استراتژی پیاده‌سازی سیستم کنترل پروژه

برنامه‌ریزی + اجرا + اندازه‌گیری + ارزیابی

(بر اساس اسنادی از AACE و CII)

ارائه دهنده:

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What we will learn?

AACE and CII DOCUMENTS

Comprehensive Guideline

- Introduction
  - Purpose
  - Background
  - Using the project controls plan with a phased project process
  - Continuous improvement during the project life cycle
- Recommended practice
- The body of the project controls plan
  1. Project Controls Plan General Requirements
  2. Functional Applications of Project Controls (as per TCM Framework)
  3. Systems and Data Integrity Plan
  4. Communications Plan
  5. Project Controls Deliverables
  6. Project Controls Plan Implementation
- Supporting information for development and implementation

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What we will learn?

CII DOCUMENT

Model planning and controlling system for EPC of industrial projects

- Introduction
- Phases and their characteristics
  - Characteristics of the Conceptual Engineering Phase
  - Characteristics of the Detailed Engineering Phase
  - Characteristics of the Procurement Phase
  - Characteristics of the Construction Phase
  - Characteristics of the Start-Up Phase
- The control structure
  - The schedule
  - The budget
  - Breakdown structures
  - reporting

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What we will learn?

CII DOCUMENT

Model planning and controlling system for EPC of industrial projects

- Project control within phases
  - Approach
  - Start-Up Control
  - Construction Control
  - Procurement control
  - Detailed engineering control
  - Conceptual control
  - General logic diagram

Background

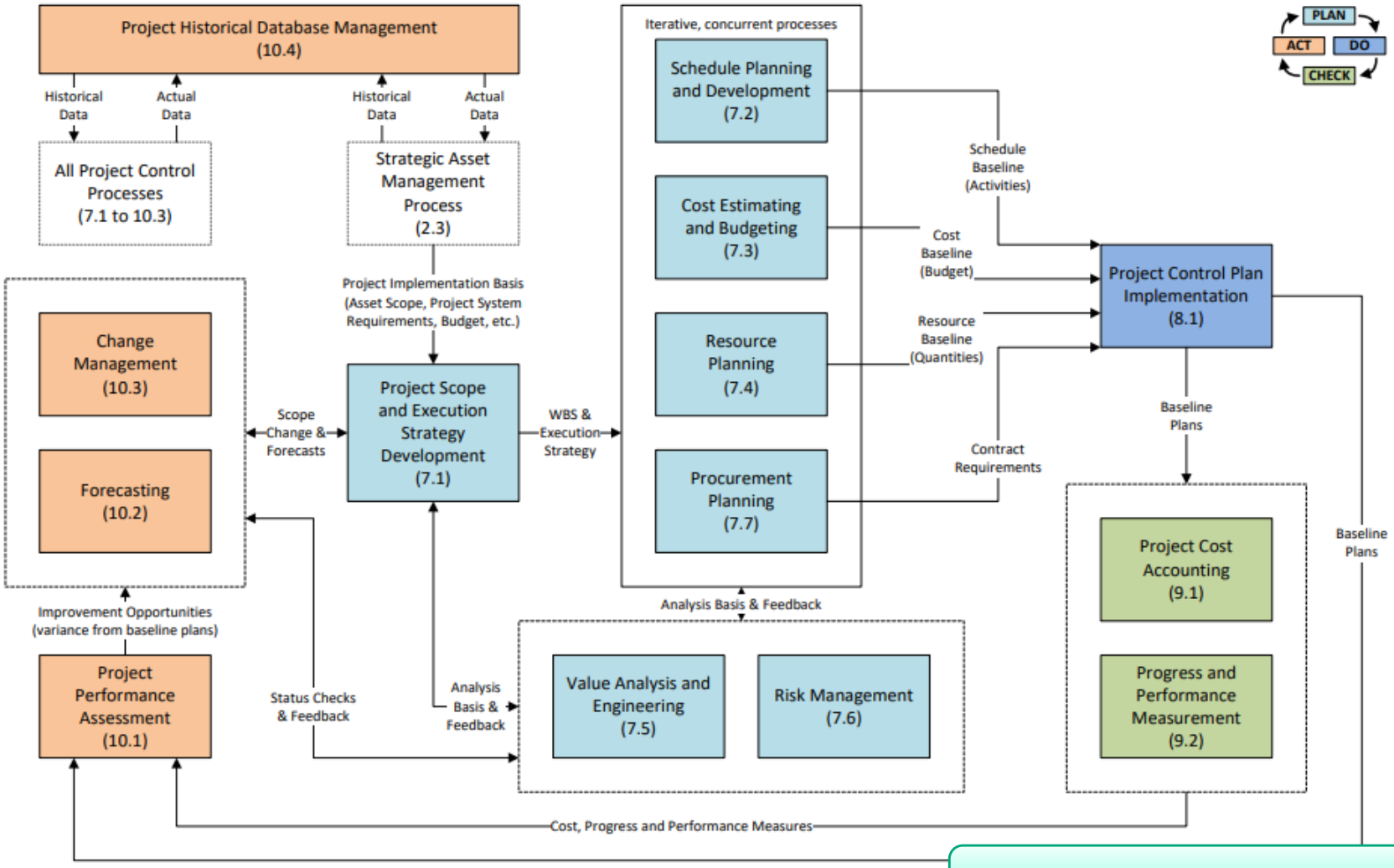

Figure 1 – Project Controls Process - *Total Cost Management Framework*

How this RP helps experts?

The Body of the Project Controls Plan

(3. Systems and Data Integrity Plan)

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Systems

- **This section** of the project controls plan should
  1. **Address how** project information will be collected and processed,
  2. **Identify** the systems interface requirements based on the **organization**, or within the **alliance** or **joint venture**.

What should be described in this section?

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Systems

- The plan will **describe** how information will be **transferred** between the systems in order to **expedite** the data mining process for
  1. Increased usability and
  2. Data integrity.
- The project controls plan should also **describe** the systems to be used during development, execution and closeout of the project.

What else?

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Systems

- The **expectation** that the process of how information flows should still be **represented** in the project controls plan.
- The plan should include **how information** will be mapped throughout
  - Systems,
  - Data collection cut off times
  - Synchronization times.

- The **following diagram** is an **example of how systems** will integrate with other systems.

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Systems

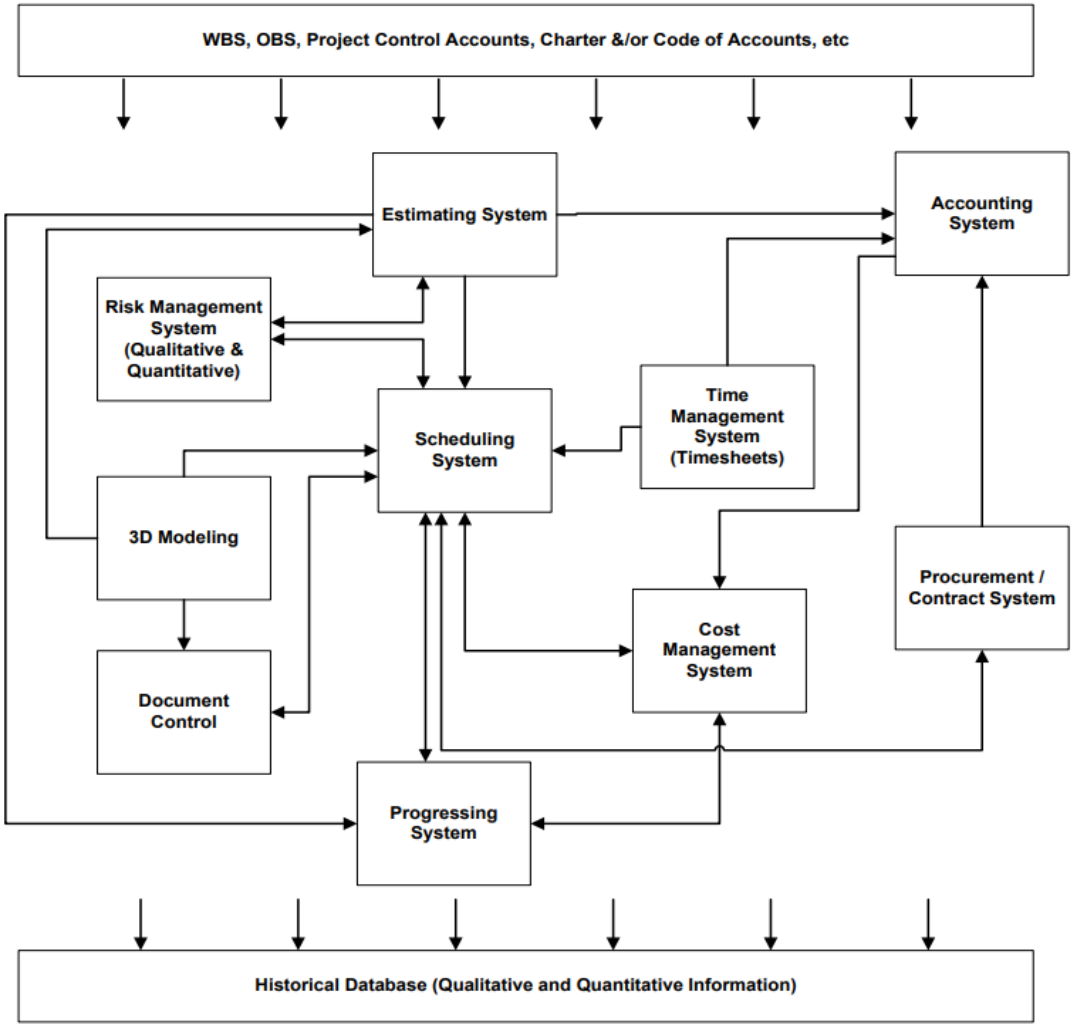

Figure 2 – Example of Project Controls Systems Integration

What coding structures support transferring project data?

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Systems

- The following **identifies** some of the types of coding structures that support the **transfer of project data**:
  - Work breakdown structure (WBS)
  - Organization breakdown structure (OBS)
  - Cost breakdown structure (CBS)
  - Schedule of pay value (SOPV) structure
  - Project control accounts
  - Code or chart of accounts
  - Resource classifications
  - Accounting code structures
  - Balance sheet
  - General ledger
  - Taxation and depreciation
  - Cost classifications,
  - Cost types

What if the coding structures are different?

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Systems

- **Prior to the start of the project**, and

  depending on the **use of the coding structures**,

  the project team should construct a mapping index

  that **identifies** the **relationships** between coding requirements

  in reference to the **systems and their requirements**.

- The project team should provide the system architectural criteria and the validity of the match information (in comparison to all structures).

- The plan should also include

  who will have access and **security rights** to certain systems

  within the project environment.

What common types of users?

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Systems

- The following identifies some of the **types of users** that may be assigned to or support the project:
  - Administrators
  - Super-users
  - Read / write access
  - Read access only

What information should be used to define these users?

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- The project team may want to use the OBS (organization breakdown structure) or RACI (responsible, accountable, consulted and informed) chart

  to **determine** who can have access to certain project areas,

  whether they are **geographical or functional**.

Could we change coding structures that identified?

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Systems

- Please note: Due to **effort required** for setting up the project systems, it is **imperative** that the coding structures identified for use are **approved and "frozen"** (not to be changed under any circumstances).

Why frozen?

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Systems

- **Most financial systems** are transaction based, and therefore, depending on the **size of the project**, thousands of records can be produced in a **single day**.

What if the change is unavoidable?

ACEMI **Systems**

- If the **coding structure** were to **change after** the project has started,

  the **past records** (and budgets, mapping, etc.) would be required to be corrected and updated.

Do we need a backup?

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Data integrity and backup

- In order to ensure a **robust** system, as well as **reliable**, **secure** and **efficient** information,

  the project team should develop a **plan** that **identifies the responsibility** of

  1. Who is backing up information,
  2. What information is being backed up,
  3. Frequency, and the storage requirements.

  As part of data **integrity**, the project team should define **how information** will be shared between users.

What we need for that?

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Data integrity and backup

- As part of data **integrity**, the project team should define **how information** will be shared between users.

- This will include a connectivity plan for computer connectivity.
  - The connectivity plan will **communicate how information** will be **shared**,
    1. Whether a server is placed on site for network purposes,
    2. Stand alone computers are used, or
    3. Satellite and fiber optics are used.

What about file transferring?

Electronic file transfer

- Electronic file transfer is the **transmitting** of files over a
  1. Computer network or
  2. Internet.

- There are numerous **ways and protocols** to transfer files over a network.
  - Therefore, the project controls plan should **communicate how electronic** file transfers will be executed.
  - The electronic file transfer **protocol** of the project controls plan will **describe** the **convention of how** to transfer files between **two computing endpoints**.

The Body of the Project Controls Plan

(4. Communications Plan)

Introduction

- The **purpose** of the communication plan is to

  provide the project team with an **understanding** as to the methods and protocols required for conducting communications for

  1. Development,
  2. Publishing,
  3. Reviewing and
  4. Approval

  of project information between project team members and the project stakeholders.

The following information should also be **included as part** of the project controls plan.

Meeting requirements

- The **purpose** of the project meetings table is to

  provide the project team with the **understanding** of meeting requirements to manage the project.

  - An example of **meetings** and **frequency** is presented in the following table.

- The organization may include more reporting requirements and frequencies based on the needs of the stakeholders of the project.

Meeting requirements

Method	*Frequency*
Project team meetings	As required, based on project milestones (at least monthly)
Technical steering team meeting	As required to support project milestones
Individual status report	Weekly
Weekly project status report	Weekly
Weekly change management meeting	Weekly
Monthly project status report	Monthly
Monthly performance update meeting	Monthly
Monthly stewardship and financial update meeting	Monthly

Table 1 – Example of Meetings and Frequency

What information reporting section defines?

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Reporting and frequencies

- The project reporting section **defines**
  - Scope,
  - Format,
  - Content and
  - Responsibilities

    for

    - Preparation,
    - Submittal and approval

      on the **project reports**.

What else?

Reporting and frequencies

- This section will also include the required information necessary to **provide management**

with a period-specific evaluation and consistent measurement of

the plan versus actual and forecast values in terms of

- Overall cost expenditures,
- Performance and schedule progress, etc.

What should be identified by reporting deliverables?

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Reporting and frequencies

- A list of all **project reporting deliverables** which identifies the
  1. Frequency, and
  2. Who the report is distributed to

  should be **attached** to the project controls plan.

Do we need file index structure?

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File structures

- The **purpose** of the file index structure section is to provide the project team with a **repository** for **storing information**.

- The project team should fully understand how documents are stored, whether this is a paper copy, or an electronic copy.

- Therefore, the **file index** should include a dictionary that explains what information is stored where.

The Body of the Project Controls Plan

(5. Project Controls Deliverables)

Project controls deliverables

Area	Deliverable
Project controls pre-planning and preparedness	Project controls service agreement (as per functional specifications and client expectations)
	Project controls preparedness index
	Project controls kick-off meeting
Project controls	Delegation of authority log
	Audit calendar
	Project control organization
	Roles and responsibilities
	RACI chart
Coding structures	WBS
	OBS
	CBS
	Code of accounts
	Client / 3rd party codes

Project controls deliverables

Estimate and budgets	Estimate
	Estimate basis document
	Estimate risk report, log
	Estimate validation report
	Budget
	Contingency report (drawdown)
	Cash flow
	Cost report by area, function, classification, estimate hierarchy, etc.
	Forecast reports
Schedule	Schedule
	Schedule basis document
	VIP schedule (when VIP's will be introduced)
	Schedule risk report, log
	Schedule validation report
	Schedule reserve report
	Forecast schedules
Risk management	Risk log
	Risk forms
Change management	Change log
	Change forms
Graphical reports	Commodity reports
	Resource histogram
	Equipment plan (timescale)
	Indirect and staffing plan (timescale)
Others Communications	Subcontract report
	Meeting requirements list
	Reporting matrix
	File structure
	Project calendar
Systems	Mapping index
	Data synchronization schedule
	Backup log
	Access and security log

Table 2 – Example of Deliverables that Support Delivery of a Project

The Body of the Project Controls Plan

(6. Project Controls Plan Implementation)

Project controls plan implementation

- As defined in the **TCM Framework**, the project control plan implementation is
  1. **Process** of integrating all aspects of the project control plan;
  2. **Validating** that the **plans** are comprehensive and consistent with requirements and ready for control;
  3. **Initiating** mechanisms or systems for project control; and
  4. **Communicating** the integrated project control plan to those **responsible** for the project's work packages.

The following diagram represents the project controls plan implementation process of the Total Cost Management Framework:

Project controls process

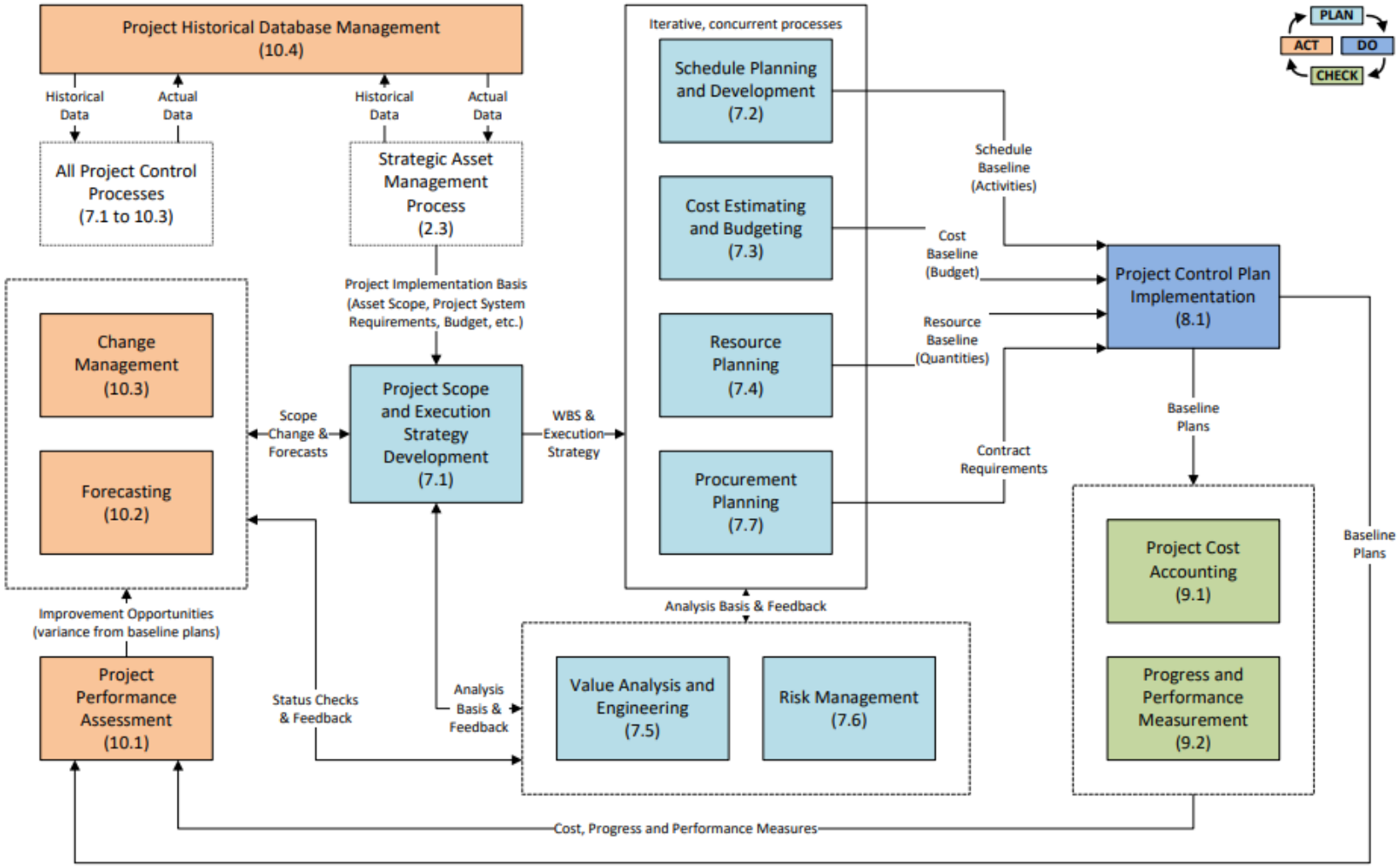

Figure 1 – Project Controls Process - *Total Cost Management Framework*

Project controls plan implementation

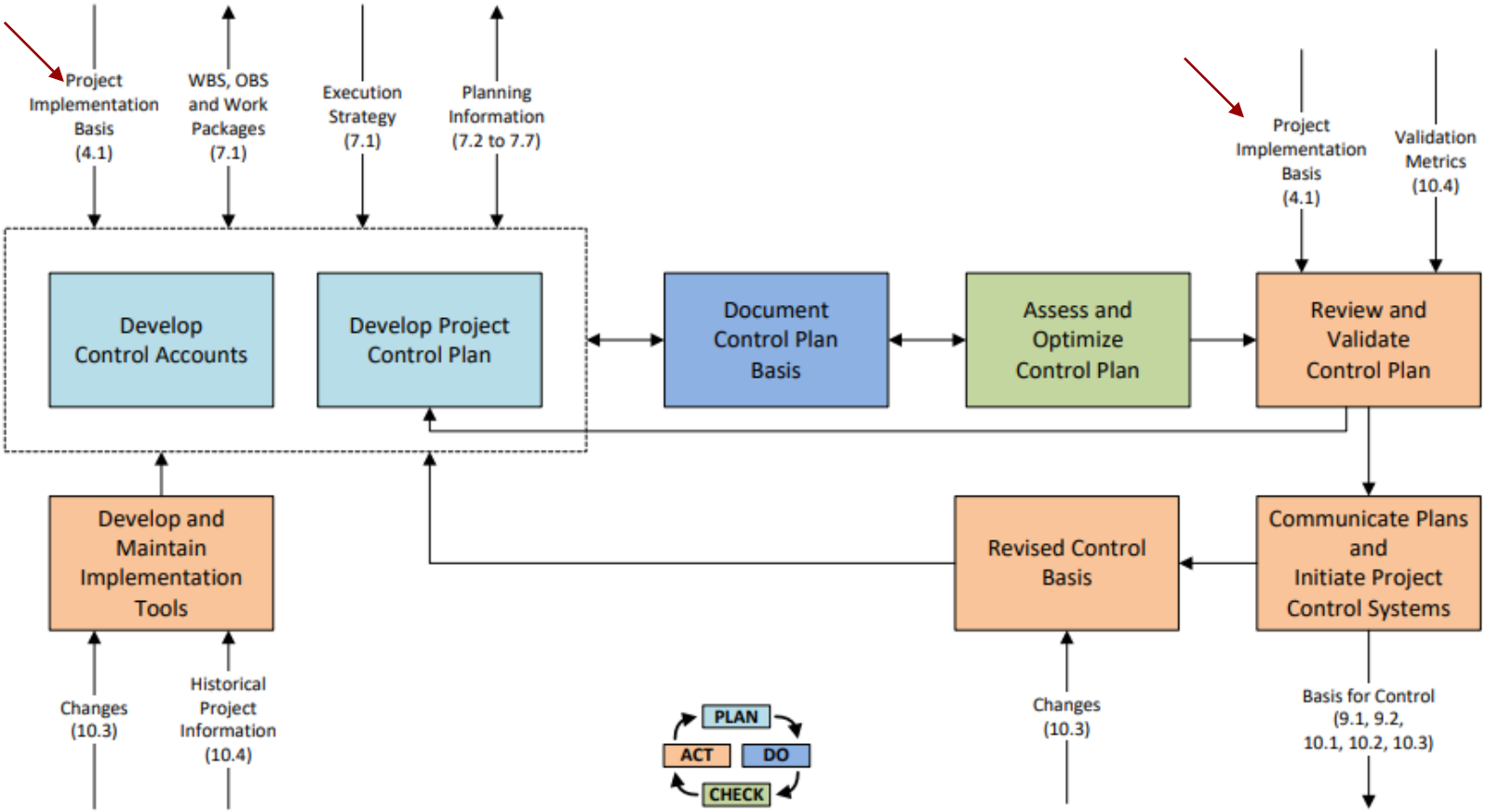

Figure 3 – Process Map for Project Control Plan Implementation

Review and validate

- The project controls plan, control accounts, and documentation should be reviewed and validated by the project team to **determine** whether the project controls plan, control accounts, and documentation provide the **required information** and is suitable as a **manageable basis** for control.
- The documentation should also be **reviewed and validated** to ensure that they meet project objectives and requirements, and whether they are **competitive** with industry best practices and historical approaches.
- The project team may want to introduce a readiness checklist to s**upport the implementation** of the project controls plan.

What should be done at the conclusion of this process?

Communicating the project controls plan

- At the **conclusion** of project controls plan **implementation**,
  1. The project controls plan will have been documented and communicated to the project team,
  2. Those **responsible** for work packages will understand their **control responsibilities** and their **control accounts**, and
  3. Project controls systems and tools will be set up and ready to support
     i. Project controls measurement,
     ii. Performance assessment,
     iii. Forecasting, and
     iv. Change management processes.

What is the role of training?

Training

- The project controls plan should also provide an **understanding** of the training requirements for the project team and stakeholders.

- This training would include:
  - Implementation of the project controls plan
  - Deliverables; set up; maintenance and use
  - Systems; set up; maintenance and use
  - Others

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Training

- The training plan should **identify**
  1. Project teams training goals, and
  2. Expected topics and skills one would expect from the training.

- Finally, the **training plan** should **identify** the timelines of when personnel would be trained.

Who should audit?

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Audits

- Once the project controls plan has been **approved**,

  it is recommended that a **separate entity audit** the project team

  to ensure compliance of the project controls plan throughout the delivery of the project.

- If **items** within the project controls plan are **no longer warranted**,

  then the project **controls plan** will need to be updated and redistribute.

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Audits

- A **list identifying who** will be performing the audit and the frequency at which the audit(s)

  will take place should be **attached** as part of the deliverables for the project controls plan.

- The audits will provide **valuable information** as to
  - What is working well,
  - What isn't working well,
  - What needs to be changed and
  - What needs to be deleted.

What else the audits should provide?

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Audits

- The audits should also provide
  1. An **understanding** as to **compliance**, and
  2. The **reasons for non** compliance, such as:
     - **i. Process Design** – Is there a flaw in the project controls plan, implementation or monitoring?
     - **ii. Resource Constraint** – Is there a lack of resources to complete the deliverables as identified by the project controls plan?
     - **iii. Training Requirements** – Is there sufficient skill, training, or knowledge to ensure compliance?
     - **iv. Process Discipline** – Is the project team displaying proper process discipline to carry out the deliverables as identified by the project controls plan?

Supporting information for development and implementation

List of procedures

- The following is a list of procedures that may be developed to support the use and implementation of the project controls plan:

- Team development procedure
- WBS development procedure
- Project control account development procedure
- Estimate and budget development procedure
- Schedule development and management procedure
- Cost management procedure
- Change management procedure
- Progress measurement procedure
- Performance assessment procedure
- Forecasting procedure
- Purchasing / contract administration procedure
- Glossary of terms, acronyms and formulas
- Risk management procedure
- Value improving practices (VIP) procedure
- Accounting and invoicing procedure
- Financial stewardship procedure
- Contingency management procedure
- Claims and dispute resolution procedure
- Project closeout procedure
- Historical data collection and benchmarking procedure
- Communication procedure
- Systems integration procedure
- Audit / compliance procedure

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Model Planning and Controlling System for EPC of Industrial Projects

(Introduction)

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Introduction

- The **purpose of this document** is to describe a planning and controlling system for the **EPC of an industrial project**.

- An **industrial project** is utilized as the model due to its complexity, yet most of the principles and techniques described are **applicable to other types of construction**.

- Also, this model is **idealized** based on the philosophies listed below, and as such should be looked upon as an objective.

What philosophies?

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Introduction

- The system to be described is based on these **philosophies and conditions**:
  - The **starting point** for planning is the owner's need date for the facility.
  - **Planning** proceeds in reverse order fashion **from this key milestone date** and is **not complete until** all phases have been adequately addressed.
  - **Scope** can be adequately defined early in the project.
  - A **control base** estimate and schedule can be established early in the project.
  - Detailed engineering work packages required for **field construction** must be **configured** to
    1. **Satisfy** the contracting strategy, and
    2. Be of a **completeness** and **quality** that could permit construction to be handled on a multiple, fixed-price contract basis (although other contract forms may be employed).

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Introduction

- The system to be described is based on these **philosophies and conditions**:
  - **Procurement activity** must be planned to satisfy both engineering and construction need **dates**;
  - **Engineering activity** must be planned to satisfy both procurement and construction need **dates**.
  - A **team atmosphere** must be established among project participants to assure complete and effective **communication** and **coordination** over the project's life.
  - A **computerized control system** which effectively integrates or interrelates the many component project functions and provides the managers with **timely information** needed

    for forecasting and responsive control must be available and used.

What are the basic requirements?

Introduction

- In presenting this system,
  1. EPC project phases and their included activities will be **described first**.
  2. Next, the **details** of the overall control structure will be presented.
  3. Finally, the **control methods** appropriate for each phase will be derived.

Model Planning and Controlling System for EPC of Industrial Projects

(Phases and Their Characteristics)

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The phases of EPC

- The **life cycle** of an industrial facility encompasses the **total time** between
  1. **Identification** of a requirement for the facility through
  2. Its **final demobilization**.

- **This report** is concerned with that **portion of the life cycle** between
  1. Time an **authorization** is given to **proceed with engineering** until
  2. The **facility** is complete and operational.

What phases?

The phases of EPC

- Within this time period are five phases:
  - Conceptual Engineering
  - Detailed Engineering
  - Procurement
  - Construction
  - Start-Up

The phases of EPC

- As stated previously, the usual choice is to **overlap** these phases to bring a facility on line as **quickly as possible** to meet a market need.

- **Overlapping** also **reduces** the time-value-of-money costs associated with investments that are not yet productive.

- **Figure 1** is a representation of this project format.

The phases of EPC

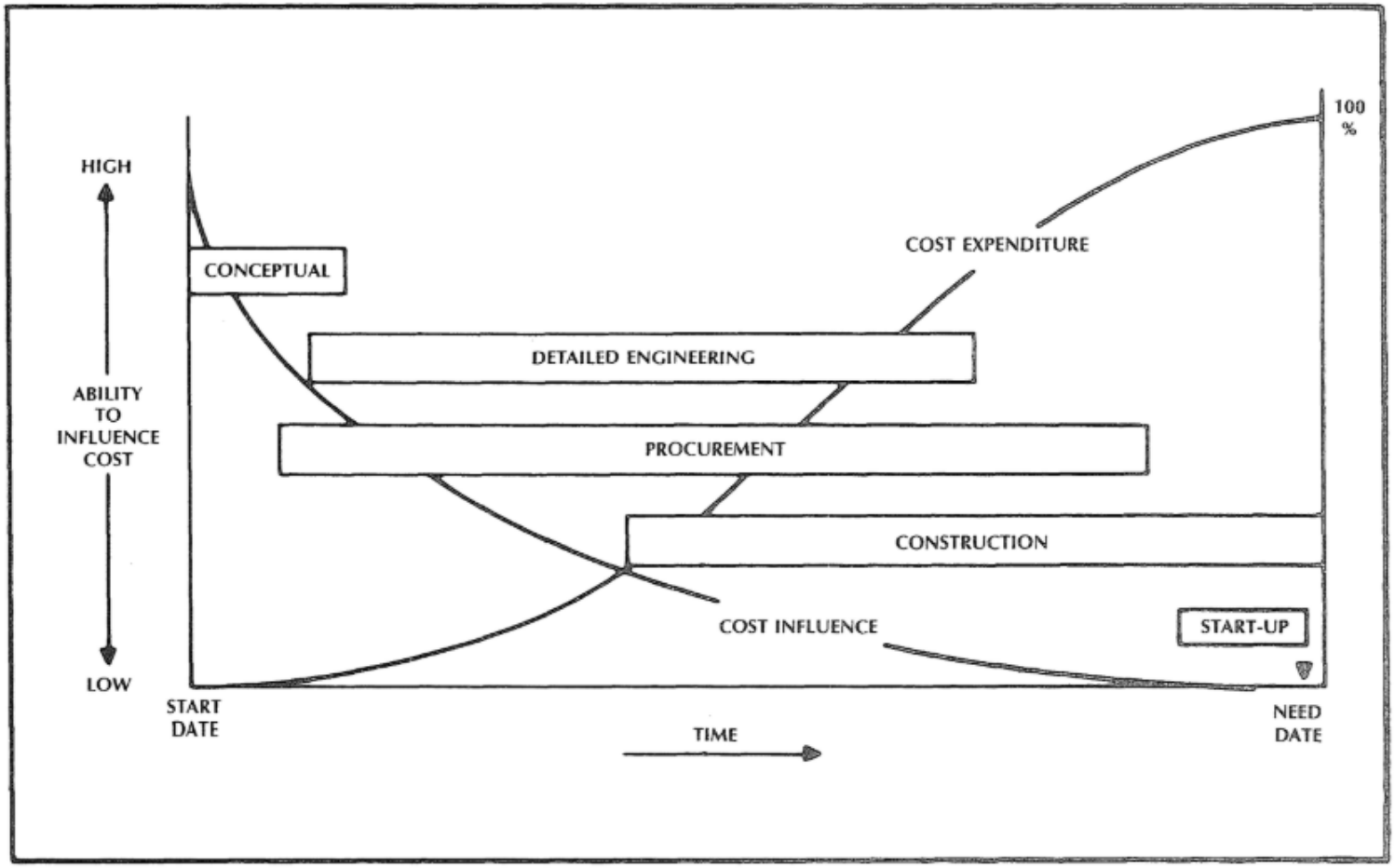

Figure 1. Ability To Influence Final Cost Over Project Life

Characteristics of the conceptual engineering phase

- A **major objective** of this phase is to

  achieve a **firm** definition of project scope to

  minimize changes during detailed engineering.

- As illustrated in Figure 1, the **ability to control final cost** is greatest in the conceptual engineering phase and rapidly diminishes thereafter.
  - Thus, it is essential that **adequate attention** and **resources** be applied during this phase to perform the **scope definition function**.

Characteristics of the conceptual engineering phase

- This phase provides **project parameters** through:
  - **Preparation** of
    - ✓ Process flow sheets,
    - ✓ Heat and material balances, and
    - ✓ Equipment performance specifications.
  - **Establishment** of operating and maintenance **strategy**.
  - **Preparation** of studies to select the **best concept** among available alternatives.
    - ✓ Included are value engineering studies (i.e., life cycle economic analysis), constructability analysis, risk analysis, and loss prevention analysis.

What technical parameters defined at this stage?

Characteristics of the conceptual engineering phase

- This phase provides project parameters through:
  - Preparation of
    - ✓ Mechanical flow diagrams,
    - ✓ General design specifications,
    - ✓ Instrument summary sheets,
    - ✓ Major equipment specification sheets,
    - ✓ Preliminary equipment arrangements,
    - ✓ Preliminary sized-piping line lists,
    - ✓ Plot plan,
    - ✓ Electrical one-lines, and
    - ✓ Special owner instructions.

Should we establish execution strategy at this stage?

Characteristics of the conceptual engineering phase

- This phase provides project parameters through:
  - **Establishment** of the execution strategy via a Project Execution Plan that
    - ✓ Describes basic organization and responsibilities of project team members,
    - ✓ Establishes contracting method(s) to be employed,
    - ✓ Evaluates the labor market,
    - ✓ Examines potential problems and contingency options,
    - ✓ Describes risk allocation philosophy, and
    - ✓ Establishes general timing.

Characteristics of the conceptual engineering phase

- The **drawings and other documents** developed in this phase are **screened** to identify special equipment and material items that will be required for the project.
  - Also, the **approximate quantity** for each item is identified.
  - Lead time for each of these items is established so that the **latest date** for the **start of its procurement** action can be determined.

Should we start procurement at this stage?

Characteristics of the conceptual engineering phase

- **Procurement** must be initiated for any items that have a **start date during this phase**,
  - Those with **complexity** that makes them a **high risk**, or
  - Those which require **development** and have a **major impact** on detailed engineering.

What to do with permits?

Characteristics of the conceptual engineering phase

- If licensing or permits are required and have **not already been obtained**,
  1. **Plans** for obtaining these are formulated during this phase and
  2. **Actions** initiated to obtain them.

- **Applications** for certain permits,
  particularly those involving **environmental issues**,
  can attract the attention of activist groups
  with the result that **approval becomes delayed or denied**.

Does owner get deeply involved in this phase?

Characteristics of the conceptual engineering phase

- For **some projects**, the owner will **not get deeply involved** in conceptual engineering until such time as **approval of permits** and licenses is complete or assured.

- In some instances, **permitting delays** extend so long that it becomes uneconomical to proceed with the project.

Do we need constructability at this stage?

Characteristics of the conceptual engineering phase

- Constructability is an issue to be considered from **this phase** through the **construction phase**.

- Since **decisions** made during this phase establish the structure for the total project, constructability must be **one of the tests** against which each conceptual decision is **evaluated**.

Do we need constructability at this stage?

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Characteristics of the conceptual engineering phase

- Project control parameters for detailed engineering are a **major product** of **this phase**.

- Based on **firm definition** of project scope,
  1. Cost control accounts and
  2. Breakdown structures that provide the format for project control

     are developed and

     project control **coding structure** is cross-referenced to the owner's structure, if necessary.

Do we gather estimating data at this stage?

Characteristics of the conceptual engineering phase

- Estimating data from **outside sources** are gathered in this phase.
  - Such data might include
    - ✓ Labor rates and productivity,
    - ✓ Workforce availability,
    - ✓ Other construction activity planned for the area at the time of this project,
    - ✓ Prices for equipment and bulk materials (firm or preliminary),
    - ✓ Preliminary unit prices for construction work,
    - ✓ Etc.

What about master schedule?

Characteristics of the conceptual engineering phase

- The master project schedule is **refined** to determine
  1. Overall project duration and
  2. Interrelationships between various project phases.

- At this point the **schedule** is
  - A summary level barchart or
  - Summary network with key constraints.

What is the end product of detailed engineering phase?

Characteristics of the detailed engineering phase

- The **end products** of the detailed engineering phase are **drawing and specification work packages** to support procurement and construction work.

Do we initiate engineering activity in this phase?

Characteristics of the detailed engineering phase

- Engineering activity is initiated on the basis of the **control parameters defined** during the conceptual engineering phase.
  - Those parameters are verified and expanded throughout **this phase**.

This phase is divided into…

Characteristics of the detailed engineering phase

- This phase is divided into:
  1. Preparation of technical procurement documents.
  2. Preparation of construction documents.

Is engineering from the bottom up?

Characteristics of the detailed engineering phase

- While **construction work** generally proceeds in bottom-up sequence
  - *Site development (roads, drainage, etc.), Supports (foundations, structures, etc.), Buildings, equipment assembly/setting, piping, electrical/instrumentation, and surface coatings (painting, insulation, etc.)*

    the **detailed engineering phase** will not exactly mirror this **sequencing**.

What does that mean?

Characteristics of the detailed engineering phase

- This is a **consequence of needing** to
  1. Have detailed information about the **varied items** of equipment and
  2. How they are to be connected together

     before detailed engineering of site development and supports can be performed.

     - Expressed another way, **engineering of a facility** is from top down or inside out;

       construction is from the bottom up.

- **Early releases** can be made for some civil and structural components, however, if the owner, engineer, and constructor have **agreed upon parameters** affecting their design by the end of the conceptual phase.

Do we need constructability?

Characteristics of the detailed engineering phase

- Other actions are:
  - Constructability studies are **intensified** to assure incorporation of the most cost-effective designs before drawings are released.
    - ✓ It must be emphasized that these studies are proactive; *the Constructability interests must be fully represented when concepts and approaches are brainstormed.*
    - ✓ Constructability is **not only a design review** function.
      - o **Waiting until designs** are complete for consideration of constructability may force **expensive design rework** and loss of time.

What are other actions taken at this stage?

Characteristics of the detailed engineering phase

- Other actions are:
  - **Remaining action** to obtain licenses and permits is completed.
  - The **construction schedule** is expanded in **detail** as project definition develops.
  - The **detailed engineering schedule** is refined so as to assure proper interface with procurement and construction schedules.
  - The Project Execution Plan is **finalized**.
  - The project **cost estimate** and **cash flow** is established,

    preferably as soon as a **clear definition** of total project **scope** can be made.

Let's see procurement phase!

Characteristics of the procurement phase

- This phase has **three parallel and overlapping** actions:
  1. Procurement of long lead-time equipment and materials.
  2. Procurement of other equipment and materials.
  3. Award of construction contracts.

Characteristics of the procurement phase

- Within the procurement phase, it is essential that:
  - **Equipment/material vendor information** be available by the **need dates** designated on the detailed engineering portion of the project schedule.
  - The required **equipment/material items** are **delivered** to the **appropriate site** by the need dates designated on the construction schedule.
  - **Contractors** are mobilized and ready to perform by the **milestone start dates** for the various construction contracts.

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Characteristics of the construction phase

- During the construction phase, the facility is constructed according to
  1. **Drawings** and **specifications prepared** during the detailed engineering phase
  2. **Using** equipment and material **obtained** in the **procurement phase.**

- **Although** listed as a procurement function,

  selection of the contractor becomes a **major activity in the scheduling** of each construction contract.

Characteristics of the start-up phase

- In the typical industrial facility,

  a **number of process systems** incorporate

  civil, mechanical, electrical, and instrumentation components.

- **Each component** is subjected to
  - Individual inspection or testing
  - Testing of the combinations of these components that make up a process system.

What does that mean when we talk about testing of the combinations?

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Characteristics of the start-up phase

- Since **system testing** cannot commence until

  all components of each operating system are available for operational testing as a package,

  construction activity relating to these components must be **completed** so that it **coordinates** with the needs of the start-up schedule.

  - On the other hand, **component testing** should proceed as soon as components are **installed** and available for testing.
  - **Some temporary systems** (e.g., steam or compressed air supply) may have to be **erected** to support start-up.

Should we plan start-up simultaneously?

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Characteristics of the start-up phase

- It is **not essential** that all start-up activity be accomplished **simultaneously**.
- It is **more efficient** to sequence (with some overlap) the start-up of the various process systems.
  - Of course, this requires that **special attention** be given to the planning and controlling of the **construction work**

    so that **process system components** are available in the sequence desired.

How to speed up construction and start-up process?

Characteristics of the start-up phase

- To **speed up** construction and start-up, it may be advantageous to utilize a **validation center**, **often off site**, for preassembly and checkout of various components.
  - This activity can be accomplished **concurrent** with other **construction activities**.

- While the process will add the **additional costs** associated with preassembly, teardown, movement, and re-assembly (or just movement to point of final installation in the case of components not disassembled after testing), these costs may be offset by the time savings realized.

When turnover to the owner occurs?

Characteristics of the start-up phase

- **Turnover** to the owner occurs when a process system is **accepted by the owner**.

- It can be accomplished **system by system**,

  or for the project as a **whole**.

Model Planning and Controlling System for EPC of Industrial Projects

(The Control Structure)

Introduction

- Total EPC control involves
  1. **Individual control** of each phase (conceptual engineering, detailed engineering, procurement, construction, and startup) and
  2. Their **integration**.

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The schedule

- The **key** project schedule control milestone is the **owner's need date**.
- To meet this date requires that:
  - The **start-up** schedule support the **owner's project need date**.
  - The **construction** schedule be coordinated with the **start-up schedule**.
  - The **procurement** schedule for materials and equipment take into consideration
    - ✓ **Need dates** associated with **vendor information** required for completion of detailed engineering and
    - ✓ **Need dates** for **delivery** of equipment and materials to support construction.

The schedule

- The **key** project schedule control milestone is the **owner's need date**.
- To meet this date requires that:
  - The **procurement schedule** for contractors take into consideration the **time factors** associated with qualification and selection of contractors.
  - The **detailed engineering schedule** be coordinated with both the **construction** and **procurement** schedules so that
    - ✓ **Technical documents** required for inquiries and
    - ✓ **Purchase orders** are available when required, and so that
    - ✓ **Required** construction drawings and specifications are provided at the correct time.
  - The conceptual engineering schedule be coordinated with the **need dates** for **initiation of procurement** of
    1. Long-delivery equipment and material items and
    2. Start of detailed engineering.

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The schedule

- **Detailed short-range planning** utilizes the rolling wave or moving window approach.
- Using
  - **"Status to date"** as the starting point and
  - The **control schedule** as the target,

    detailed plans and schedules are developed for the forthcoming 30-90 days.
- These **short-range plans** are updated at least monthly,

  often **weekly**, during planning **sessions** involving all key project participants.
- Changes must be carefully evaluated to determine the **true impact** on the **control schedule.**

In what phase the original budget and control estimate established?

The budget

- The **original budget** for the project is often established during the conceptual phase.
- The **control estimate** established during the detailed engineering phase is
  - More detailed and
  - Based on best available quantities and procurement information,

  But the **estimate** remains budgetary in nature.

When budgeting becomes more exact?

The budget

- As
  - Engineering progresses and
  - Purchase orders and
  - Contracts are awarded,

the **budgeting**

becomes more **exact** and

may require **adjustment** of the total project cost.

So, how to control the cost?
Wait to have detailed cost estimate?

The budget

- **Cost control** during the **various phases** will be against the level of **estimating detail** that exists at that time.
  - Close attention will be given to **variances** between budgeted and actual costs in **each control account**.
  - These will be watched via cost tabulations and trend charts.

- It is often necessary to prepare additional definitive confirmation estimates at various points during the remainder of the project.

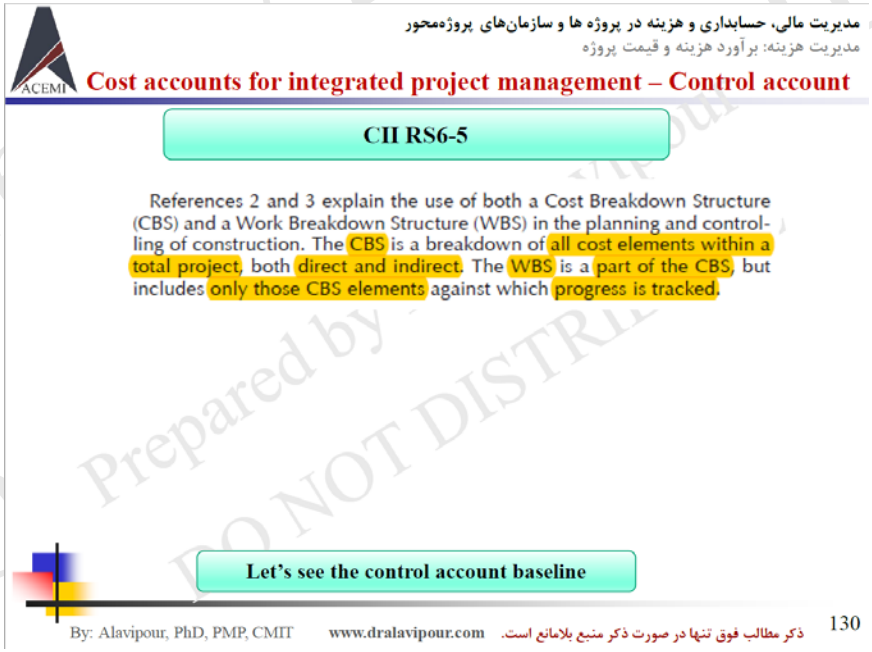
- **Changes** must be **carefully evaluated** to determine the true impact on the **control estimate.**

Breakdown structures

- The **WBS** is made up of **project elements** which relate to work progress measurement (work tasks),

  whereas the **CBS** is made up of project elements that relate to cost tracking (cost control accounts).

  The WBS elements are included within the CBS.



Breakdown structures

- **Figure 2** illustrates the CBS/WBS relationship as seen by a **design-engineer**
- **Figure 3** illustrates it for a **construction contractor**, and
- **Figure 4** shows the relationship as seen by the **manager** of the total project.

Breakdown structures

ENGINEERING BUDGET MATRIX

ACTIVITY OR COST ELEMENT / FUNCTION		DESIGN & DRAWINGS	SPECS	PROCUREMENT SUPPORT	FIELD SUPPORT	SUPERVISION & CONTROL	TRAVEL	SUPPLIES & SERVICES
MANAGEMENT						WH & $		
PROCUREMENT				WH & $	WH & $			
DISCIPLINES	CIVIL	WH & $	WH & $	WH & $	WH & $	WH & $	$	$
	ELECTRICAL	WH & $	WH & $	WH & $	WH & $	WH & $		
	ETC.	WH & $	WH & $	WH & $	WH & $	WH & $		

The COST BREAKDOWN STRUCTURE (CBS) is composed of all elements in the Budget Matrix for which dollars have been budgeted. The total dollar value of all of these elements equals the total engineering budget.

The WORK BREAKDOWN STRUCTURE (WBS) is developed from those budget items in the Budget Matrix which cover tasks that lend themselves to progress control, such as drawings and specifications. These items have been shaded in the matrix. The detailed WBS would be expanded from these budget items. For example, a drawing list would be developed to include all drawings in the Electrical Drawings budget, and each drawing would be budgeted a number of work-hours (WH). The total of these work-hours would equal the total in that budget item.

Figure 2. Engineering CBS and WBS

Figure 2 illustrates the CBS/WBS relationship as seen by a **design-engineer**

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Breakdown structures

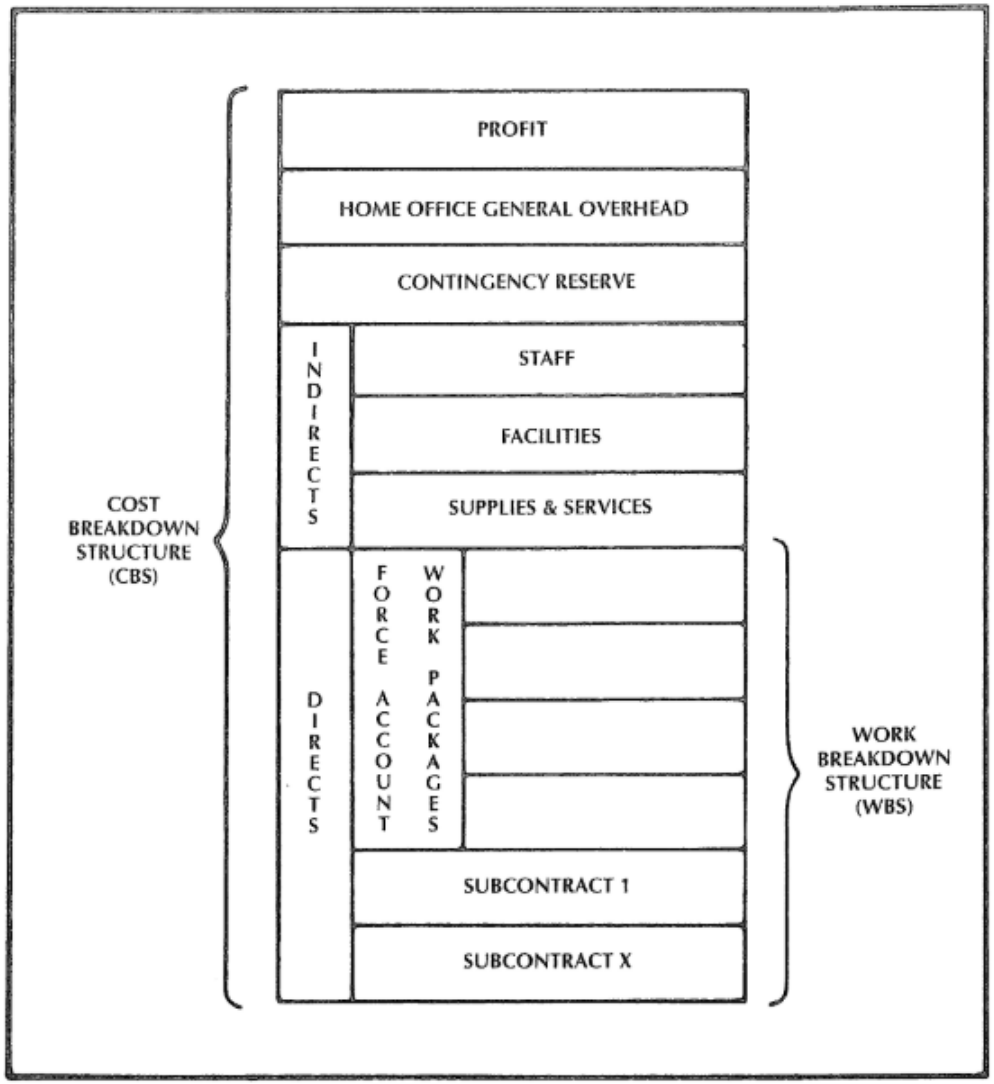

Figure 3. Construction CBS and WBS

Figure 3 illustrates it for a **construction contractor**, and

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Breakdown structures

PHASES	INDIRECTS (1)	DIRECTS		
		LABOR	MATERIAL	EQUIPMENT
Conceptual Engineering	$	WH $	$	$
Detailed Engineering	$	WH $	$	$
Procurement	$	WH $	$	$
Construction	$	WH $	$	$
Start-Up	$	WH $	$	$
Other (2)	$	WH $	$	$

Legend:

The COST BREAKDOWN STRUCTURE (CBS) is composed of all elements in the matrix for which dollars ($) are budgeted. The total dollar value of all of these elements equals the project budget.

The WORK BREAKDOWN STRUCTURE (WBS) is composed of those direct labor elements in the matrix for which work-hours (WH) are budgeted and lend themselves to work progress measurement.

Footnotes:
1. Supervision above first level, staff, facilities, supplies and services, travel, etc.
2. Home office overhead, contingency reserve, profit, etc.

Figure 4. Total Project CBS and WBS Relationship

Figure 4 shows the relationship as seen by the **manager** of the total project.

Breakdown structures

- **Figure 5** provides a **visual representation** of the relationship between control accounts and the schedule activities for **construction**.

- **Comparable control accounts** for
  1. Engineering (e.g., Work-hours per engineering activity) and
  2. Procurement (e.g., Work-hours per type procurement action)

  should be part of the **generic database**

  for use in planning of engineering and procurement work.

Breakdown structures

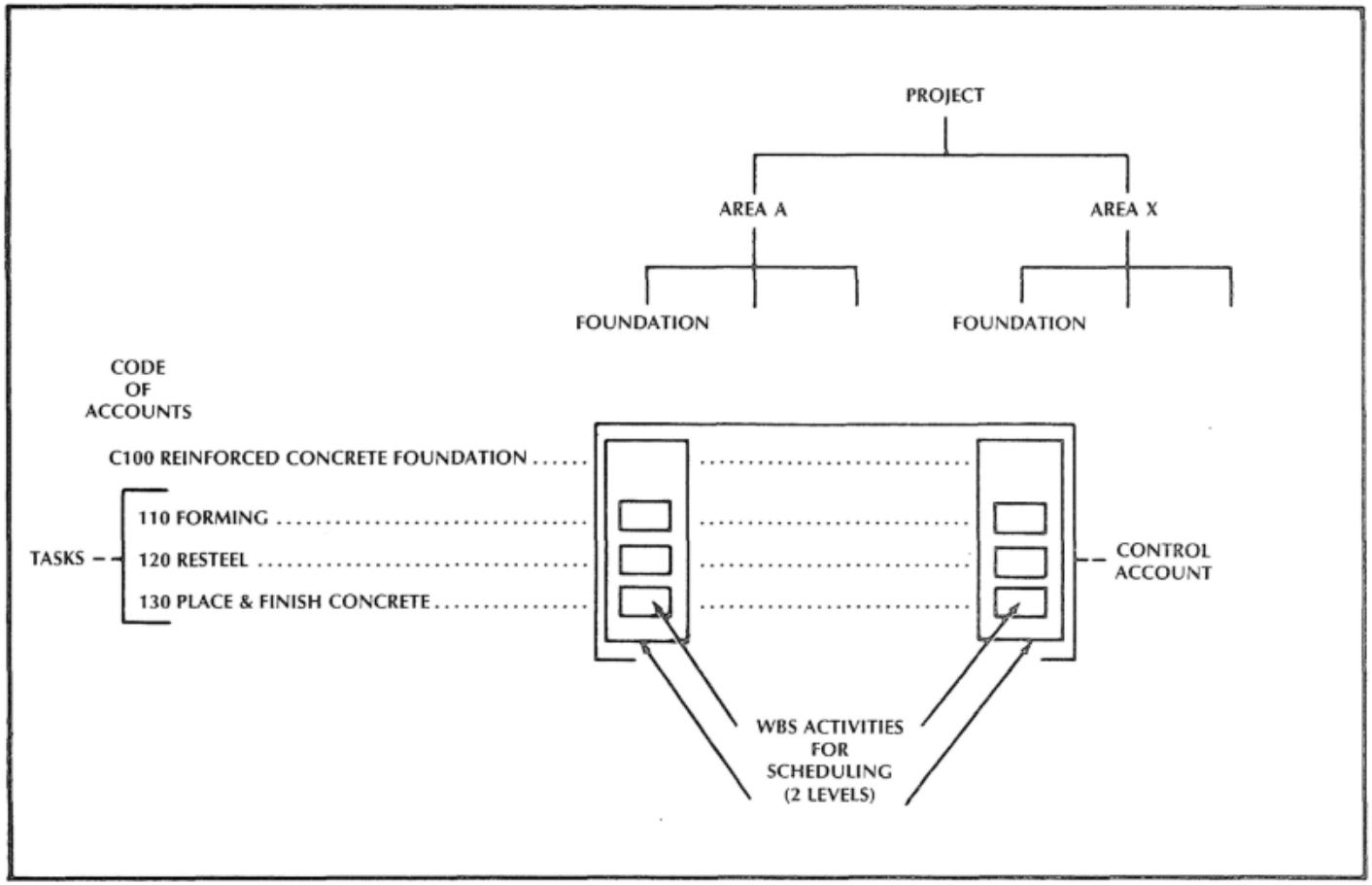

Figure 5. Control Account/Schedule Activity Relationship

Again referring to **Figure 5**, it can be seen *how this structure directly supports data collection both for*

1. Day-to-day control of the project and
2. Historical purposes.

Breakdown structures

- **Actual** performance data can be **summarized** against
  1. Schedule activities for purposes of **progress control** and
  2. Control accounts for **historical** purposes and **productivity** studies.

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Breakdown structures

- The **control accounts** referred to above and illustrated on **Figure 5** will have these characteristics:
  - **Logical levels** for
    1. Estimating,
    2. Budgeting, and
    3. Accumulating

       actual quantities and work-hours.
  - **Hierarchical** within the generic database.
  - **Each control account** may apply to one or more activities of the same type in the WBS.
  - The **unit rate** used in budgeting must be **truly applicable**

    to **all work** included within the account.

Reporting

- **Work progress** is
  1. Reported at the activity level and
  2. Analyzed using earned value techniques.

- **Cost reporting** normally is accomplished at the control account level.

- **Reports** can be generated at various levels within the **WBS and CBS** to satisfy project and **higher management** needs.
  - To make this possible, the **code of accounts** utilized to define the WBS and CBS must be **hierarchical** in format to facilitate **roll up of information** to the various levels.

Model Planning and Controlling System for EPC of Industrial Projects

(Approach)

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Introduction

- Planning and controlling of a **phase** requires:
  - **Dividing it** into controllable segments (e.g., procurement trains, installation areas, start-up process systems).
  - **Defining** the WBS activities within each segment.
  - **Estimating** work-hours and/or cost value for each **activity or group** of related activities
  - **Identifying** resource requirements and availability.
  - **Determining** the duration for each activity.
  - **Identifying** the **relationships** between activities within the segment, with
    - ✓ Related activities in other segments of the phase,
    - ✓ Related activities in other phases, and
    - ✓ The project milestones.

Introduction

- Having done this, a **logic network** can be prepared to which the CPM can be applied.
- As noted previously, **planning** proceeds in reverse order –

  from the **start-up phase** back through the conceptual engineering phase –

  using the **owner's need date** as the starting point.

Figure 6 is a visual representation of this sequencing.

Start-up control

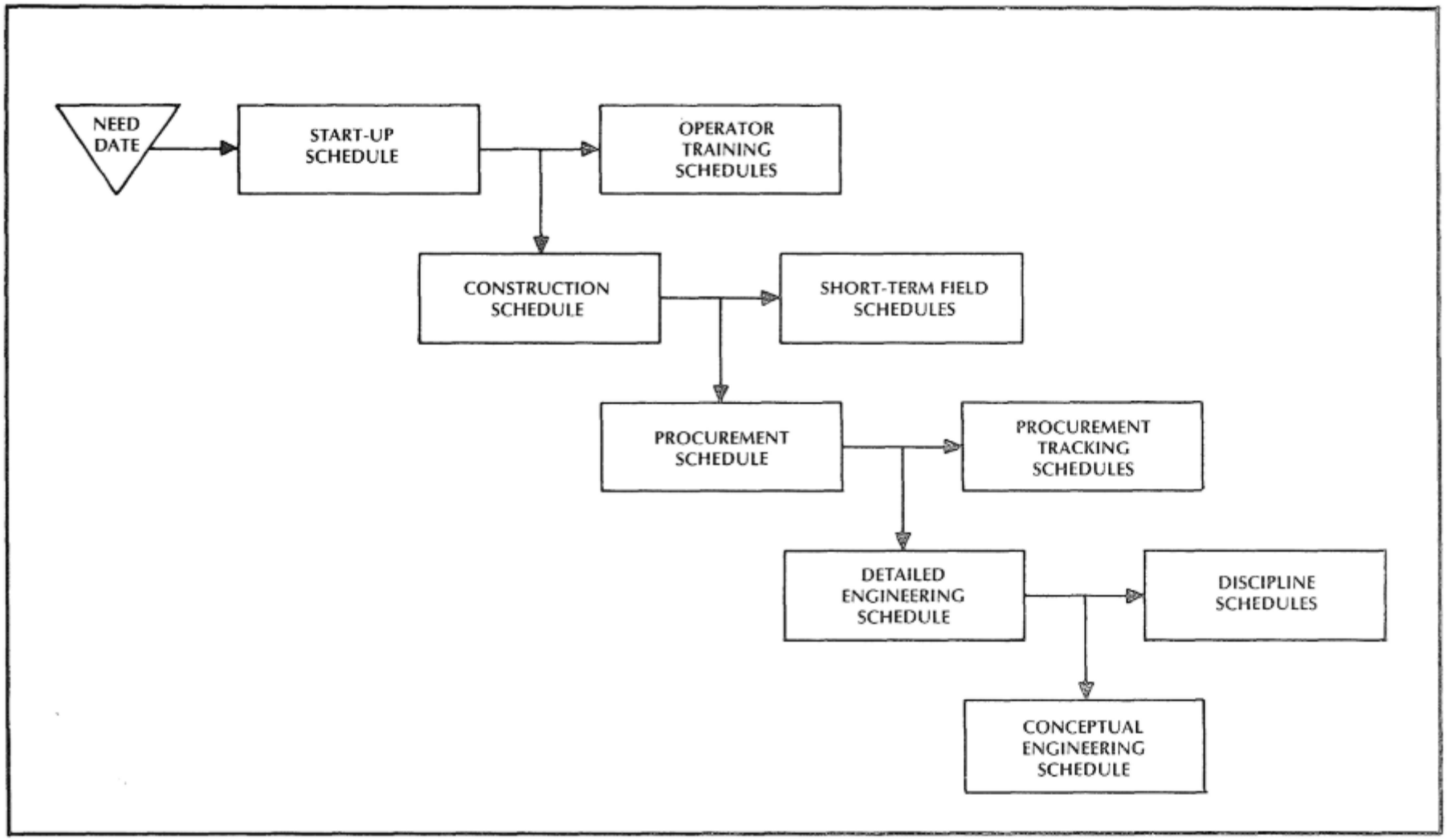

Figure 6. Scheduling Sequence for EPC Project

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Start-up control

- Planning and controlling of this phase requires **dividing** it into the process systems that make up the facility.

- **Start-up schedules** must reflect the sequence in which various operating systems must be brought on line to **support subsequent** operating systems.

Construction control

- Planning and controlling of the **construction phase** requires **dividing** the facility into **controllable areas/elements** of the facility.

When work should start in construction?

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Construction control

- As a matter of policy, **work** should **not be started** on any work package until
  1. **Applicable** drawings and specifications are on **hand**, and
  2. **Acceptable** equipment and material delivery is assured.
     - **Compliance** with this occasionally may **force planners** to **shift activities** on the detailed schedule to **compensate** for delivery deviations.

What does shifting activities mean?

Construction control

- **When construction progress** has reached about 70-85 percent complete (cable trays installed, instruments and electrical connections essentially complete, piping erection about 90 percent complete),

  the **logic** of the work activities **left to be complete** is revised in a manner that they can be related to **start-up process systems**.

  - This allows for **coordination** of this phase with the start-up phase.

Construction control

- **More detailed information** on project control for construction will be contained in the, Project Control for Construction.

Maybe in the future!

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Procurement control

- Planning and controlling of material/equipment procurement requires **dividing** the **total procurement effort** into separate procurement trains.
- **Because** so many functions and agencies are involved in a **procurement train** (owner, purchasing, engineering, quality control, expediting, receiving, warehousing, vendors, transportation, etc.),

  Individual work activities that make up

  1. Materials identification-inquiry-bid,
  2. Tabulation-order-vendor,
  3. Documents-fabrication-deliver-acceptance sequence

  are required elements for **detailed control.**

What does having subsystem for procurement mean?

Procurement control

- A **subsystem** for materials control is within the overall project controls system.

- This subsystem must **relate** procurement line items to work packages
  in order to provide the **necessary tie** to the cost and schedule control system.

- The **materials control subsystem** must include a **warehousing module**
  to **track** equipment/materials between
  1. **Receipt** at the designated site and
  2. Their issue for **use**.

What does it mean when we say length of time needed for procurement control?

Procurement control

- It is important in the **scheduling of construction contracting** to allow for the **length of time** between
  1. **Availability** of construction documents and
  2. Point in time when the **successful contractor is mobilized** and **ready to commence** productive work.
     - This time period can be **surprisingly long** and must be accounted for in the **overall schedule**.

What are other parameters need this?

Procurement control

- Dependent upon the contracting method used, the planning of construction procurement requires that **adequate time be allowed** for any of the applicable following:
  - **Development** of a bidders list.
    1. This may involve a **qualification step** wherein a number of contractors are **asked to submit qualifications**

       from which a bidders short list is developed.
    2. Or, the **owner may develop** such a list based on past experience with contractors.

Procurement control

- Dependent upon the contracting method used, the planning of construction procurement requires that **adequate time** be allowed for any of the applicable following:
  - Assembly of work package bidding documentation (inquiry package).
  - Issuance of the inquiry packages.
  - Pre-bid orientation and site visits.
  - Preparation of bids by contractors.
  - Extension of bidding time because of addenda to inquiry documentation.
  - Analyzing of bids.
  - Awarding of the construction contract.
  - Premobilization orientation meeting.
  - Mobilization of the contractor.

Detailed engineering control

- The procurement and construction activities establish need dates for **completion** of various **engineering actions**.
  - Thus, **before** the schedule for activities within the detailed engineering phase can be **finalized**,

    it will be **necessary** for the **procurement phase** to be **defined** in terms of

    1. Controllable procurement trains and
    2. Construction phase

    into controllable areas/elements of the facility.

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Detailed engineering control

- The **detailed engineering schedule** also must reflect the method by which **engineering deliverables** are **logically** developed.

- Designing, calculating, drafting, checking, and owner review (if applicable) are separate activities that must be related both within and among **engineering disciplines.**

Why scheduling and control of engineering work is complicated?

Detailed engineering control

- The scheduling and control of **engineering work** is complicated by the fact that a **given engineering deliverable** can be part of several activities (work packages) on the control schedule.
- **Figure 7** provides a **visual description** of the relationship between
    1. Engineering deliverables and
    2. Activities on the control schedule.

Detailed engineering control

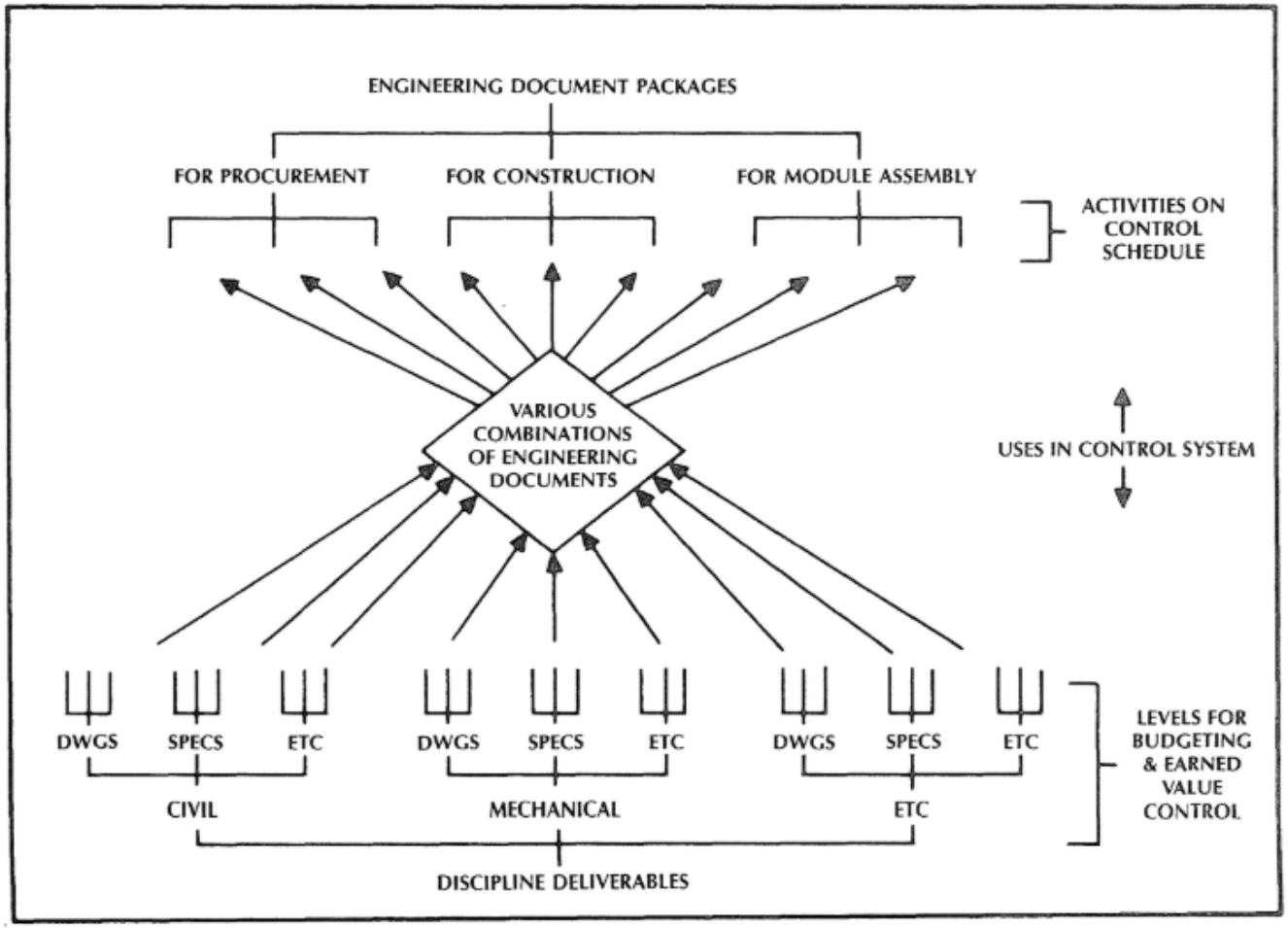

Figure 7. Engineering Control System

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Detailed engineering control

- **Engineering work** is definitely **incorporated** in the project control schedule,

  but the **engineering activities** on this schedule are packages of engineering documents

  that are **required** for a **procurement or construction activity**.

Should EVM performed at activity level or control level for engineering activities?

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Detailed engineering control

- Since a **given engineering document** may be part of several control packages on the control CPM,

  it is important that **earned value calculations** for purposes of overall engineering progress statusing be handled at the engineering task level,

  not at the control CPM level.

Why not control level?

Detailed engineering control

- This does **not preclude** the use of **earned value techniques** within each package on the **control schedule** to calculate **percent complete** of a package.
  - However, these should not be **wrapped up among packages** at the control level

    to produce an **overall percent complete** since this would have the effect of giving credit to some **deliverables more than once.**

Is it appropriate to include schedule activity identifier in engineering deliverable?

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Detailed engineering control

- Because an **engineering deliverable** such as a drawing may relate to **more than one schedule activity**,

  it is **not recommended** that a schedule activity identifier be part of the deliverable's identification.

What is the solution?

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Detailed engineering control

- Because an **engineering deliverable** such as a drawing may relate to **more than one schedule activity**,

  it is **not recommended** that a schedule activity identifier be part of the deliverable's identification.

  - Rather, it is recommended that a dataset within the total integrated control system be set up to **relate**

    1. Schedule work packages to
    2. Included deliverables.

- With the more modern computer systems, this **dataset can be linked** to the scheduling module and other datasets to provide the **integrated control desired**.

Detailed engineering control

- Further information on the subjects above can be found in the CII publications, Project Control for Engineering (Publication 6-1) and Scope Definition and Control (Publication 6-2).

Conceptual engineering control

- The nature of this phase requires that **initial planning** use **work activities** (see the WBS, Figure 2) that are **broad in scope**.
- As the scope of the **basic functional features** of the project is determined, **activities** can be expanded to a greater level of detail and thus improve **controllability**.
- Long lead-time equipment/material items should be identified during this phase and procurement action started on those with lead times that are critical with respect to need dates.

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General

- **For this EPC project format** to succeed,

  performance of the **detailed engineering phase** must be integrated with the **needs** of the procurement and construction phases.

  - To do so often **precludes** efficient and/or cost-effective utilization of **engineering personnel**.
    - ✓ This also means that the **detailed engineering effort** may **cost more** under an EPC format **than** if **completion of detailed engineering** preceded the start of construction.

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General

- The **financial accounting/payroll function** of the company must **adapt** to the project **controls program**,

  not vice versa, since

  project controls involve **more detail** and require a **more involved coding structure** than does accounting.

- Also, the **project control accounts** must be responsive to

  the contract terms and

  these terms may establish a **structure quite different** than that used for normal **company** accounting and payroll.

- Of course, the **accounting subsystem** should link with the integrated project control system so that most basic work-hour and cost data

  need only be **entered once** to serve both systems.

Logic diagram

- A **logic diagram** which illustrates the major EPC phase activities and their interrelationships is displayed in **Figure 8.**

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Logic diagram

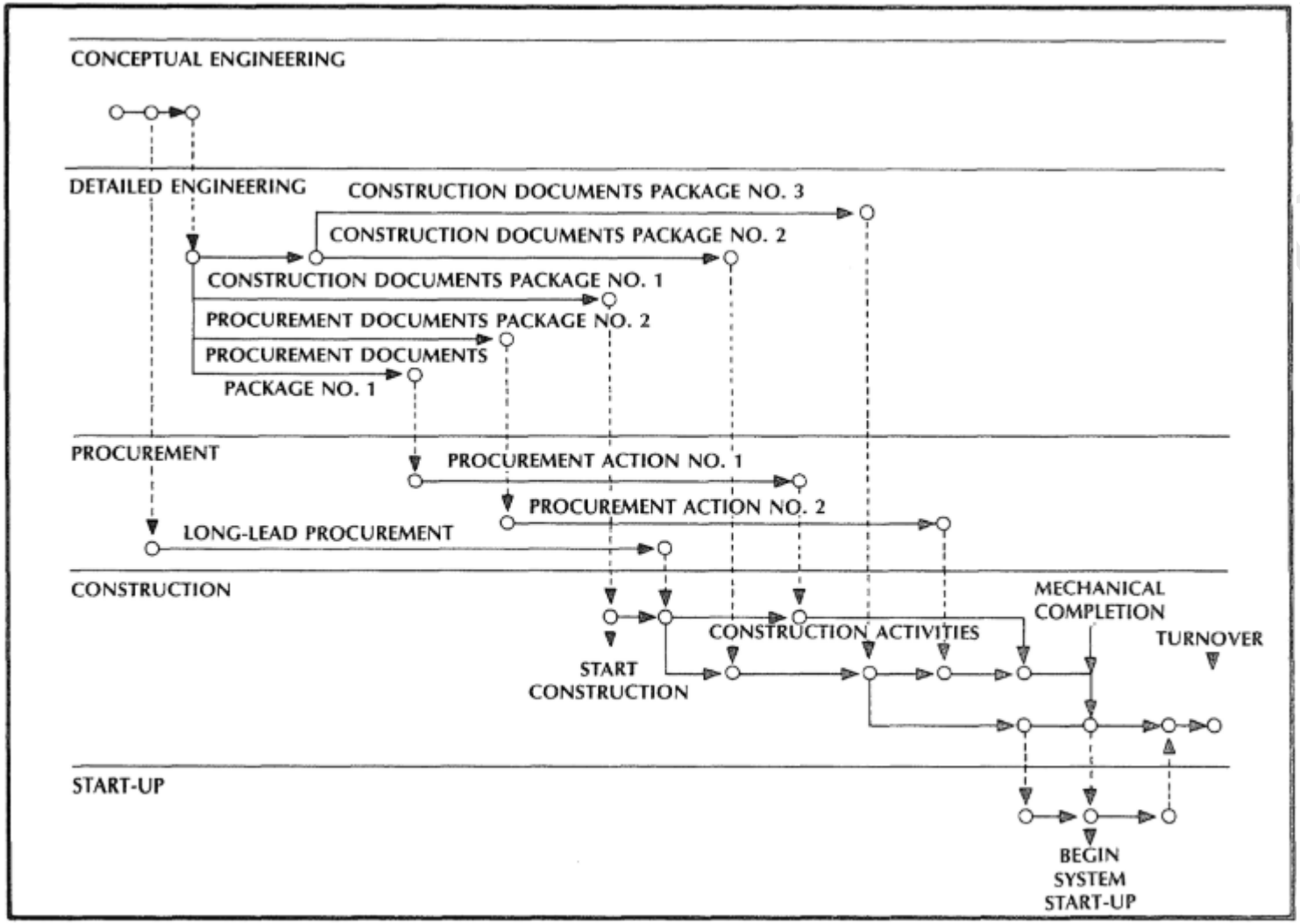

Figure 8. General Logic EPC Project

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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