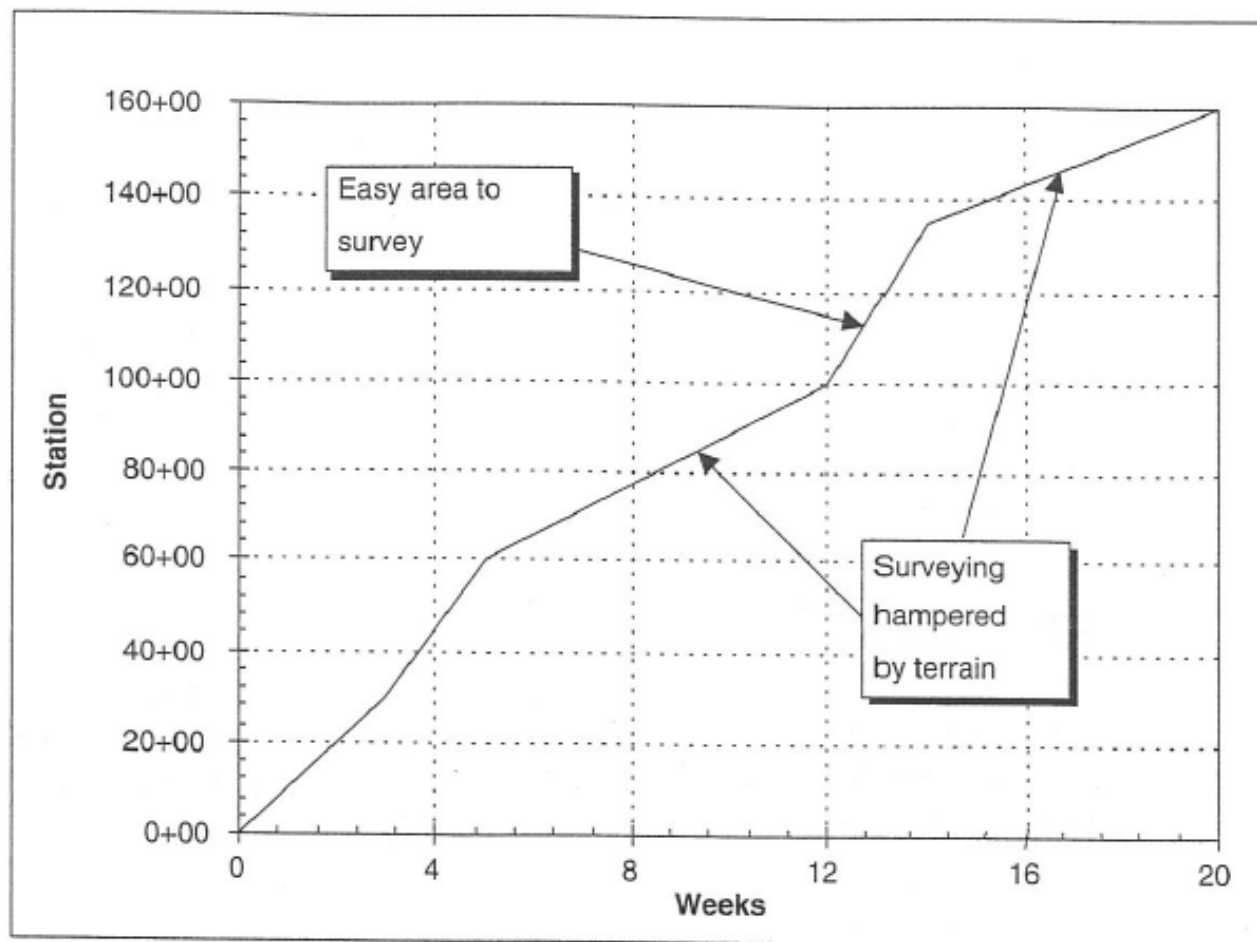
➡ It is **practical** to use **non-constant productivity**.

❑ **Far fewer activities** needed and resulting diagram is much **easier to interpret**.

❑ Easier to **communicate**

Construction phase – Advantages of linear schedule

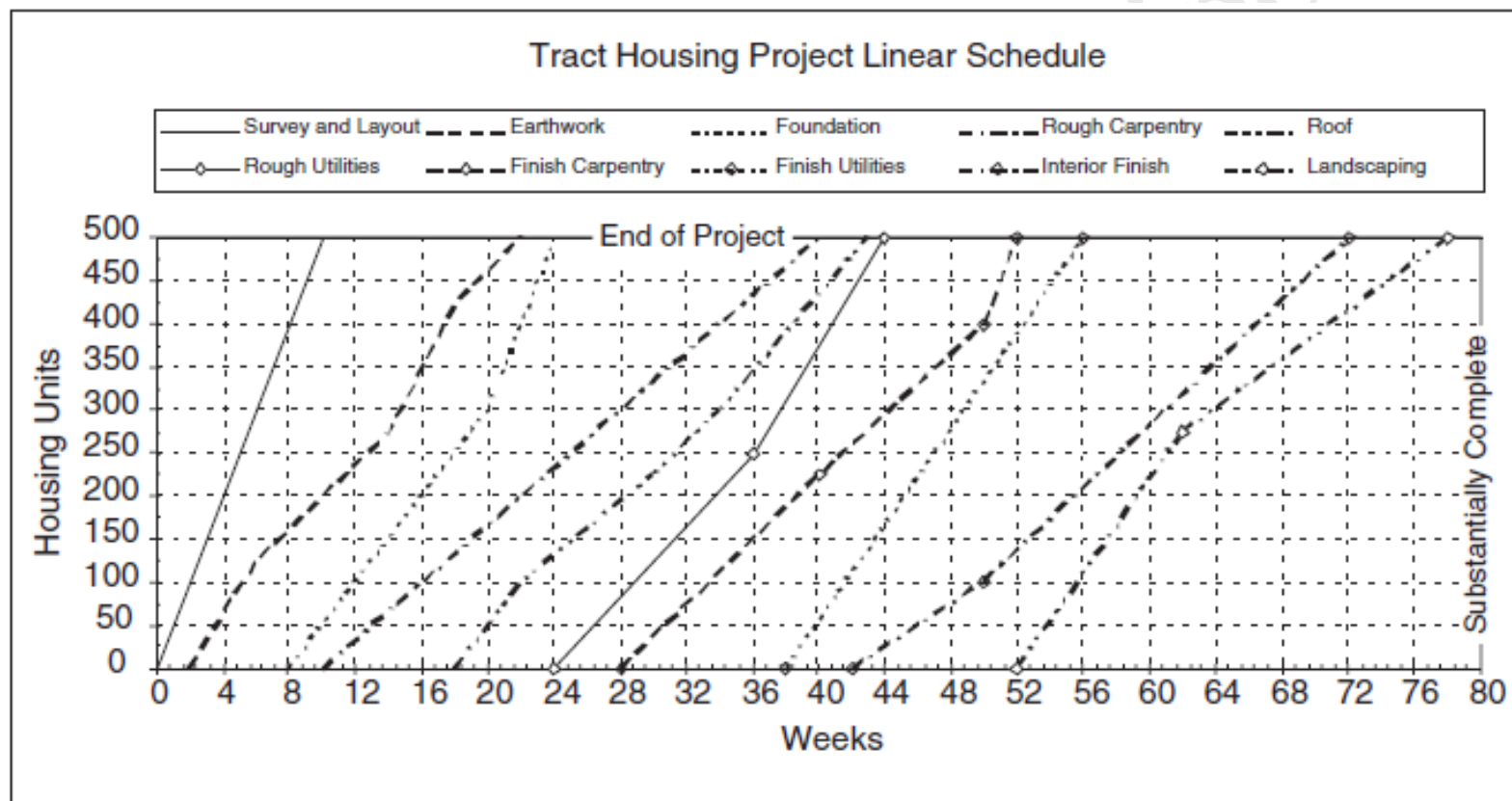
❑ Non-constant productivity



Construction phase – Disadvantages of linear schedule

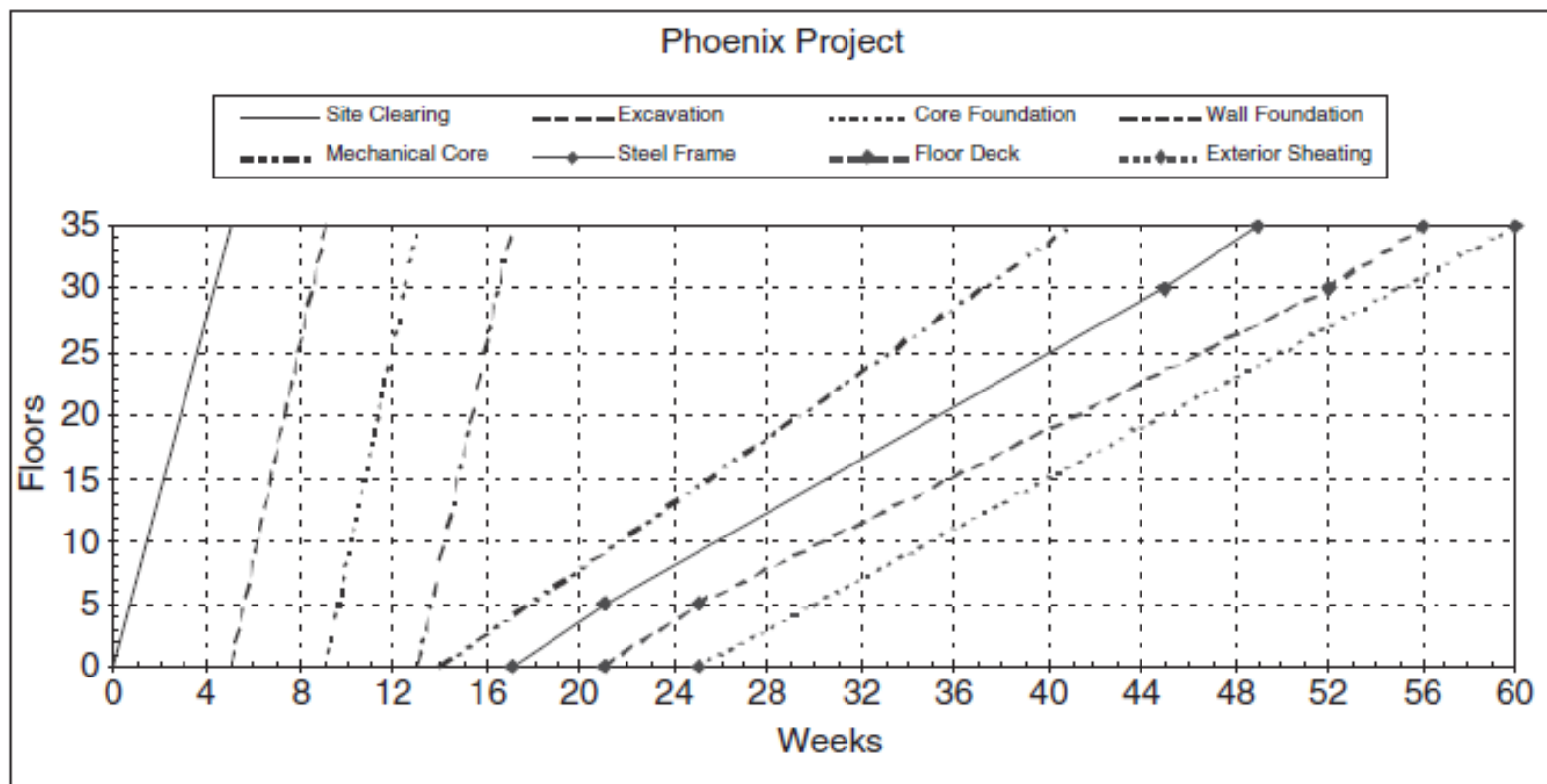
- ❑ **Where is the critical path in the linear schedule?** This is **not an easy question** to answer.
 1. The linear schedule itself **does not identify the critical activities**.
 2. **Most** of the activities will be **critical**.
 3. The **activity** that is **critical** is the one that has the **lowest slope**.
 4. Better to think of **increasing the productivity** in order to **reduce the project duration**.
- ❑ The **inability** of the linear scheduling method to **identify the Project's critical path** is **because**:
 - The schedule **activities** are **not linked to one another**, and thus
 - ➡ The schedule **cannot accurately correlate delays** to the **completion** of the project
 - ➡ One of the **major reasons** that **many owners and contractors** have chosen the **CPM scheduling technique** over the linear scheduling methods is this.
- ❑ Fail to show **relationships** among **activities**
- ❑ Fail to consider **resource requirements** and **constraints**.

Construction phase – Linear schedule (example)



Tract Housing Project Linear Schedule.

Construction phase – Linear schedule (example)



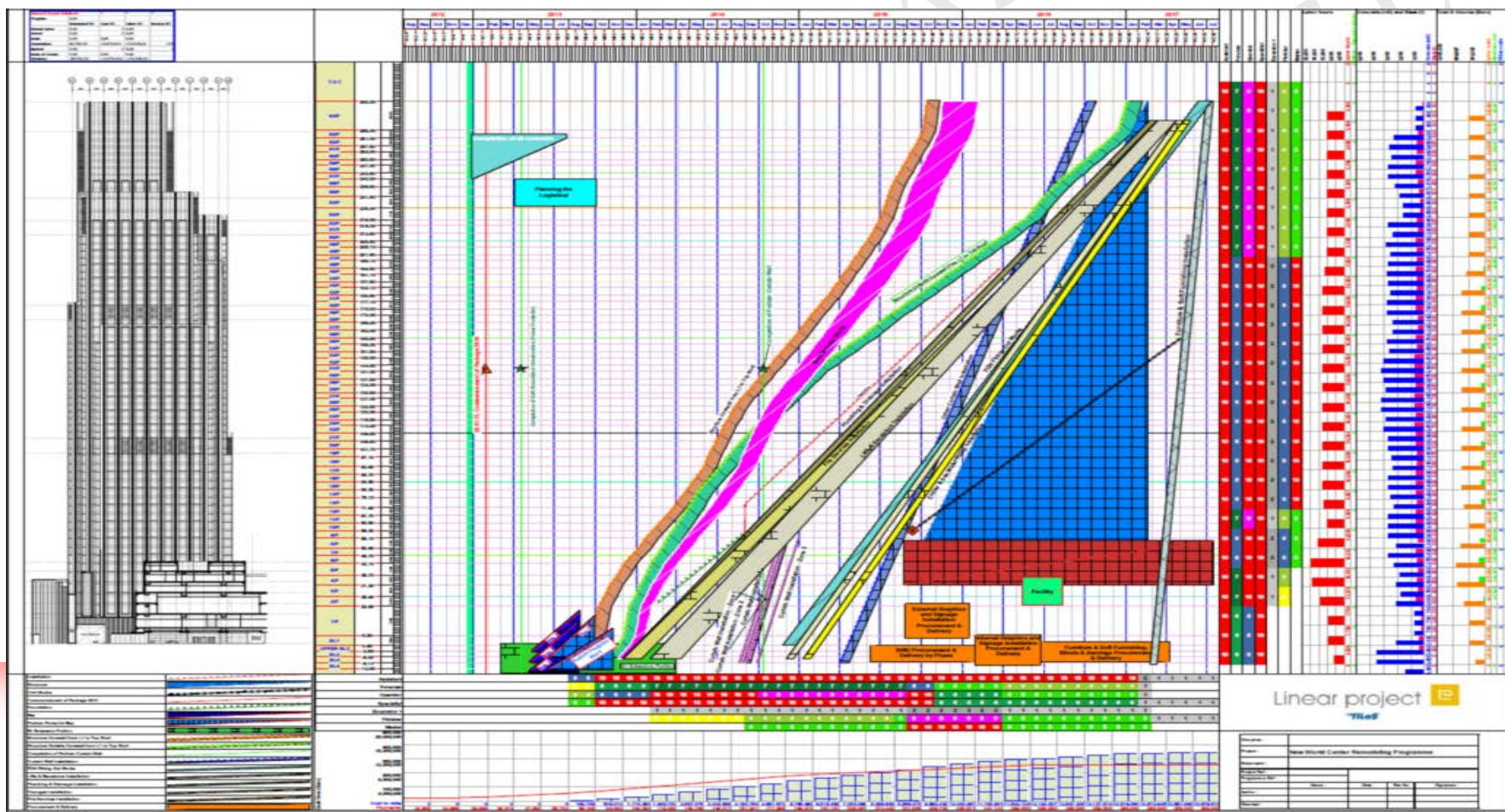
Linear Schedule for a High-Rise Building.

Construction phase – Linear schedule

- ❑ **TRIMBLE TILOS** is the Globe's Premier Linear Scheduling Software and is trusted by **4 out of 5 of leading international linear infrastructure construction companies.**

❖ <https://tilosamericas.com/try-tilos-free/>

- ❑ You can **Import** data from **Primavera P6** professional (P6) into **TILOS**



Construction phase – Linear schedule

Read an article

Line of Balance Planning Technique for more info

Construction phase – Critical path method (CPM)

- ❑ The CPM schedule **links work activities** to one another according to **planned sequence**.
- ❑ The linking or **interdependency** of the **work items** is a **major strength of CPM** because:
 - ➡ It **enables the identification** of the **critical path**
 - ➡ The critical path predicts the earliest date that the Project can be completed

Construction phase – Critical path method (CPM)

ISSUES WITH CPM

- ☐ Very convoluted in assessing the start-to-start and finish-to-finish relationships.
- ☐ Unlimited resources
- ☐ No consideration of financial constraints
- ☐ No time-cost tradeoff
- ☐ Deterministic model
- ☐ Misuse of float
- ☐ Activity completion gain/loss
 - ❖ **Even** if an activity is **completed before its planned completion date**, the **time gain cannot** be utilized by **the next activity**, **because** the **next activity** has to **wait** until its **early start date**.
 - ✓ However, the **opposite is not true**. If any **previous activity is delayed**, delay will be passed to the **next activity**, and this **may** cause a **delay in the project**.
- ☐ Student syndrome
 - ❖ Team members **do not start** the task **until** the **last moment**.

Construction phase – Critical chain method (CCM)

❑ CCM developed by **Eliyahu M. Goldratt in 1997**. Difference with CPM?

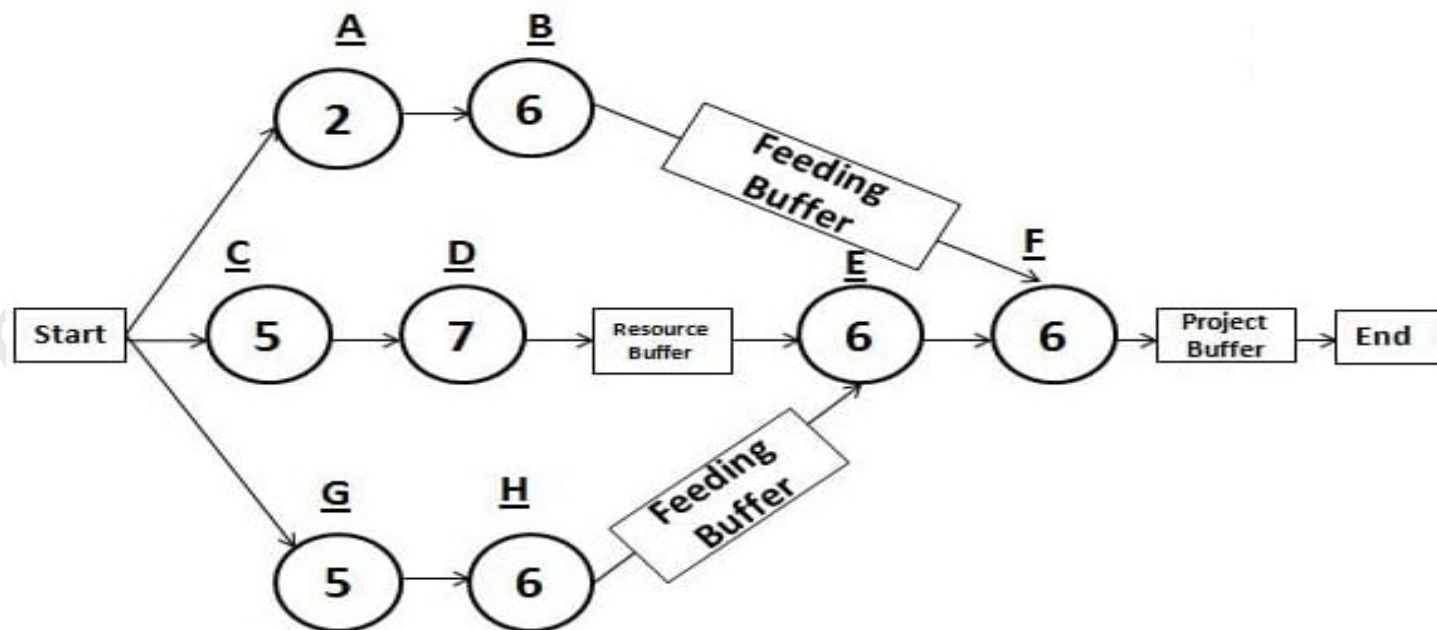
❖ **Availability of resources** are considered.

❖ **Buffers** are used instead of **float** to **eliminate** the concept of **float**.

1. **Project buffer (act as a contingency)**

➡ Gain or loss to project === delay eat buffers and early finish add to this buffer

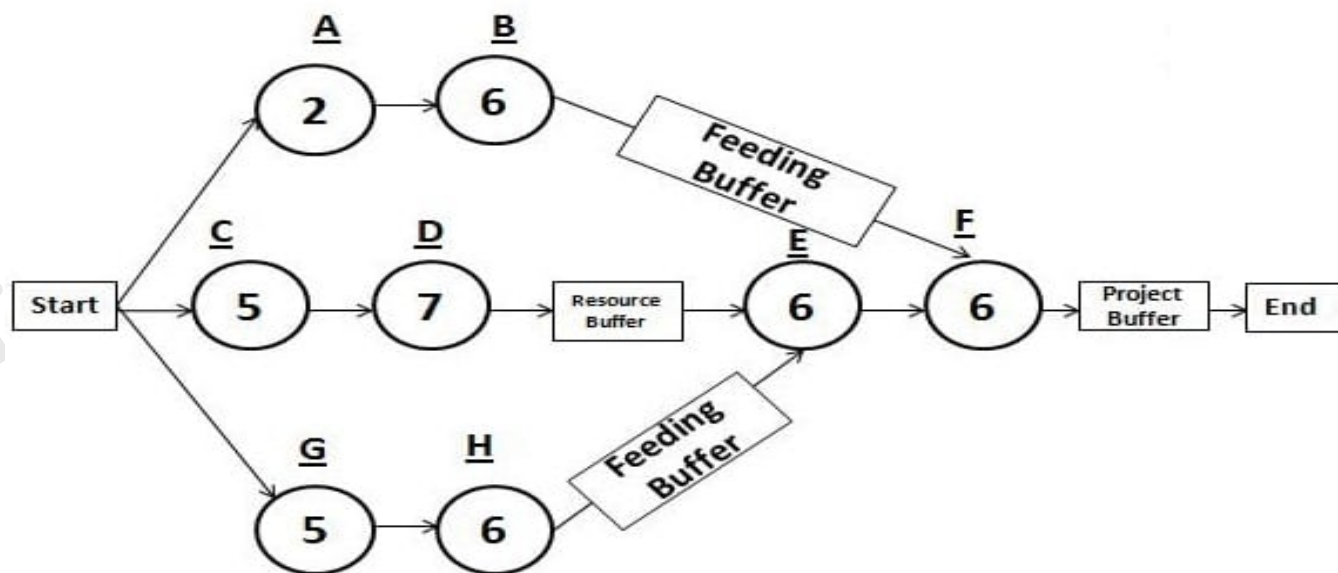
✓ This helps to **move uncertainty** from **each task** to the **project buffer**.



Construction phase – Critical chain method (CCM)

2. Feeding buffers (added to non-critical chain)

- ❖ Between the **last task** on a **non-critical chain** and the **critical chain**
- ❖ **Feeding buffers** and the **project buffer** are calculated the **same way**.
- ❖ The **duration** of these buffers is based on some **fraction** of the **safety removed** from the **tasks on non-critical chains**.

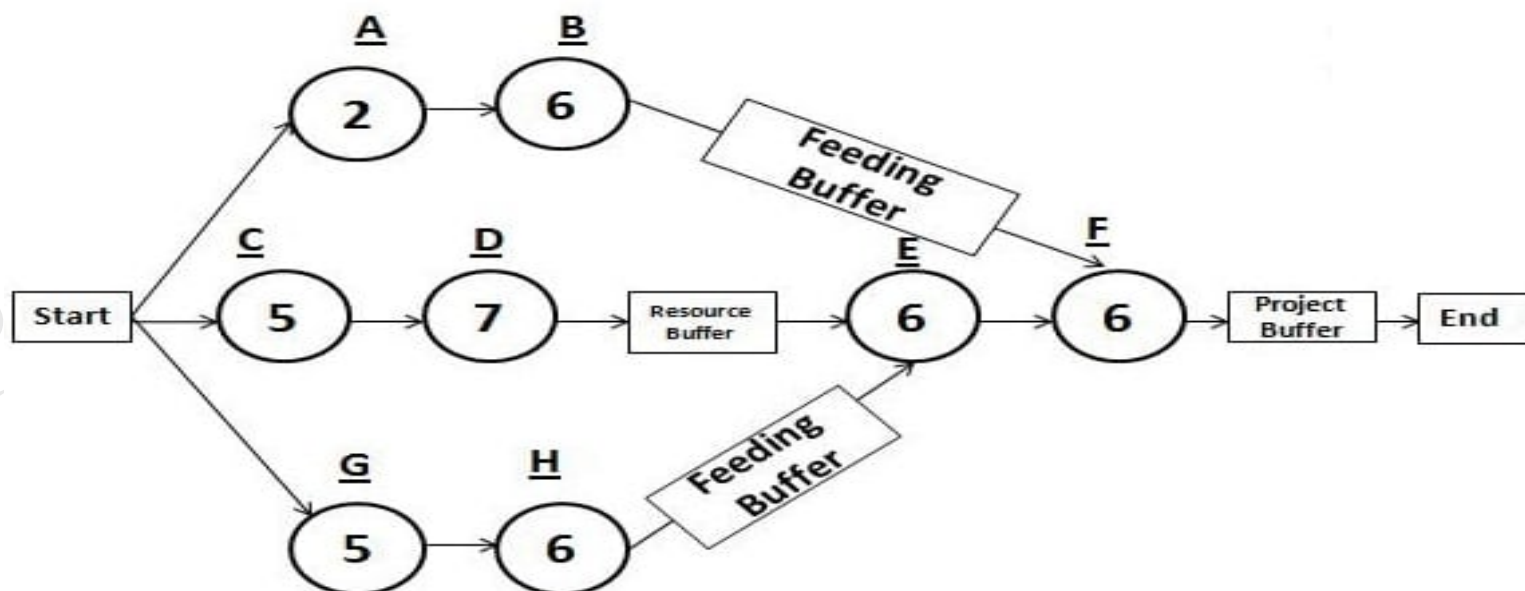


Construction phase – Critical chain method (CCM)

3. Resource buffer

- ❑ Are kept **alongside** the **critical chain**
- ❑ Known as **critical resources** (can be human resource or equipment)

➡ Since the critical chain **considers** the **resource constraints** as well, it **may be longer** than the schedule **based on the critical path**.



Construction phase – Critical chain method (CCM)

❑ The following are a **few differences** between the **float** and **buffer**:

- ❖ **Float** is a **critical path phenomenon**, while **buffer** belongs to the **critical chain**.
- ❖ A **float** is a **difference** between the **duration of the critical path** and the **non-critical path** while a **buffer** is based on **contingencies**.
 - ✓ For example, the **project buffer** is about **50% of the safety time** that you have **removed from the activity estimate duration**. Based on the definition of buffer, it is **not zero** on a **critical chain** or any **other chain**.
- ❖ Buffer can be divided into **three categories**: project buffer, feeding buffer and resource buffer. Float can be either **total float** or **free float**.



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Construction phase – Critical chain method (CCM)

❑ <https://aurora-ccpm.com/#ccpm>

Benefits and Features

By combining Critical Chain Project Management with Aurora's powerful and sophisticated scheduling technology, Aurora-CCPM provides many benefits:



Critical Chain provides superior on-time performance. Aurora's intelligent scheduling provides the shortest Critical Chain

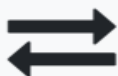
Result: faster throughput



More flexibility and an improved ability to accommodate change that is, disruptions to the original plan including interjections of new tasks during execution.



Fast scheduling, even though Aurora-CCPM creates the most efficient schedules, they are calculated fast. This also permits many what-ifs can be performed rapidly.



Interfaces with Primavera P6, Microsoft Project, Siemens TeamCenter, Artemis, PSS, Open Plan, PS8, Oracle and other enterprise applications; to import, analyze, and export schedules.



Provides intelligent conflict resolution. Helping users to find options for resolving conflicts faster. Click on conflict reports to be taken directly to conflict in the network.



Aurora-CCPM provides enterprise solutions not otherwise available, including support for any time durations for tasks, minutes, hours, days; and support for large projects and any number of large projects.



One global priority system: everyone understands what is most important to the organization.



Provides explanations on why each activity/task was scheduled where it was, improving transparency and provide more insight in how schedule could be further improved.



Aurora-CCPM drives bottom line results, the increased throughput accelerates profit

Construction Phase – Types of construction schedule related to the progress

1. Baseline or As-planned schedule

2. Schedule update

❖ Reschedule

3. Schedule revision

1. Replan

2. Recovery

3. Mitigation

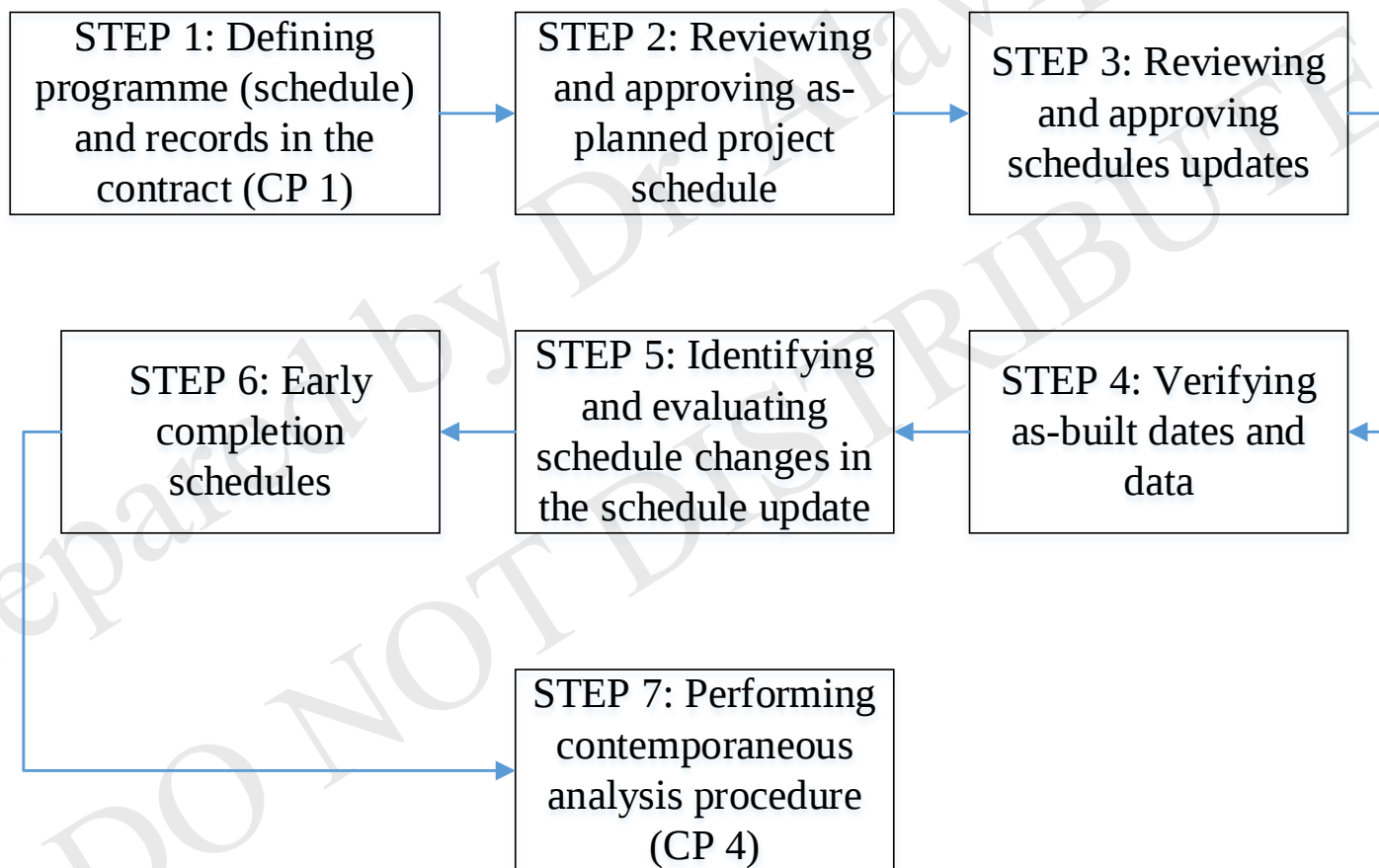
Which one is identical with Catchup plan?

4. As-built schedule

Schedule and Records in Contract

Contemporaneous analysis procedure

❑ The following Steps needed to be taken for contemporaneous analysis:



STEP 1: Defining programme (schedule) and records in the contract (CP 1)

We will talk about records in Delay Analysis and Documentation Courses!
Now, we want to talk more about the first category, programme in this course

This part has mostly extracted from **SCL Protocol.**

<https://dralavipour.com/blog/view/SCL-translation>

STEP 1: Defining programme (schedule) and records in the contract (CP 1) – Programme

- ❑ The **form** and **software** for the **programme** should be specified in the **tender documents** and the **contract**.
- ❑ As **early as possible**, the **contractor** should **submit** and the CA (AE/reviewer) should **accept** a programme or ask for **revision**.
- ❑ **Most standard forms of contract** contain **inadequate requirements** for **generating accepted (as-planned)/updated programme**.
- ❑ It is **highly recommended** to reach a **clear** and **documented agreement** on the requirements.
 - ❖ This is called **scheduling specifications**

What is the purpose of **scheduling specs**?

STEP 1: Defining programme (schedule) and records in the contract (CP 1) – Programme

- ❑ The **purpose** of **specification requirements** is to ensure
 1. Uniformity and accuracy
 2. Proper accounting for progress
 3. Sufficient detailing of the scope of work
 4. Ways to communicate the schedule to the stakeholders
 5. Ability to account for change and impacts to the project to the satisfaction of all parties concerned

Read this article

<https://dralavipour.com/blog/view/Schedule-specs>

You will learn more and see the samples of schedule specs in **CONTRACT MANAGEMENT COURSE**

However, let's see some important points mentioned in SCL Protocol!

STEP 1: Defining programme (schedule) and records in the contract (CP 1) – Programme

❑ The **agreement** should **cover** the **following matters** and be **documented** in the **contract**:

1. **Form** of the **contractor's** proposed programme
2. **Detail** within the **proposed programme**
3. **Interaction** with **method statements**
4. **Time** within which to **submit a proposed programme** for acceptance
5. **Mechanism** for obtaining the **CA's (AE or reviewer) acceptance** of the proposed programme
6. **Requirements** for **updating** and **saving** the **as-planned (accepted)/updated programme**

STEP 1: Defining programme (schedule) and records in the contract (CP 1) – Programme

1. Form of the contractor's proposed programme

- ☐ Usually **CPM** is used
- ☐ The **complexity** should be **proportionate** to the **project**
- ☐ Both the **contractor** and the **CA (AE or reviewer)** should have a **copy** of the **programme**
- ☐ The **contractor's proposed programme** should be provided in **its native electronic form** (**not just as a PDF**)

Which matters should be included in the contract?

See next slides!

شرایط عمومی پیمان – نشریه ۴۳۱۱ و حتی قراردادهای EPC در اینباره
عموما سکوت کرده است!

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