



## اجرا و مدیریت پروژه به روش اصول ناب (Lean Project Management)

فصل دوم: بکارگیری مفاهیم و اصول روش ناب در مدیریت پروژه (Lean Project Management)  
بخش سوم: استفاده از اصول روش ناب در مرحله ساخت/اجرا (Construction) پروژه

ارائه دهندگان:

سید محمدرضا علوی پور

(PhD, PMP, CMIT)

کامبیز کردانی

(M.Sc., PMP)

## What we will learn?

- ❑ Lean in construction phase of LPDS
  - ❖ Concepts
  - ❖ Lean supply
  - ❖ Lean assembly
  - ❖ Lean use
  - ❖ Learning loops
  - ❖ Production control and work structuring
  - ❖ The last planner system in construction
  - ❖ LC levels of implementation

# **Lean in Construction Phase of the LPDS**

## **(Concepts)**

## Introduction

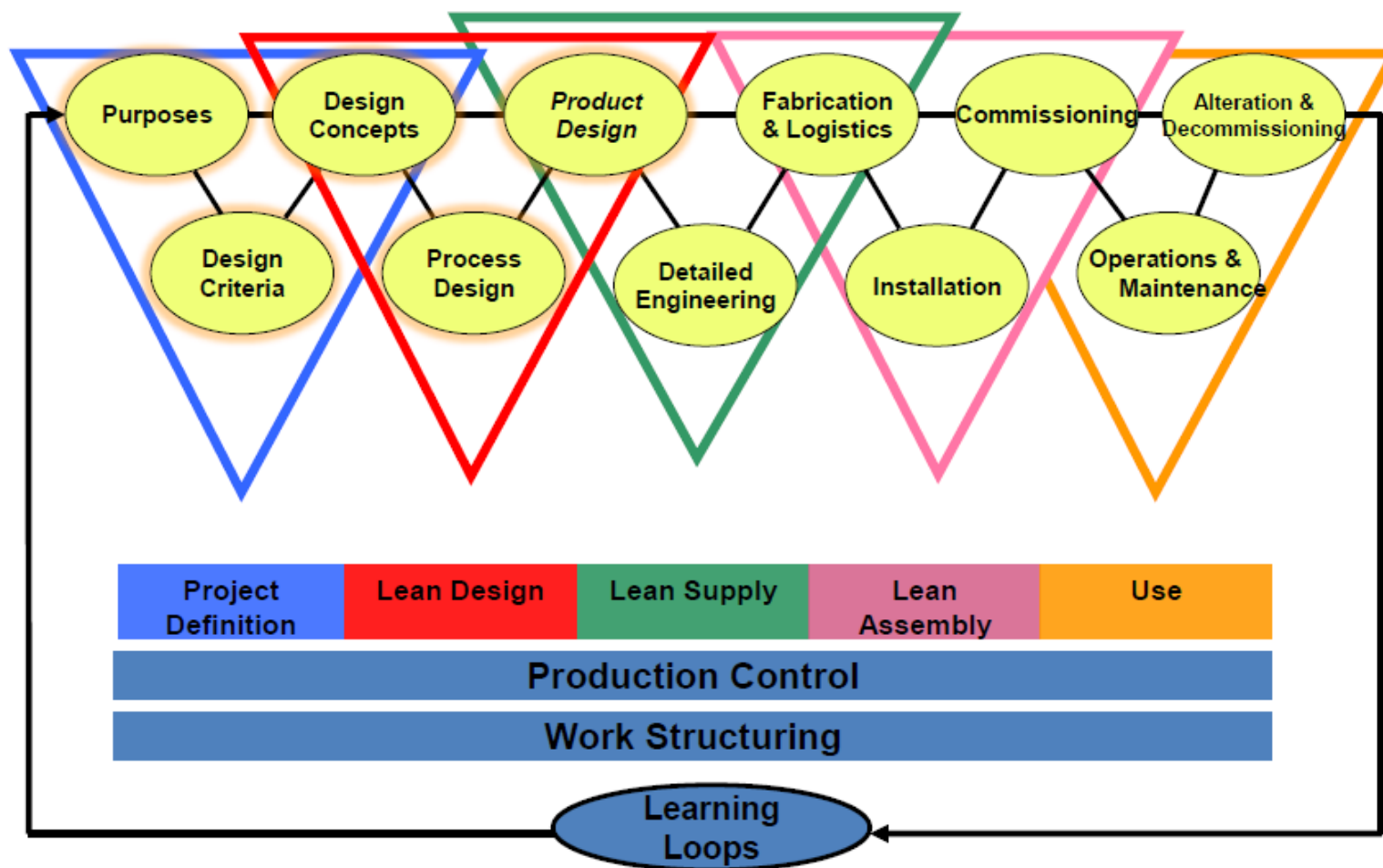
- ❑ The previous section provided an overview of the lean project delivery system (LPDS) with an emphasis on the programming and design phase of projects.
- ❑ It also presented the **Last Planner® System** from the **perspective of design**, in preparation for the **construction phase of projects**.
- ❑ This section presents lean in the construction phase of the LPDS, including **lean supply, lean assembly**, and **use**.
- ❑ The **Last Planner® System** is described **extensively** with regard to the **joint activities** of different specialists in the project team.

# **Lean in Construction Phase of the LPDS**

## **(Lean Supply)**

## Structure of the lean project delivery system (LPDS)

❑ Source: Adopted from Ballard and Howell, Building Research and Information, 2003



## Introduction

### ❑ The third triad, **lean supply** requires

1. Up-front product
2. Process design

to define

1. What is needed
2. When it should be delivered.

- ❖ This is especially important with **engineered to order components** as utilized in EPC projects.

**What is the difference between Lean Supply and Traditional Procurement?**

## Traditional procurement

- ❑ Traditional projects depend on **procurement specialists or buyers** to ensure that
  1. Materials are **available** for installation;
  2. Materials **operate** as a functional silo that is decoupled from **project workflow**.

### What are the flaws in this process?

- ❑ Flaws in this process result in
  1. Material shortages or incorrect materials on site when they are needed that often cause **serious project delays and losses** in construction **quality**.
  2. Alternatively, material inventories accumulate, creating
    1. **Unsafe** condition on-site,
    2. Tying up scarce **capital**.

*These situations represent examples of construction waste.*

## Lean supply

❑ Lean supply **addresses** these problems through three main approaches (Arbulu and Koerckel 2005):

- (1) Improving workflow **reliability** – maintain **constraint identification** and **removal**,
- (2) Using **web-based project management software** to increase transparency across value streams, and
- (3) Linking production **workflow** with material **supply**.

## Lean supply vs. traditional procurement

A comparison between lean supply chains and traditional procurement

|    | <i>Lean Supply Chains</i>                                    | <i>Traditional Procurement</i>                       |
|----|--------------------------------------------------------------|------------------------------------------------------|
| 1  | Based on systems thinking                                    | Purchasing function not systems based                |
| 2  | Factored in product and process design                       | Standard procedure –                                 |
| 3  | Tries to match resources with site needs                     | Seeks lowest price through competitive bidding       |
| 4  | Seeks overall cost savings via value stream strategy.        | Narrow focus on balancing price quantity and quality |
| 5  | Early supplier involvement                                   | Late supplier involvement                            |
| 6  | Pulls resources where possible                               | Pushes resources at the site                         |
| 7  | Material consolidation through centralized logistics centers | Independent warehouses/inventories                   |
| 8  | Multi-project view                                           | Individual contract view                             |
| 9  | Supply channelized to project needs                          | Project constrained by supply                        |
| 10 | Long term strategy for procurement                           | Short sighted thinking and control                   |
| 11 | Material supply is synchronized through the LPS.             | Material supply decoupled from workflow              |

Source: Adapted from AGC course Unit 5

## Supply chain management and lean construction

❑ The **main elements** of SCM are

1. Information flow,
2. Order fulfillment, and
3. Product development

❑ With

1. Faster response times,
2. Less waste,
3. More effective information flow, and
4. Smaller amounts of inventory.

**The *design process* can support the supply chain by using *standardization* to eliminate waste as well.**

**Implementation of SCM has many challenges!**

## Challenges of supply chain management in construction

- ❑ The **industry trend toward subcontracting** has resulted in
  1. Specialization and fragmentation;
  2. Each subcontractor tends to act in **its own interest** and
  3. Relationships between the various parties often **becomes adversarial**.
  
- ❑ The **sharing of information is critical** for both SCM and lean construction.
  - ❖ *A general contractor (GC), for example, should be able to **extract a reliable commitment** from an air conditioning **subcontractor** that a chiller has been **ordered** from a specified supplier.*

How this could happen?

## Challenges of supply chain management in construction

- ❑ Using an **online information system**, it should be possible for the **GC and the owner's project manager** to verify the supplier's delivery schedule, although **pricing information** could be kept confidential.
- ❖ *The dimensions and capacities of the chiller could be **verified** long before delivery to **ensure** that it will be delivered and installed in seamless agreement with the **construction schedule**.*

## Just in time (JIT) and lean construction

- ❑ In **JIT**, production is driven by **customer demand**;
  - ❖ That is, the **needs of the next trade downstream** as opposed to “pushing “ to meet schedules.
- ❑ This system allows a **JIT approach** to be used, so that
  - ❖ *Chiller is **not delivered too far in advance**, when on-site storage requirements may become costly and inconvenient.*
  - ❖ *Late deliveries would be avoided.*

**Unavoidable deviations** from the **construction schedule** would be shared with **all stakeholders** and needed **adjustments made**.

## Just in time (JIT) and lean construction

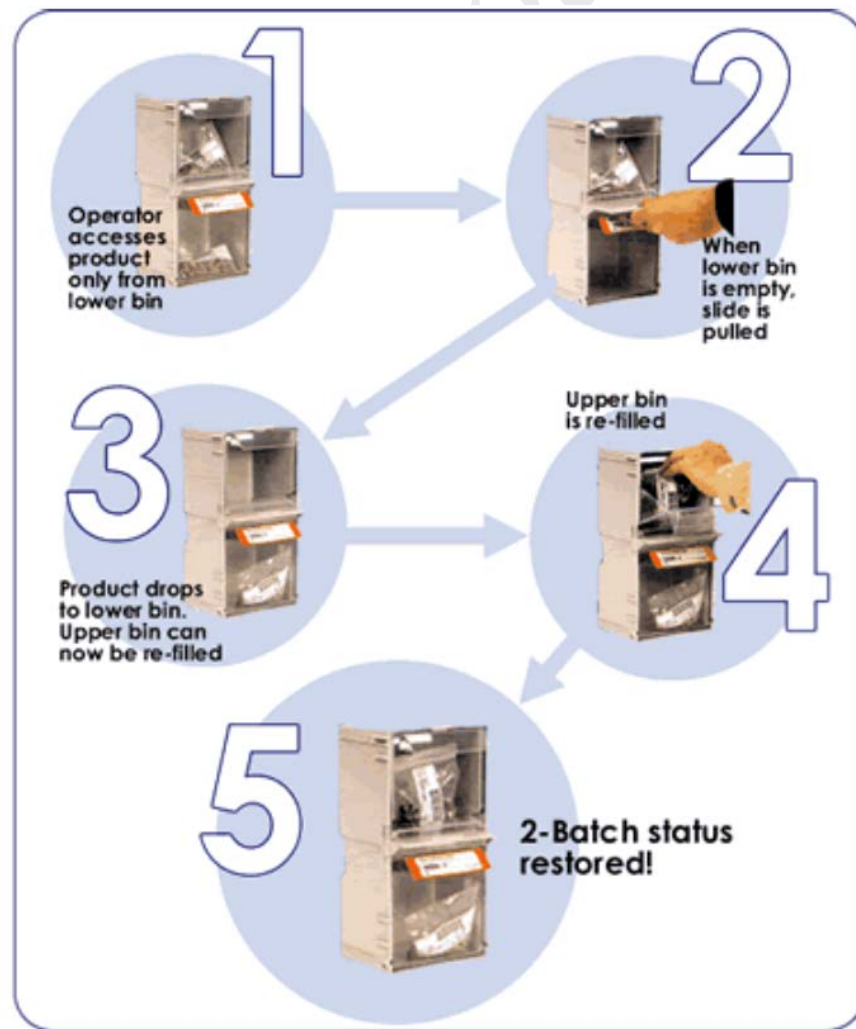
- ❑ One important function of the supply chain is to ensure the **appropriate timing of material** acquisitions to **avoid excess material inventories**.
- ❑ Materials fall within **three categories** that must each be **handled differently**:
  1. **Made to stock items (MTS)**: These are **commercial items** that are made to meet **market forecasts**.
    - ❖ *Examples are consumables such as nails and small tools.*
  2. **Made to order items (MTO)**: These are **standard items** such as **rebar** and **concrete** that are **easily produced** to meet project needs.
  3. **Engineered to order (ETO)**: Items are **customized to the project**;
    - ❖ *They include steel trusses, HVAC ductwork, systems piping for chillers, and plumbing.*

## Kanban and lean construction

- ❑ Pull/Kanban is a system of **delivery instructions** from downstream to upstream activities in which the **upstream supplier does not produce until the downstream customer** indicates a need.
  - ✓ It is an **essential part** of the **just-in-time (JIT) process**.
- ❑ In its original form, Kanban was a **card-based system** that improved process management through **visual control**.
- ❑ Kanban cards **maintaining information** on product name, number, due dates, and so on.
- ❑ The **kanban** tells the **supplying process** exactly what it wants and how many.
- ❑ The supplying process is **not authorized** to make more product **until the kanban advises** it to do so.

## Kanban and lean construction

Bin system to show when materials or parts are running low



## Kanban and lean construction

### Inventory control

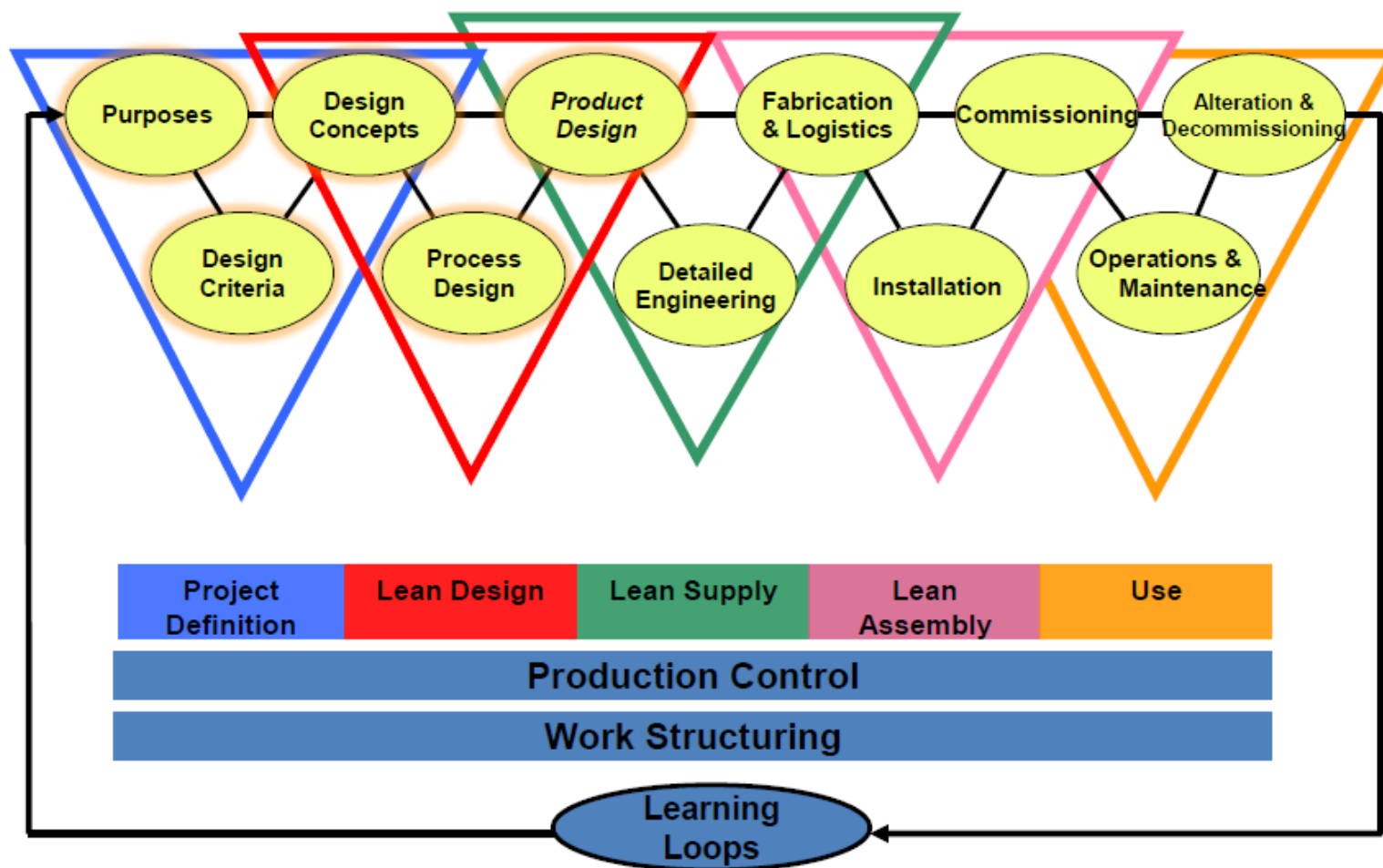


# **Lean in Construction Phase of the LPDS**

## **(Lean Assembly)**

## Structure of the lean project delivery system (LPDS)

❑ Source: Adopted from Ballard and Howell, Building Research and Information, 2003



## Introduction

- ❑ Lean assembly is practiced in the **actual construction** of a project.
- ❑ Lean assembly **puts** materials, systems, and components in place to create a completed facility.
- ❑ The **objective** of lean assembly is to **assemble building elements** in the most efficient manner possible, both onsite and offsite.
- ❑ It can be **accomplished in a number of ways**, such as  
through **prefabrication offsite** where the work can be done in  
**controlled environment** like a **factory**, and then transported to the site.
  - ✓ *Piping systems, for example, can be assembled in sections in a prefabrication facility, tested under high quality standards, then shipped to a site on a just-in- time basis.*

## Prefabrication

❑ Prefabrication is a **production technique** that can **enable a contractor** to **operate in a lean manner** by

reducing the many **nonvalue-added steps** that are required in field fabrication.

❖ Whereas **field work contends** with **uncertain conditions** such as

*weather, and limitations in the availability of skilled labor, material, and equipment, shop fabrication benefits from a predictable, controlled environment.*

## Commissioning

- ❑ The commissioning process provides **quality assurance**

**before** a facility is **completed and accepted** by the owner

by ensuring that **all systems have been installed** as promised in keeping with the **designer's plans and specifications**.

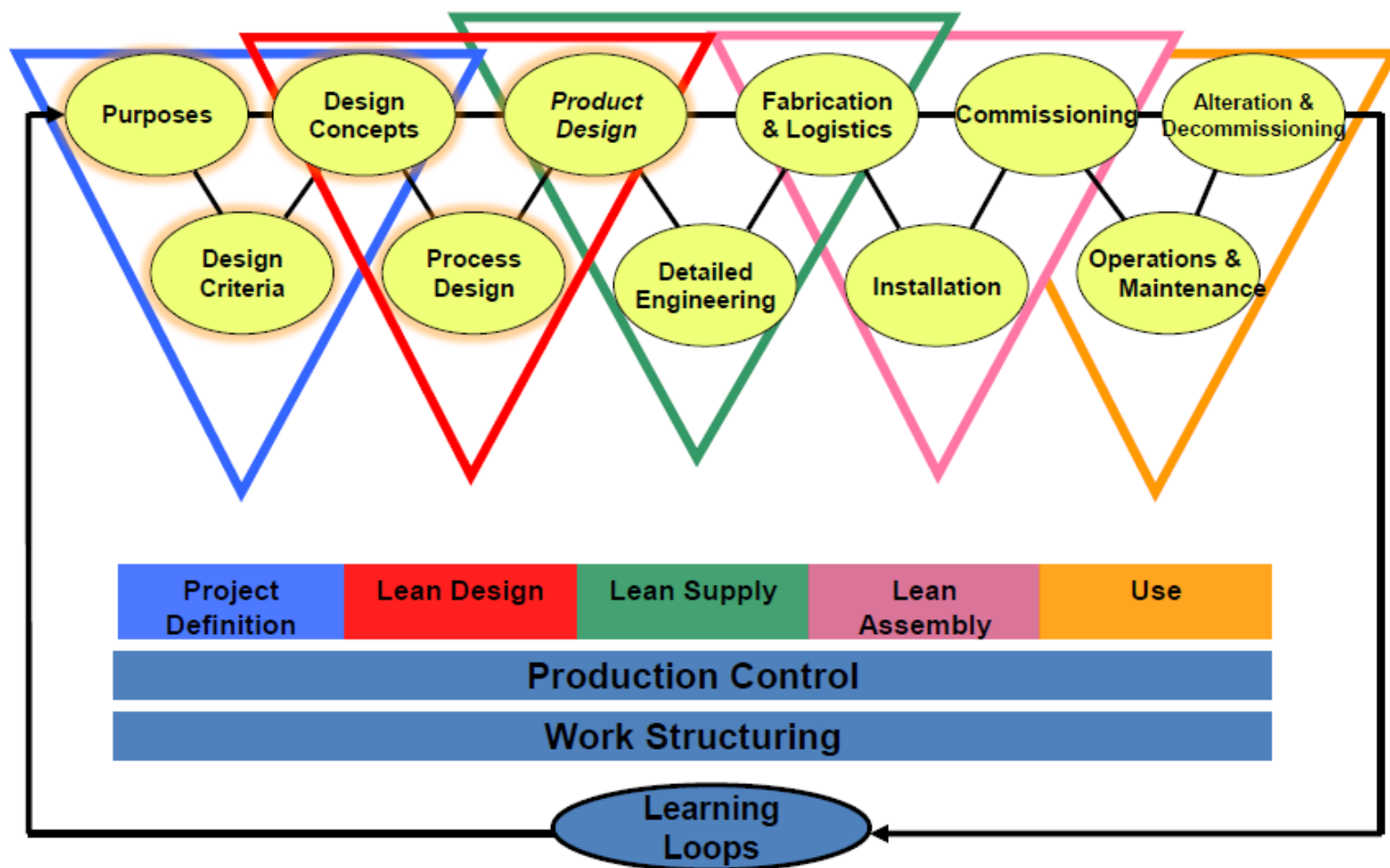
- ✓ It improves the **probability** that the facility will meet the **owner's project requirements (OPR)** and performs as expected, to provide user satisfaction.

# **Lean in Construction Phase of the LPDS**

## **(Lean Use)**

## Structure of the lean project delivery system (LPDS)

❑ Source: Adopted from Ballard and Howell, Building Research and Information, 2003



## Lean use

### ❑ The “Use” triad of the LPDS

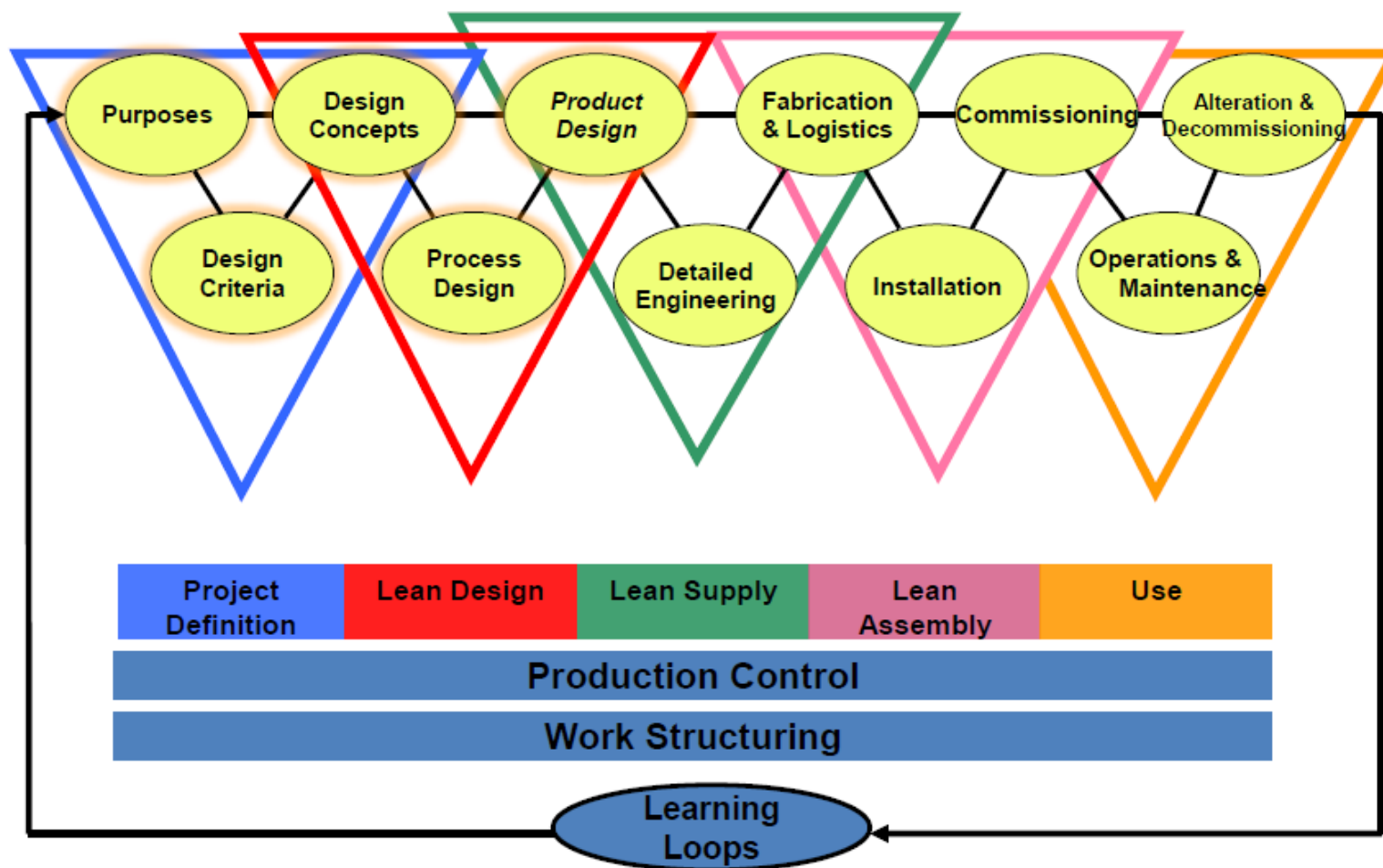
- ❖ Refers to a **completed facility**, and
- ❖ Contains the activities
  - ✓ Commissioning,
  - ✓ Operations and maintenance, and
  - ✓ Alteration and decommissioning.
    - Following successful commissioning, the facility should **undergo a protracted operations and maintenance** phase as it is used.
    - “Alteration and Decommissioning” refers to a **future activity** when the facility may be repaired, renovated, or taken out of service.

# **Lean in Construction Phase of the LPDS**

## **(Learning Loops)**

## Structure of the lean project delivery system (LPDS)

❑ Source: Adopted from Ballard and Howell, Building Research and Information, 2003



## Learning loops

❑ **“Learning loops”** refer to the **application of root cause analysis** to construction activities to

**review PPC values and commitment reliability.**

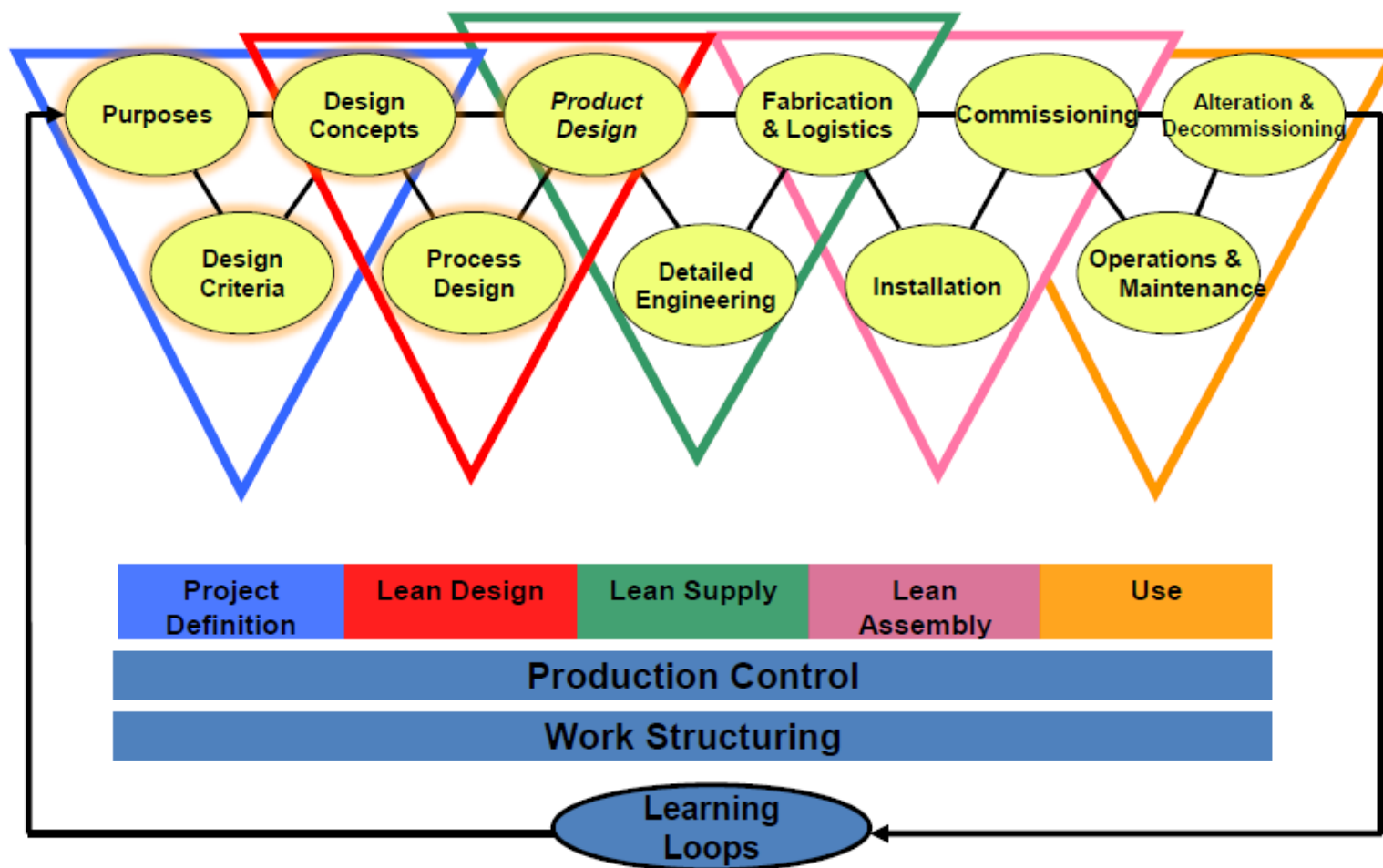
- ✓ In this review, **project teams** determine the **reasons** why the tasks planned for a particular week may **not have been accomplished**.
- ✓ **If errors are detected** in this review, the team endeavors **“not to make the same mistake in succeeding weeks”**.

# **Lean in Construction Phase of the LPDS**

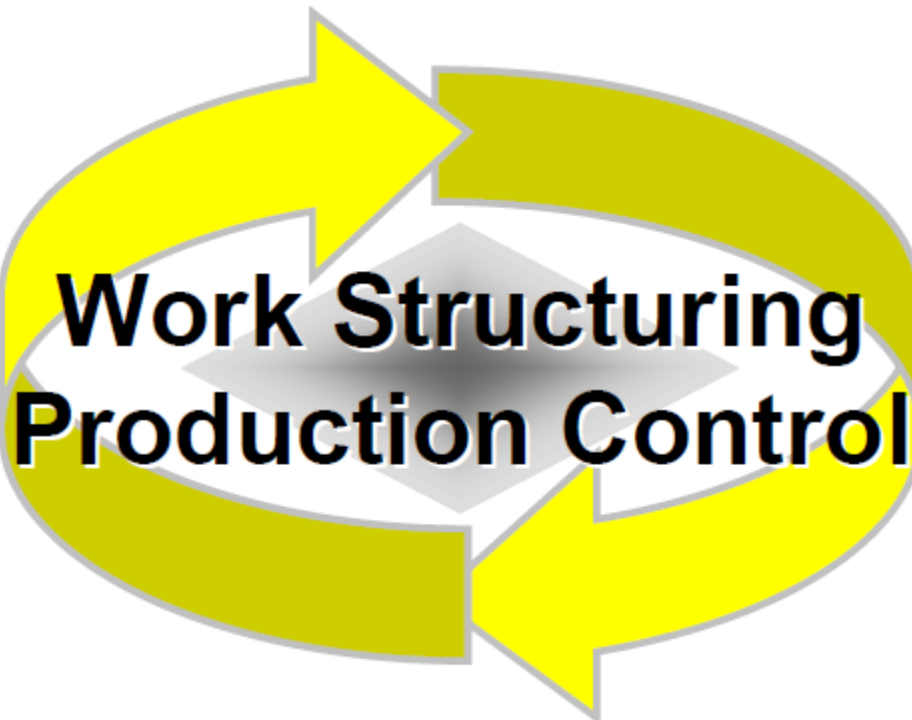
## **(Production Control and Work Structuring)**

## Structure of the lean project delivery system (LPDS)

❑ Source: Adopted from Ballard and Howell, Building Research and Information, 2003



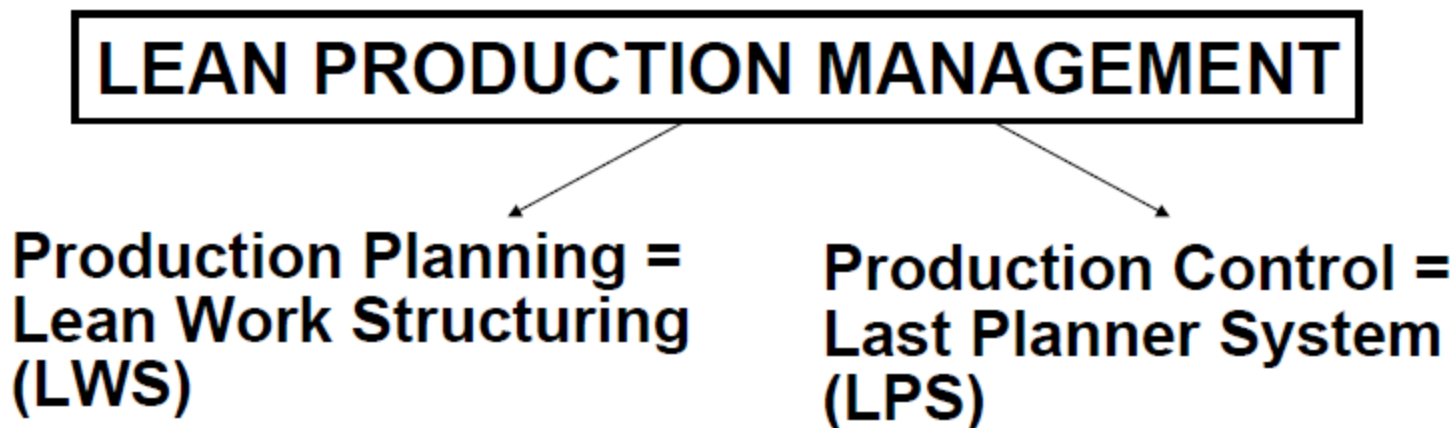
We will first discuss the  
“heart” of the LPDS:  
Work Structuring and  
Production Control



**Work Structuring  
Production Control**

## Lean production management

- ❑ **Reliable workflow** at these levels achieved using:



## Lean production management

**LEAN PROJECT AND PRODUCTION  
PLANNING**



**LEAN WORK STRUCTURING (LWS)**

## Lean work structuring

- ❑ Work structuring and production control are used **throughout a project** to manage production (Ballard 1999).
- ❑ Work structuring is a **process of subdividing work** so that pieces are different from one production unit to the next to **promote flow**.
- ❑ Work structuring develops and aligns the **project's process design** with
  1. Engineering design,
  2. Supply chain capability,
  3. Resource allocation strategies, and
  4. Assembly efforts.

Is it WBS?

## Lean work structuring

- ❑ Work structuring differs from **work breakdown structure** which was traditionally used by planners to

**decompose a project into work packages** to create a framework for project planning, scheduling, and controls in the functions it performs.

What questions WS answers?

## Lean work structuring

□ Work structuring answers the following questions:

- (1) In **what units** will work be assigned to groups of workers?
- (2) **How** will work be **sequenced**?
- (3) **How** will work be **released** from one group of workers to the next?
- (4) Will **consecutive groups** of workers execute work in a **continuous flow** process or will their work be **decoupled**?
- (5) Where will **decoupling buffers** be needed and how should they be **sized**?
- (6) **When** will different units of work be **done**?

(Howell et al. 1993 and Tsao et al. 2004).

What are some of the products of work structuring?

## Lean work structuring

❑ Some of the products of work structuring are:

❖ **Project execution strategies** including global sequencing where sequence of execution is delineated

*building A, then D, then B etc; or build floors of hi-rise in quadrants going counterclockwise starting at the north side*

❖ Project **organizational** and **contractual structure**

❖ Configuration of **supply chains**

❖ **Detailed operations design**

*how to form-rebar-pour basement walls*

❖ **Master schedules**

❖ **Phase schedules**

## Work structuring and last planner

❑ In the **Last Planner® System of production control**,

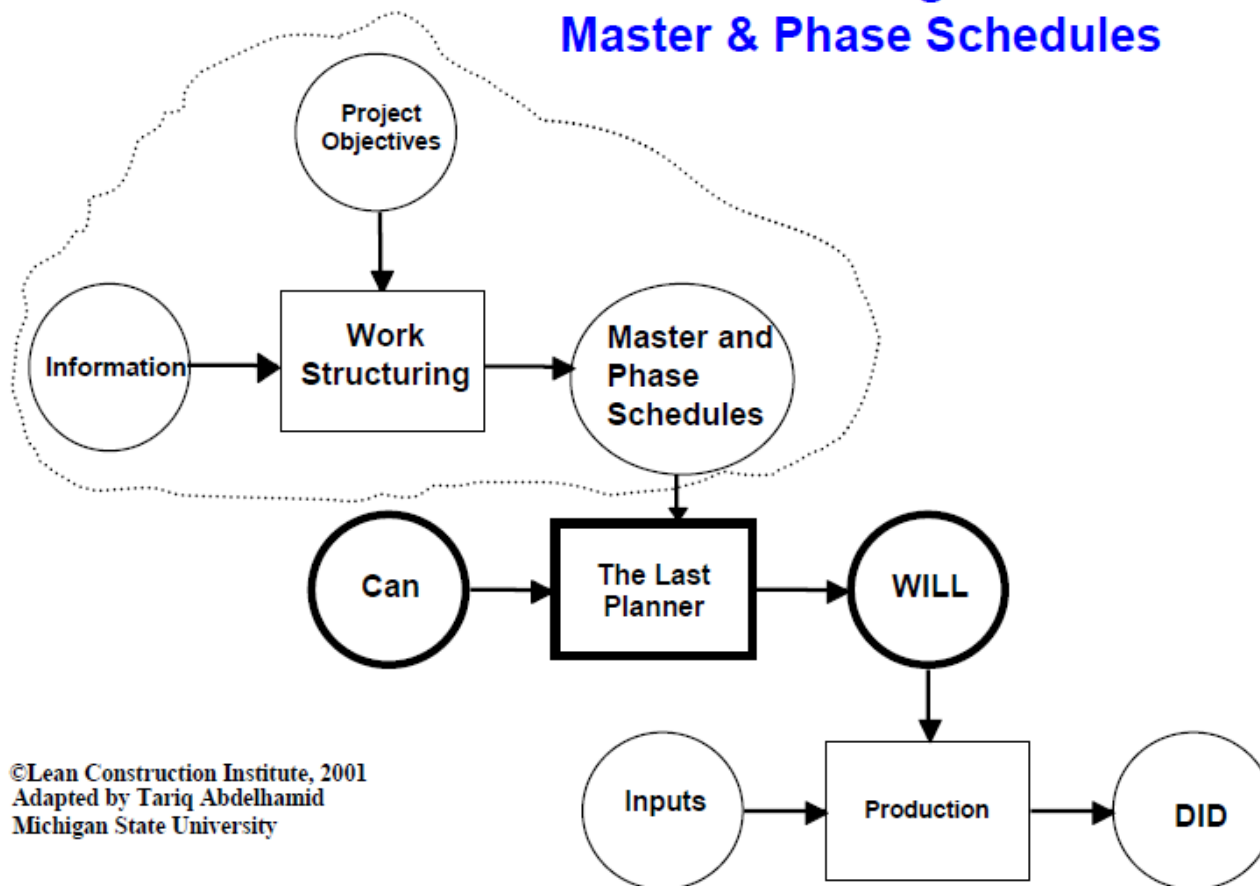
work structuring culminates in the **form of schedules** that represent **specific project goals**.

❖ **Schedules** are created for **each phase of the project**,

1. **Beginning** at the design phase, and
2. **Ending** at project completion.

## Work structuring and last planner

### Work Structuring: Master & Phase Schedules



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Adapted by Tariq Abdelhamid  
Michigan State University

## Lean production control

- ❑ **Production control** is represented in the LPDS as a horizontal bar that extends from the very inception of the project to its conclusion.
  - ❖ It consists of **work flow control** and **production unit control**.

## Lean production control and Last planner

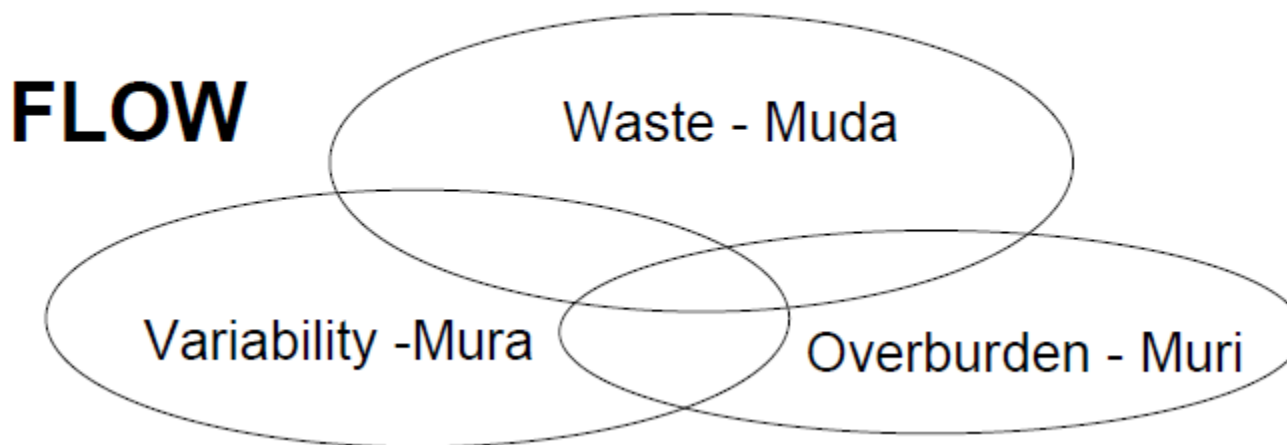
### ❑ The LPS of production control

sets up and manages schedules in order that:

- ❖ The **flow** of work is **structured** for the project.
- ❖ **Workflow** is **planned** within the **structure** of the work.
- ❖ **Work** is **controlled** to accomplish the plan.
- ❖ **Weekly measurement** evaluates **accomplishment** and **permits** fine tuning for improvement.

## Lean production control

- ❑ Improve **workflow reliability** on **your site** by thinking through **production process** during product design.
- ❑ Thinking **production (flow)** during **design** and **project planning**



# **Lean in Construction Phase of the LPDS**

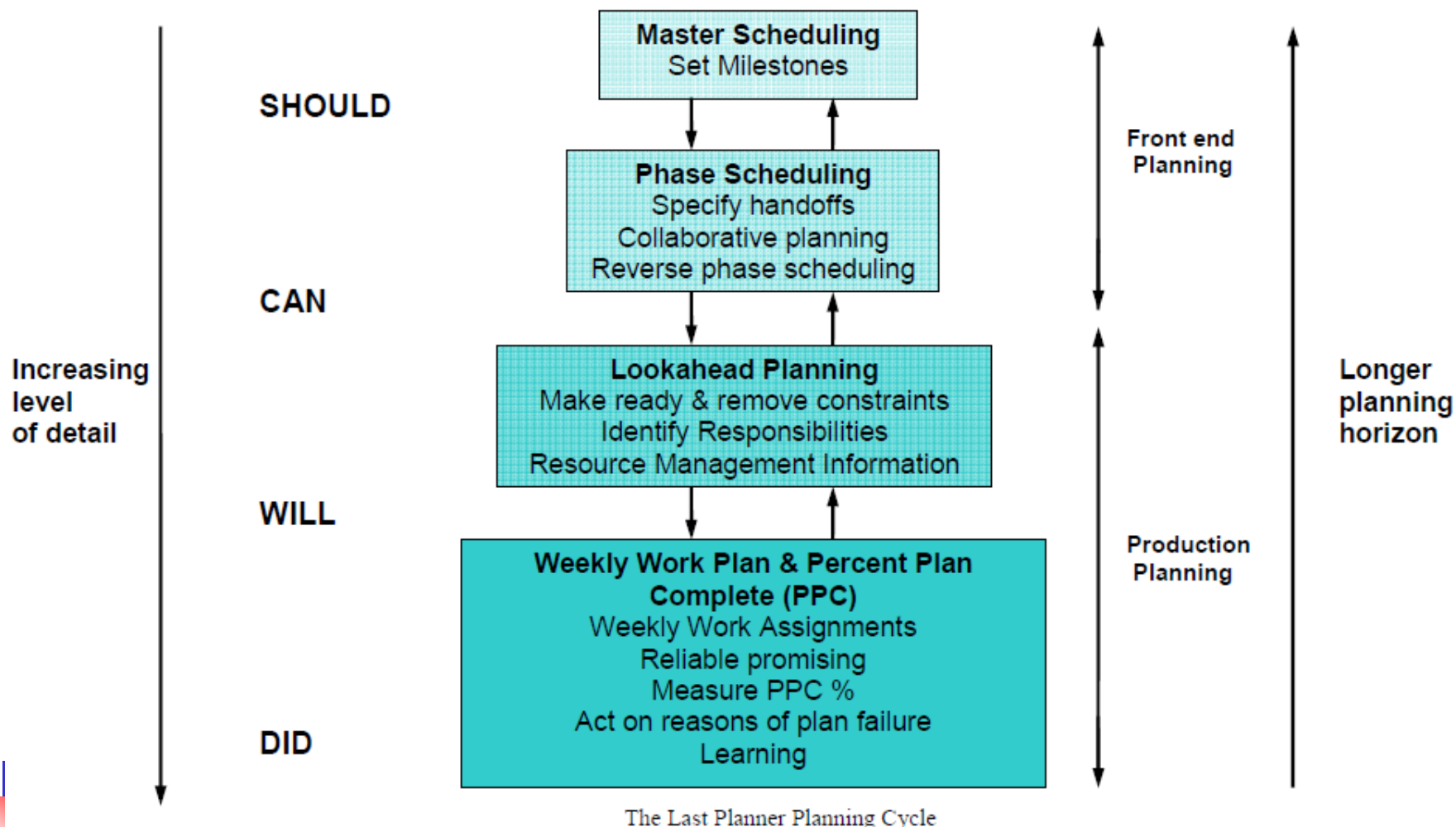
## **(The Last Planner System in Construction)**

## Requirement for successful application of the LPS in the construction phase

- ❑ The **reliability of the LPS** and **lean construction** hinges on **informed commitments** to maintain the **trust** that is essential for **avoiding waste**.
  - ❖ If **subcontractor (Sub) B** depends on **Sub A** to have a work area **available by a given day**,
    - ✓ then **Sub B** should be able to **mobilize crews** for that day **without the reservation** that Sub A might not keep its promises.
    - ✓ Should that **occur**, **Sub B** could incur **significant waste** by having workers report for duty **without being able to carry out** the scheduled tasks.

## Last planner system – Interconnected conversations

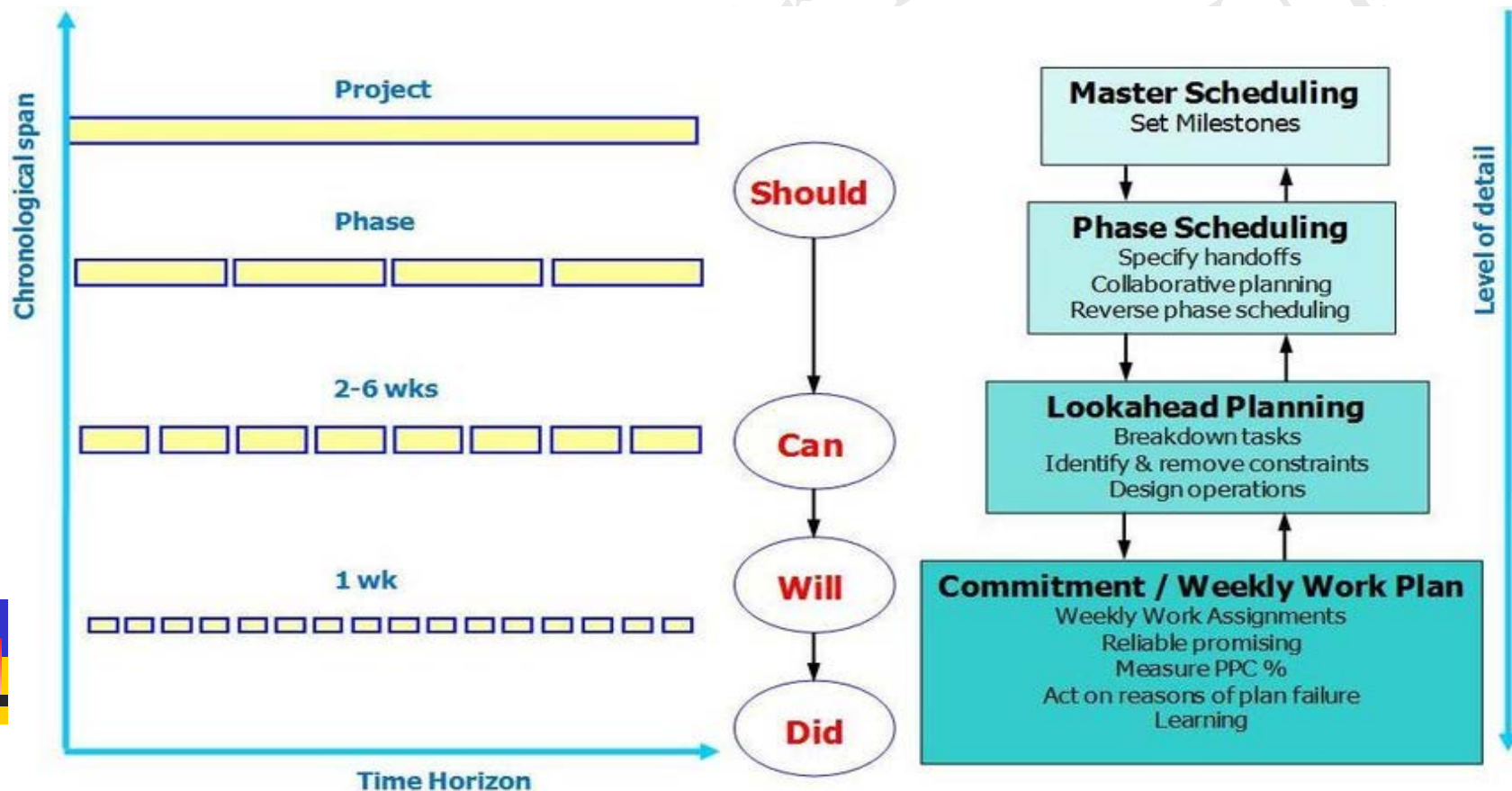
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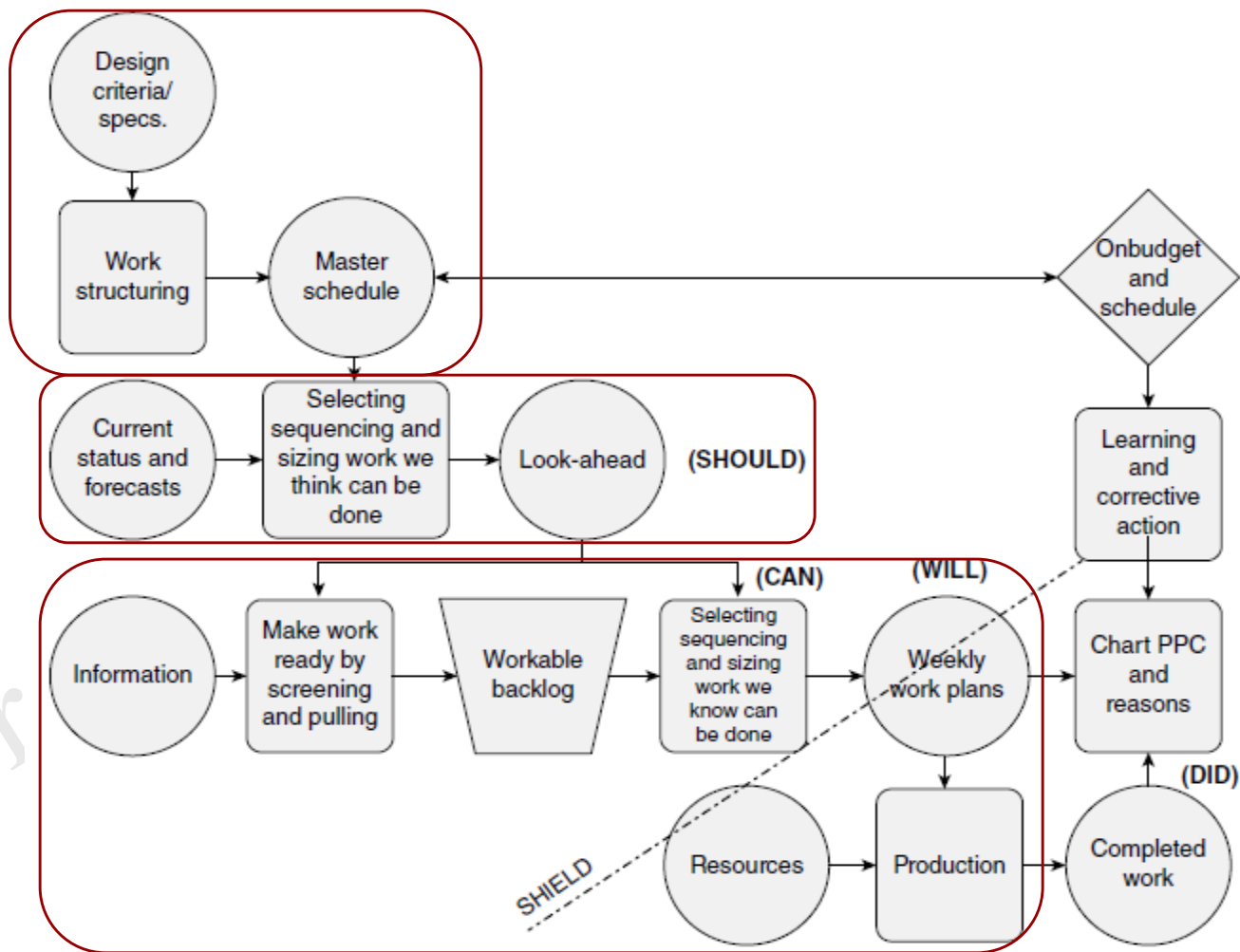
## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

1. Level 1: The master pull schedule
2. Level 2: The look-ahead schedule
3. Level 3: The WWP
4. Level 4: Certain projects may require a daily work plan

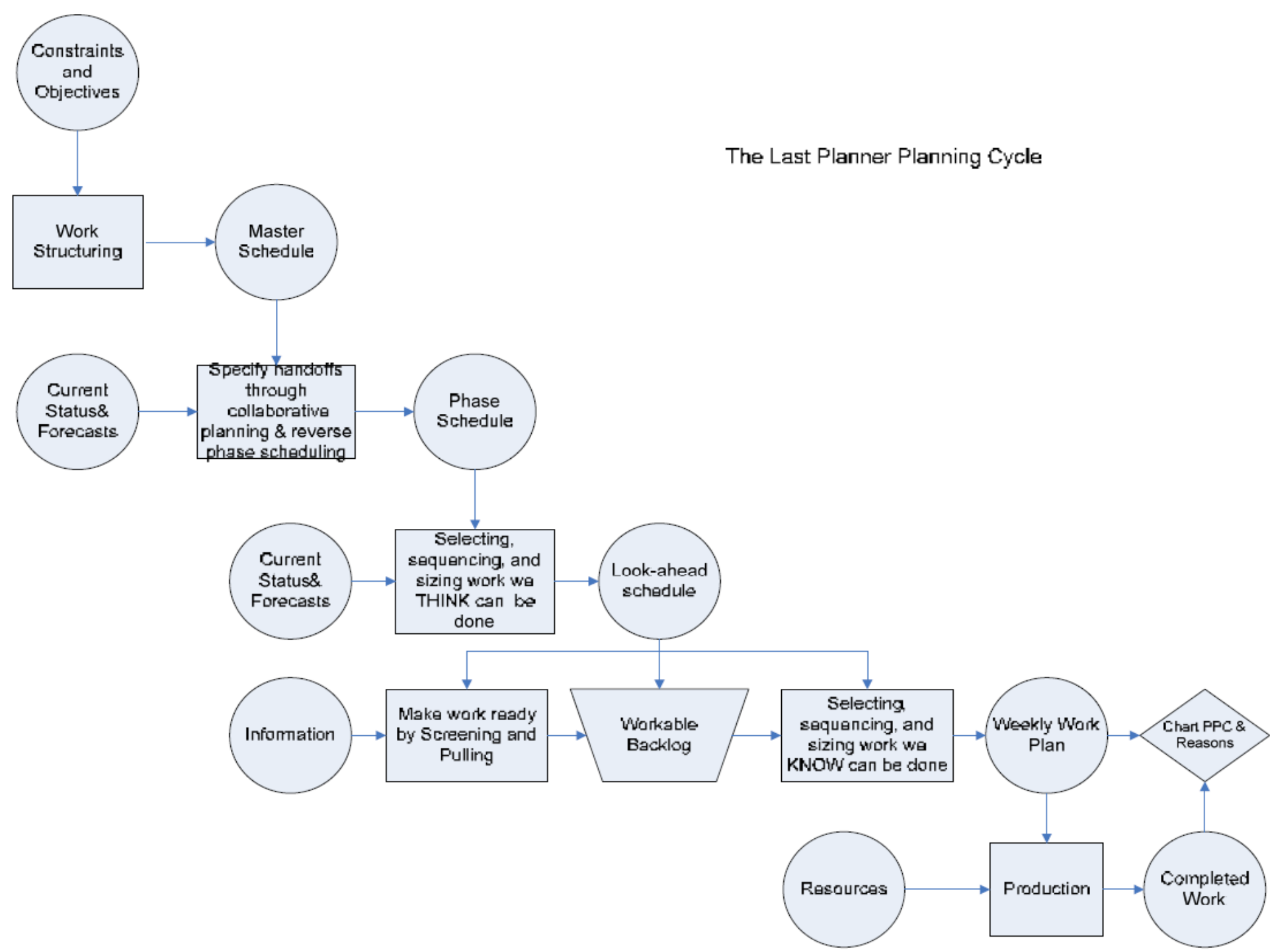


## Last planner in construction



The Last Planner® System: process flow

## The Last Planner Planning Cycle



## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

1. **Level 1: The master pull schedule**
2. **Level 2: The look-ahead schedule**
3. **Level 3: The WWP**
4. **Level 4: Certain projects may require a daily work plan**



## Level 1: Master pull schedule – Master schedule

- ☐ The **master schedule** may be used to establish
  1. **Project feasibility**
  2. **Likely duration**.
  
- ☐ It identifies **long lead-time items**.
  
- ☐ If it is prepared **before design work** is completed,
  1. **Establishes** packages for action by designers
  2. **Plans** their **sequencing** and **timing**.

**We should have a meeting first!**  
**What should be done in the process of meeting?**

## Level 1: Master pull schedule – Master schedule

- ❑ This **planning** occurs in a **meeting of project participants and stakeholders**.
- ❑ The **steps** in the meeting process are:
  1. Have an **agenda** ready for the **meeting**;
  2. **Introduce** the **entire team** so that stakeholders will know each other;
  3. **Ensure** that all required **project data** are **available**;
  4. Use **“Post It” notes** on a **wall-mounted board**;
  5. Use a **backward (Pull) approach** for assignments;
  6. **Promote creativity** (with controlled chaos) to generate a broad cross section of ideas;
  7. **Identify float** and **verify** with **stakeholders**;
  8. **Document** the **plan** (P6 or MS project are examples of software)
  9. **Review** and **fine tune** the **plan**.

What are the **limitations** in preparing master schedule?

## Level 1: Master pull schedule – Master schedule limitations

❑ There are significant **limitations** in the **master schedule**.

1. It is generally prepared by **people who are not going** to do the work.
2. It is similar to **preplanning**.
3. While the **master schedule** is followed closely in **traditional projects**, it is **further modified** in lean construction projects.

❖ **Phase scheduling**, on the other hand, gets people involved who are **actually going** to do the work.

✓ *For that reason it is generally more realistic to break down a master schedule into*

1. Look-ahead schedule
2. Weekly or daily schedule.

What are the **steps** in preparing master schedule?

## Level 1: Master pull schedule – Master schedule steps

❑ **Planning and scheduling** to prepare a **master schedule** may involve following steps:

1. The project is **subdivided** into **major work activities**.
2. The **duration** and **work force requirements** are determined for **each milestone**.
3. The **activities** are placed in a **logical sequence** to form the master schedule.
  - ❖ *For example, an **excavation** has to be made and **reinforcement** placed before a concrete foundation can be poured.*
4. **Project duration** is determined from the **overall sequence** of activities and their respective durations.
5. **Overall duration** is reconciled with the **contractual requirements** of each project.
6. **Activity durations** are adjusted through **resource utilization**.
  - ❖ *For example, the time required for placing reinforcement can be accelerated by increasing the number of crews carrying out that activity.*

## Level 1: Master pull schedule – Master schedule steps

❑ **Planning and scheduling** to prepare a **master schedule** may involve following steps:

5. The **master schedule** is further **refined**, using the **CPM** to

(a) **Identify the critical path**

✓ The sequence of activities that directly affect overall project duration

(b) **Identify “float” or “slack time”** that determines how long an activity can be delayed without jeopardizing the schedule.

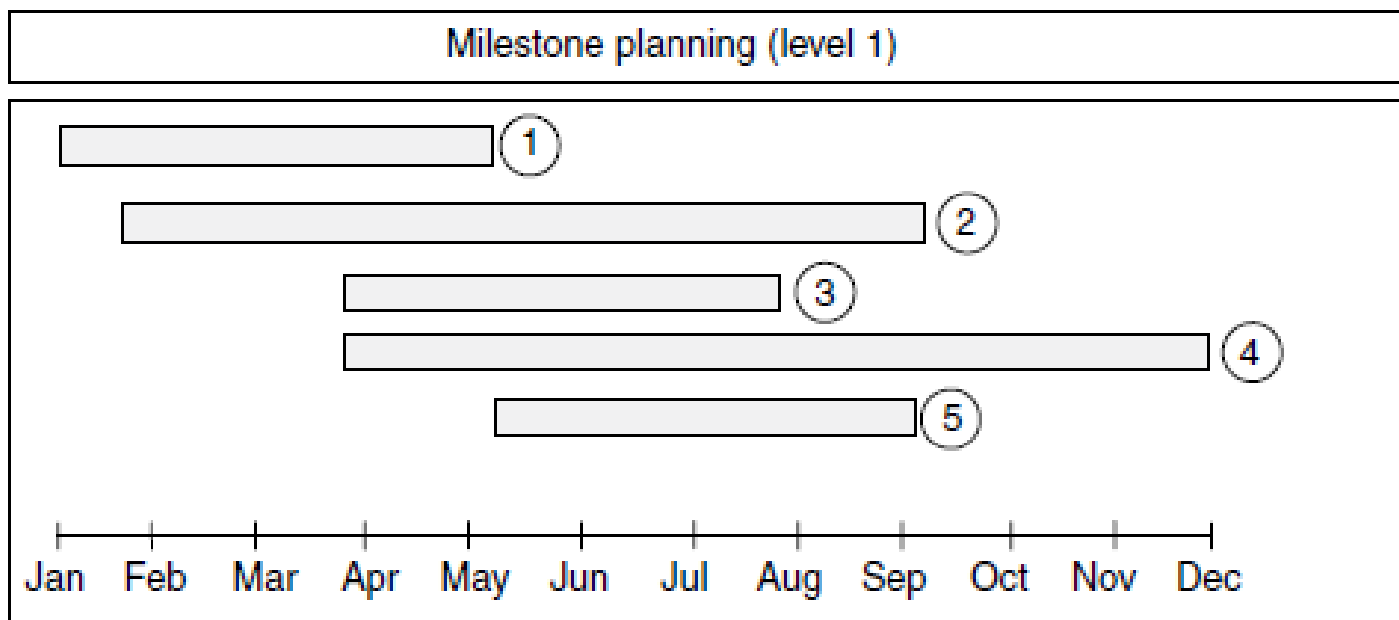
What else included in master schedule?

## Level 1: Master pull schedule – Master schedule

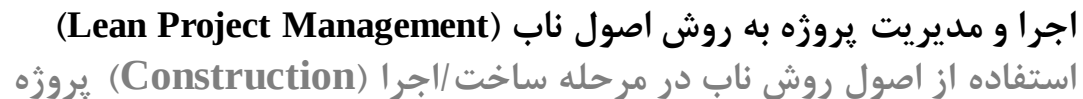
❑ The **master schedule** also includes **infrastructure items** based on:

- ❖ Estimated quantities
- ❖ Estimated craft density to complete the work safely and cost effectively.
- ❖ Standard rates for labor
- ❖ Labor distribution curves (industry based, or company based)

## Level 1: Master pull schedule – Master schedule



The master pull schedule



A sample Master Schedule.



## Level 1: Master pull schedule – Master schedule

So, why we need Reverse Phase Scheduling?

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ Traditional construction emphasizes **pushing tasks** to meet an **optimistic master schedule**,

with **little thought** to what CAN and WILL be done in a **given time frame**.

- ❑ In LPS, the **master schedule** is refined as a **reverse phase schedule** by using a team to **work backward** from the **expected completion date**.
  - ❖ This team comprises “**last planners**” from different **trades/subcontractors**.

The master schedule and reverse phase schedule indicate **what work SHOULD** be done **in order** to meet the schedule.

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ Reverse phase scheduling (RPS) (often termed “pull planning”) specifies the **hand offs between trades** for **each project** phase.
  - ❖ In practice, **subcontractors participate extensively** in **RPS**.
- ❑ They typically use **Post-It notes on a wall-mounted board** to plan their schedules in concert with the **schedule for each project phase**.
- ❑ The **integration and coordination of various specialists’ operations** is the **purpose** of the **phase schedule**.

So, what would be the **level of detail** in the **phase schedule**?

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

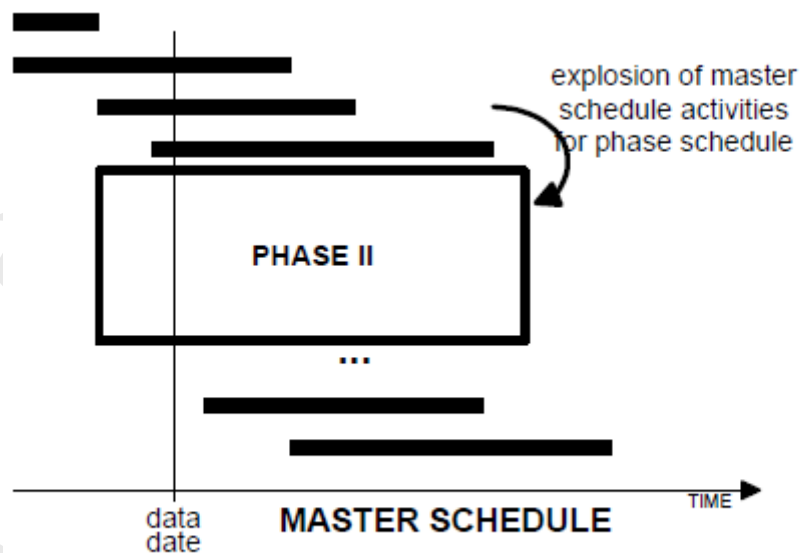
- ❑ The **level of detail** in the phase schedule is determined by **requirement** that the phase schedule specify the handoffs between the **specialists** involved in doing the work in that phase.
  - ❖ These **handoffs** then become **goals** to be achieved through production control.
  - ❖ Remember that we are in front end planning?
    - ✓ When projects are *large and complex*,
      1. A single master schedule may represent activities only in **broad terms** and
      2. A *single look-ahead* to cover **all exploded tasks** may become unwieldy.

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- Rule 1: Allow activities to remain in the Master/Phase schedule unless positive knowledge exists that it should not or cannot be executed when scheduled.

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ Accordingly, the **master schedule** may be broken up into phase schedules as shown.
- ❑ With **master schedule** activities being **exploded into sets of tasks** to cover the **entire activity duration**,  
each one grouping work that need to be performed in **close spatial**.



Exploding Master schedule into a Phase schedule

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ LCI recommends using pull techniques and team planning to develop schedules for **each phase** of work,  
from **design through turnover**.
- ❑ The **phase schedules** thus produced are based on **targets and milestones** from the **master project schedule** and provide a **basis for look-ahead planning**.

How **team planning** performed in the phase schedule?

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

1. Team planning involves **representatives** of all organizations that do **work within the phase**.
2. Typically, team members **write on sheets** of paper brief descriptions of
  - ✓ **Work** they must perform in order to **release work to others**
  - ✓ **Work** that must be completed by others to **release work to them**
3. They **tape or stick** those sheets on a **wall** in their **expected sequence** of performance.
4. Usually, **planning breaks out in the room** as people begin
  1. Negotiating sequence
  2. Batch size

when they see the **results of their activities** on others.

**What should be done next?**

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

1. The **first step** of **formalizing the planning** and the phase schedule is to develop a **logic network** by **moving** and **adjusting** the **sheets**.
2. The next step is to **determine durations** and see if there is **any time left between the calculated start date** and the **possible start date**.
  - ❖ It is critical that durations **not be padded** to allow for **variability** in performing the work.

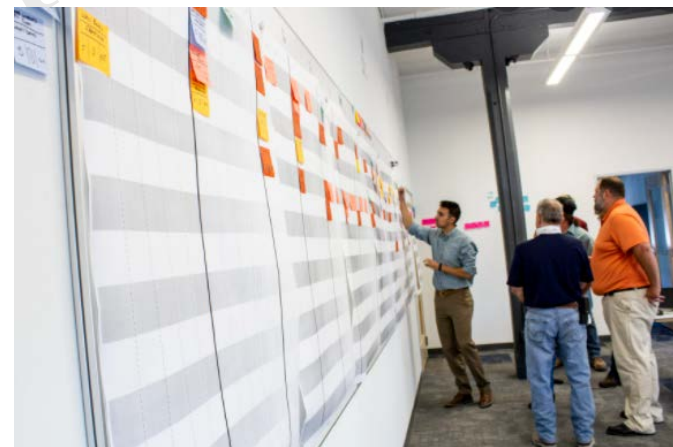
We first want to produce an ‘**ideal**’ schedule based on **average duration** estimates.



**What should the team work on next?**

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

1. The **team** is then invited to  
**reexamine** the schedule for logic and intensity application of **resources** and **methods**) in order to **generate a bigger gap**.
2. Then they decide **how to spend** that time:
  - 1) Assign to the **most uncertain** and **potentially variable task durations**,
  - 2) **Delay the start** in order to
    - i. Invest **more time in prior work** or
    - ii. Allow the **latest information to emerge**, or
  - 3) **Accelerate** the phase completion date.



**What should be done if the gap is not enough to absorb **variability**?**

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ If the **gap cannot be made sufficiently** positive to absorb variability,
  1. Phase **completion date** must **slip out**, and
  2. Attention turns to **making up** that time **in later phases**
    - ❖ The **key point** is to **deliberately** and **publicly** generate, quantify, and allocate **schedule contingency**.



What would we **achieve** at the end of this phase?

## Level 1: Master pull schedule – Reverse phase scheduling (pull planning)

- ❑ Critical path is **identified**.
- ❑ Acceptable amount of **contingency** can be introduced to accommodate **risk and uncertainty**.
  - ❖ This approach is based on the **pull technique**.
- ❑ The **resulting phase plan** provides a **framework** for **integrating** the work of various specialists that are needed to carry out their respective work plans.

It is **more realistic** than the master schedule,  
but does **not make allowances** for conditions in the field  
that **may fluctuate** from **week to week**.

What are the **steps** in preparing **reverse phase schedule**?

## Level 1: Master pull schedule – Steps to phase/pull scheduling

1. **Define the work** to be included in the phase; e.g., foundations, building skin, etc.
2. **Determine the completion date** for the phase,  
plus any **major interim releases** from prior phases or to subsequent phases.
3. Using **team scheduling** and **Post-It Notes** (i.e., sticky notes) on a wall,
  - a) Develop the **network of activities** required to complete the phase,
  - b) Working **backwards** from the completion date, and
  - c) Incorporating any **interim milestones**.
4. Apply **durations to each activity**, with **no contingency or float** in the duration estimates
5. **Reexamine** logic to try to **shorten the duration**
6. Determine the **earliest practical start date** for the phase.

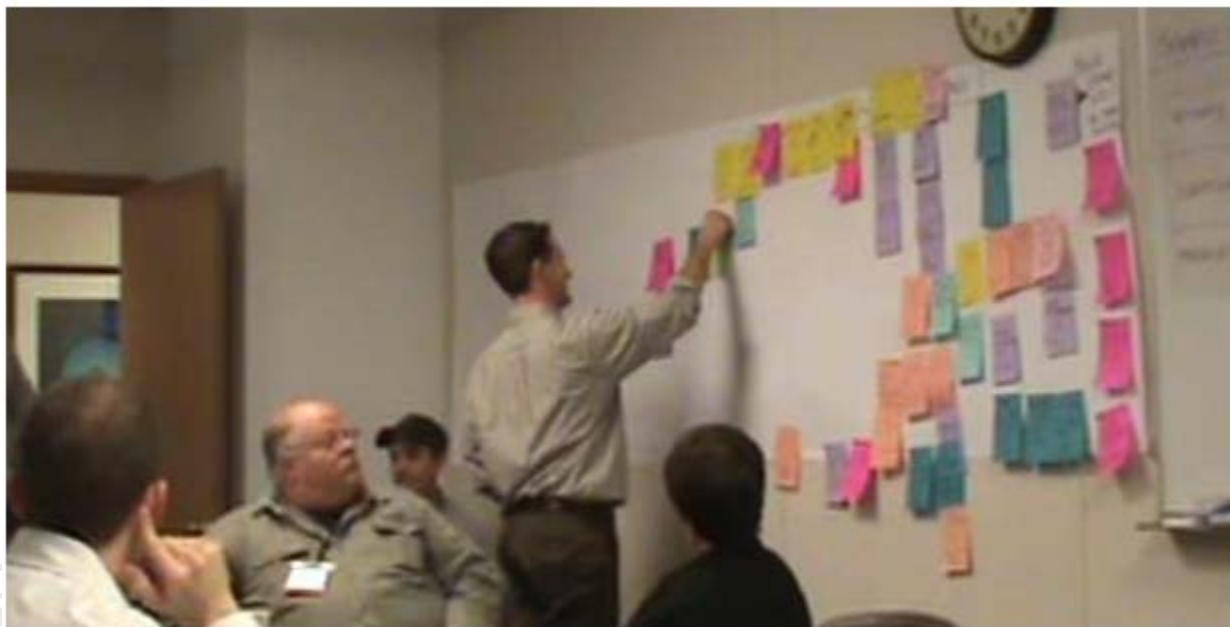
## Level 1: Master pull schedule – Steps to phase/pull scheduling

7. If there is **time left over** after comparing the time between start and completion with the duration of the activities **on the wall**,  
decide **what activities** to **buffer** with **additional time**.
  - a) Which activity durations are **most fragile**?
  - b) **Rank order** the fragile activities by **degree of uncertainty**.
  - c) **Allocate available time** to the fragile activities in **rank order**.
8. Is the **team comfortable** that the available buffers are **sufficient to assure completion** within the milestone(s)?  
If not, **either re-plan or shift milestones** as needed and possible.
9. If there is **excess time available**, decide whether to
  - a) **Accelerate** the schedule or
  - b) Use the **excess** for **other phases**

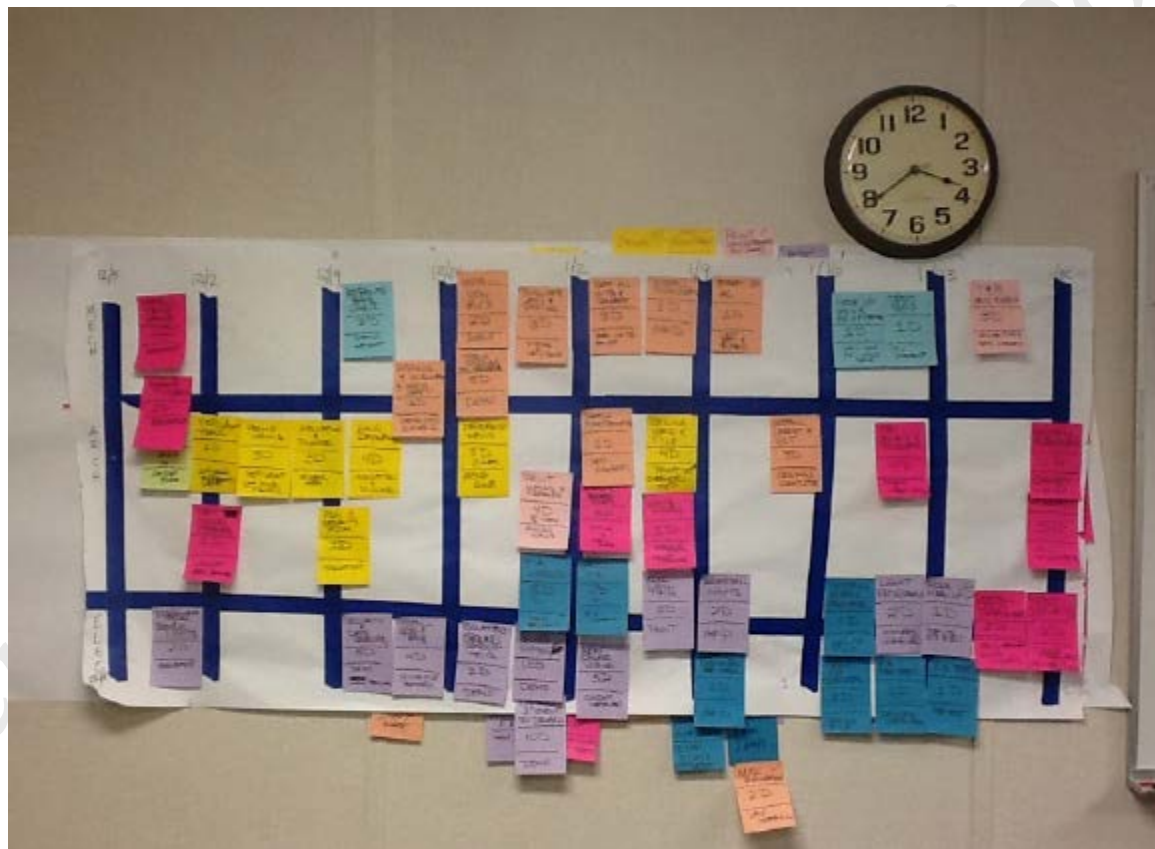
## Level 1: Reverse phase scheduling (pull planning)



## Level 1: Reverse phase scheduling (pull planning)



## Level 1: Reverse phase scheduling (pull planning)



## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

1. **Level 1: The master pull schedule**

2. **Level 2: The look-ahead schedule**

3. **Level 3: The WWP**

4. **Level 4: Certain projects may require a daily work plan**

budget and

SHIELD

## Level 2: Look-ahead planning and scheduling

### ❑ Lookahead planning involves

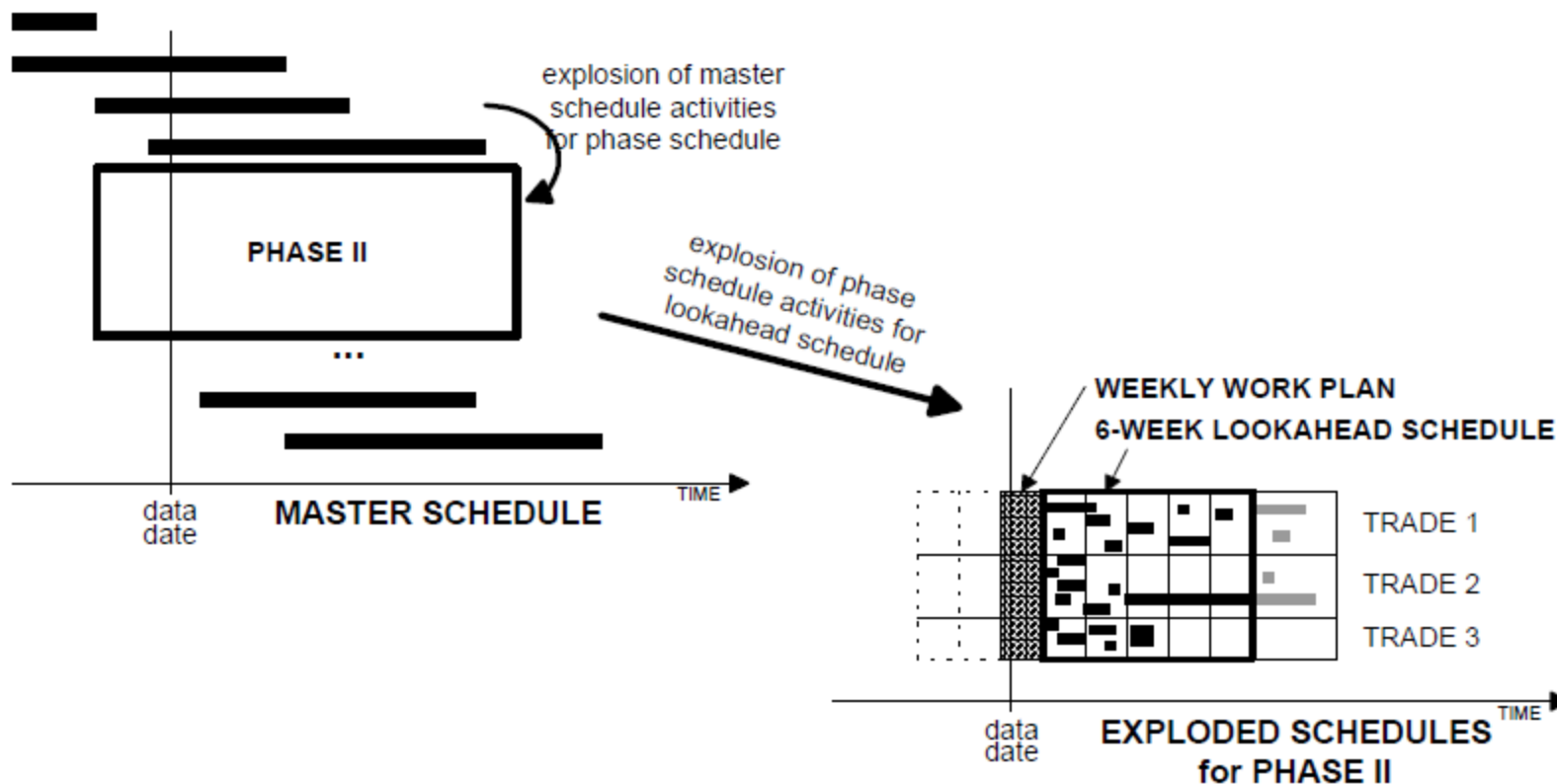
#### 1. **Taking** activities from the master schedule

- ❖ It reflects **major work items** that need to be completed for the **milestone dates** in the **master pull schedule**.
- ❖ It identifies the **work activities** that CAN be done, **within the constraints** that have been indicated.
  - ❖ **Constraints** are identified so they can be **planned for ahead of time**.
  - ❖ *The trade foremen are specifically asked what CAN be done in light of issues such as weather conditions, availability of crews, etc.*

#### 2. **Placing** them in the look-ahead schedule.

- ❖ This schedule represents a time frame that is **generally 4–8 weeks in length** for **construction tasks**.
  - ✓ That **duration** has been identified by **experience** as the **most flexible**.

## Level 2: Look-ahead planning and scheduling



Exploding Master schedule into a Phase schedule

**Which activities get posted on the look-ahead schedule?**

## Level 2: Look-ahead planning and scheduling

- ❑ The **front end planning process**, resulting in master schedule and phase schedule, covers **all activities in the entire project**.
  - ❖ By contrast, the **look-ahead** includes only **activities** that **meet certain considerations**.
  - ❖ The **look-ahead window** determines **how far ahead** of the scheduled start date activities in the **master schedule are considered** for entry into the look-ahead.

What are the **purposes** of look-ahead schedule?

## Level 2: Look-ahead planning and scheduling

- ❑ The purpose of look-ahead planning is
  - ❖ Shapes work **flow sequence** and **rate**
  - ❖ Matches work flow to **system capacity**
  - ❖ Creates **workable backlog**: a backlog of work that is ready to be scheduled
  - ❖ Prepares **detailed work** plans

What are the **brief steps** in preparing **look-ahead schedule**?

## Level 2: Look-ahead planning and scheduling – Brief steps

### *Brief Steps for Look-Ahead Planning*

1. **Move tasks** from the **Phase Schedule** (i.e., Pull Plan) onto the Look-Ahead Schedule (Four-Week Look-Ahead, Eight-Week Look-Ahead...)
  - ❖ **Add more detailed tasks** as needed
2. **Each week**, the **Last Planner Team** screens tasks for **constraints**
  - ❖ Materials, information, obstacles, permissions; anything needed to do the task
3. The Team Members **make commitments** to **remove constraint**
4. These **commitments** are **added** to the **Look-Ahead Schedule**

## Level 2: Look-ahead planning and scheduling – Brief steps

### *Brief Steps for Look-Ahead Planning*

5. Keep a **log of constraints** for which commitments have **not been made**.
6. The **Project Last Planner Team** only allows tasks to **keep their scheduled dates** if the team is confident all constraints will be **removed** in time to perform the task.
7. As tasks near their start date (**about 3 weeks out**), Last Planner Team
  1. **Breaks** the tasks into **operations** and
  2. **Develops detailed (daily) plans** for how the work will be done
    - ❖ These daily tasks form the Weekly Work Plan

What **major criteria** look-ahead schedule should have?

## Level 2: Look-ahead planning and scheduling – Major criteria

❑ Look-ahead schedule items should meet the **following criteria**:

1. Manageable size:

- ❖ Schedule items are **small enough**, so they can be **detailed to show downstream tasks** that prompt work release.

2. Readily measurable:

- ❖ **Progress and remaining durations** should be measurable.

3. Free of constraints:

- ❖ It should be made clear **where those constraints** that have **not been resolved** are so as not to obstruct the flow of work.

Let's look at five quality criteria!

## Level 2: Look-ahead planning and scheduling – Five quality criteria

- ❑ In a **landmark paper** on shielding, **Ballard and Howell** proposed **five quality criteria** against which a **task must be checked**

**before it is allowed** into the weekly work plan (Ballard and Howell 1998)

1. **Definition:** Is the task specific? Will it be clear when it has been finished?
  - ❖ The work should be **specific** such that its **requirements** and **completeness** are clear.
2. **Soundness:** Are all materials available, including completed prerequisite work, for the task to be performed?
  - ❖ **Prerequisites** are **identified** and **constraints** are **removed**.
3. **Sequence:** Is the task being performed in the correct order?
  - ❖ The **sequence** of activities should be **best for constructability**.
4. **Size:** Is the task sized to the capacity of the crew?
  - ❖ The assignments should be matched to the capacity of the crew.
5. **Learning:** When assignments are not completed, are they tracked and reasons identified?

## Level 2: Look-ahead planning and scheduling – Five quality criteria

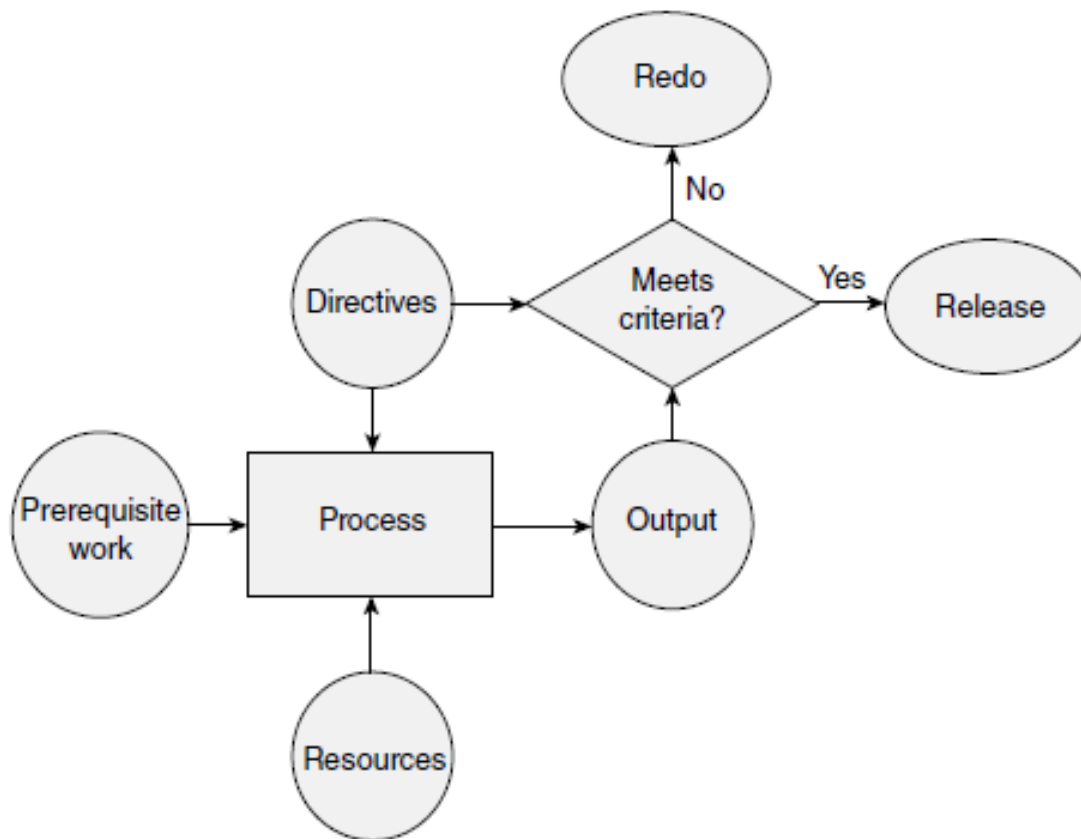
- Rule 2: Allow activities to remain in the lookahead window only if the planner is confident that it can be made ready for execution when scheduled. (Screening)

How to **define activities** while preparing look-ahead schedule?

## Level 2: Look-ahead planning and scheduling – Activity definition model

- ❑ It governs **assignments** that are moved from the phase schedule to the look-ahead plan.
- ❑ It represents design tasks or construction processes and enables planners to enhance scheduled tasks to a **level of detail**.
- ❖ Directives, prerequisite work, and resources are **three main sources** of constraints.
  - ❖ This evaluation requires
    1. **Determination of constraints** by examining directives to carry out tasks
    2. **Comparing** them with **available resources**
    3. **Evaluating the status of prerequisite work**.
      - ✓ If the **prerequisite work** for a task has **not been carried out**, then the **task cannot be carried** through to completion **even if the resources are available**.

## Level 2: Look-ahead planning and scheduling – Activity definition model

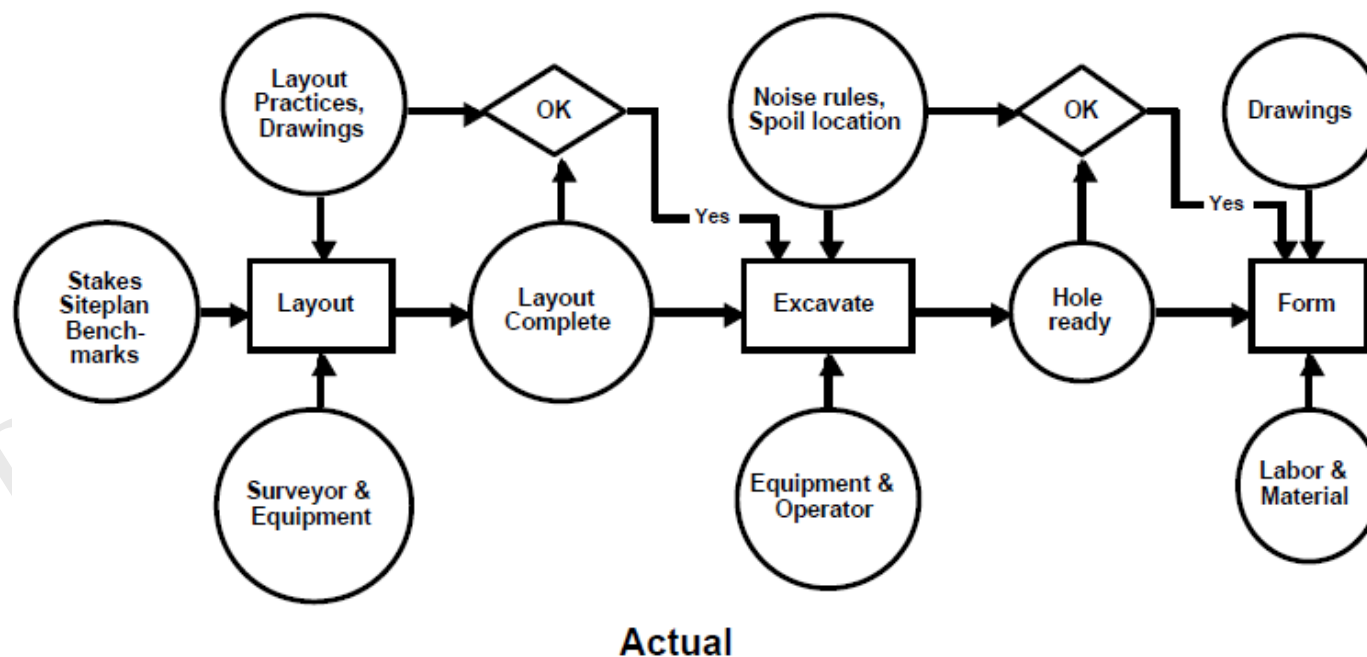
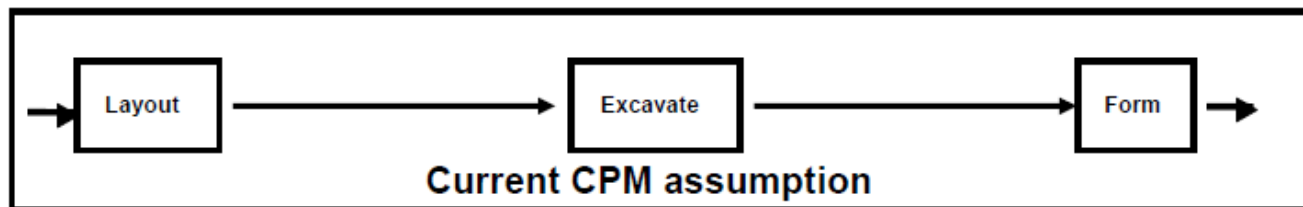


The activity definition model

Source: From Ballard, G., and Howell, G., *Building Research and Information*, 2003a. With permission

## Level 2: Look-ahead planning and scheduling – Activity definition model

### ❑ Task explosion



Who is responsible for **developing** and **maintaining** look-ahead schedule?

## Level 2: Look-ahead planning and scheduling – Responsible parties

- ❑ In the case of construction, the **supervisors** who are tasked with executing the schedule are assigned to **developing and maintaining** the **look-ahead schedule**.
  - ❖ They **obtain input** from the owner, designers, and material and equipment suppliers.
  - ❖ They **reconcile** the **work requirements** with the **contractor's labor estimates** for the project.

What if there is a **discrepancy** between **look-ahead** and **master pull plan**?

## Level 2: Look-ahead planning and scheduling – Discrepancy

❑ If there is a **discrepancy** between

1. Look-ahead schedule
2. Level 1 schedule,

Then, **re-planning is done** to bring them in line with each other.

What does **constraint** mean?

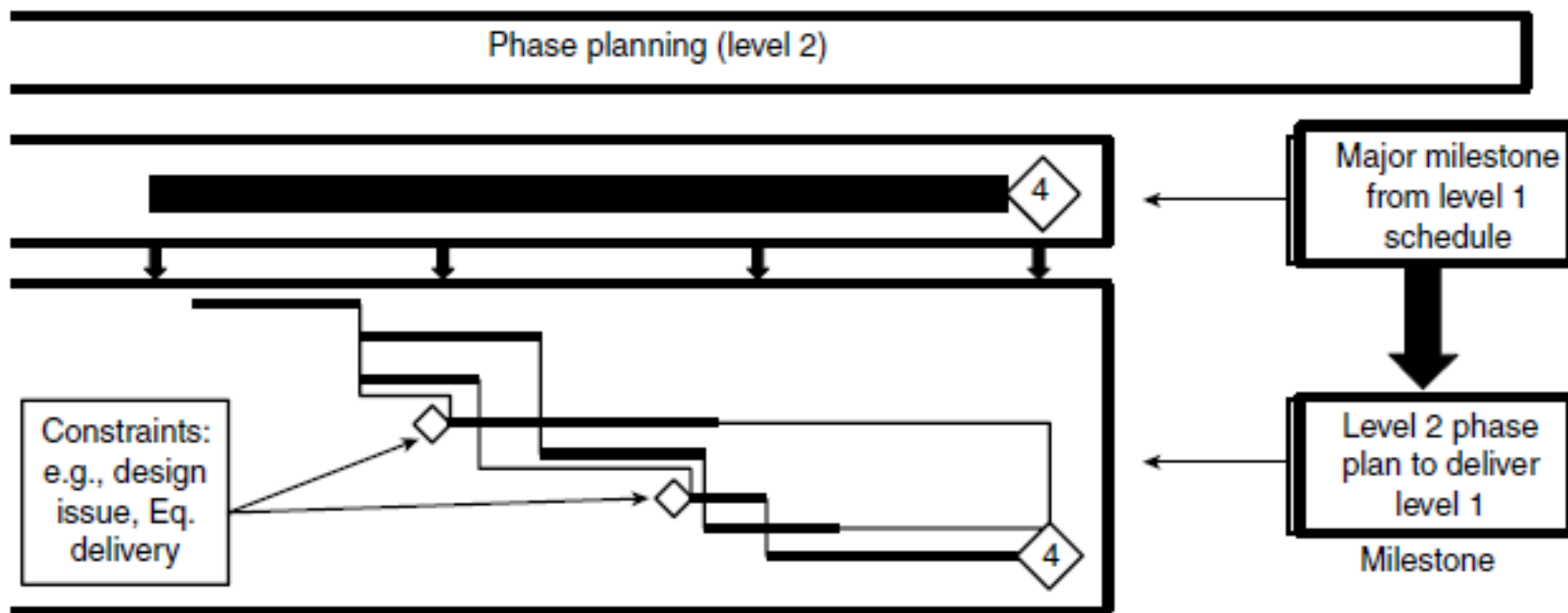
## Level 2: Look-ahead planning and scheduling – Constraint

- ❑ A **constraint** is an **obstacle** that **inhibits** the execution of a task that is required in the **look-ahead plan**.
- ❑ It should also be **beyond** the **control of the last planner** and should be **removed** so work tasks can be assigned.
- ❑ They have to **maintain communication** with the **foremen**, who as **last planners**, **coordinate** the work with **their counterparts** in **other trades**.

How **constraints** look in the schedule?

## Level 2: Look-ahead planning and scheduling – Constraint

- ❑ Lookahead planning includes constraints.



What are **typical constraints** included in look-ahead schedule?

## Level 2: Look-ahead planning and scheduling – Typical Constraints

### ❑ Typical constraints on design tasks are

- ❖ Inputs from others,
- ❖ Clarity of criteria for what is to be produced or provided,
- ❖ Approvals or releases, and
- ❖ Designer or engineering resources

### ❑ Typical constraints on construction tasks are

- ❖ Completion of design or prerequisite work
- ❖ Availability of
  - ✓ Materials
  - ✓ Information,
  - ✓ Labor
  - ✓ Equipment resources

### ❑ *Examples of constraints are:*

- ✓ *Adverse weather conditions,*
- ✓ *Unexpected events,*
- ✓ *Open RFIs, and*
- ✓ *Design modifications*

**What is the constraint analysis?**

## Level 2: Look-ahead planning and scheduling – Constraint analysis

❑ Constraints analysis involves **observing the rule** that

*no activity can be kept to its schedule date unless the planners are sure there are no outstanding constraints.*

❖ This approach ensures that **only “sound” assignments** are made that can be depended upon, be **free of limitations**, and will **not cause problems downstream**.

❑ Constraints analysis applies to the **production aspects** of projects, in **design**, **fabrication**, or **construction**.

How the **constraint analysis** should be performed in this step?

## Level 2: Look-ahead planning and scheduling – Constraint analysis

❑ Constraints should be **formally recorded** in a **log** to indicate

- ❖ Date of record,
- ❖ Requestor,
- ❖ Responsible party – who should take action on the constraint,
- ❖ Description of the constraint,
- ❖ Tasks/activities affected by the constraint,
- ❖ The date required for constraint removal (based on the look-ahead plan),
- ❖ Commitment date by the promissory,
- ❖ The cost impact of the constraint,
- ❖ Prerequisite work completed, and
- ❖ Resources that are unavailable, if any.

## Level 2: Look-ahead planning and scheduling – Constraint analysis

- Constraints show up on the Look-Ahead Schedule

| SIX WEEK LOOK AHEAD PLAN |       |                      |  |                   |                |      |      |      |      |      |            |
|--------------------------|-------|----------------------|--|-------------------|----------------|------|------|------|------|------|------------|
|                          |       | CONSTRUCTION MANAGER |  |                   |                |      |      |      |      |      |            |
|                          |       | PROJECT NAME         |  |                   |                |      |      |      |      |      |            |
|                          |       | PROJECT NUMBER       |  |                   |                |      |      |      |      |      |            |
|                          |       | SUBCONTRACTOR NAME   |  |                   |                |      |      |      |      |      |            |
| DURATION                 | Batch | Activity             |  | RESPONSIBLE PARTY | DATE 11-Dec-11 |      |      |      |      |      | CONSTRAINT |
|                          |       |                      |  |                   | WEEK           | WEEK | WEEK | WEEK | WEEK | WEEK |            |
|                          |       |                      |  |                   | 1              | 2    | 3    | 4    | 5    | 6    |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |
|                          |       |                      |  |                   |                |      |      |      |      |      |            |

- ...and also on a Constraints Log

| CONSTRUCTION MANAGER:   |             |                        |  |      |                                     |                    |                       |                  |                  |
|-------------------------|-------------|------------------------|--|------|-------------------------------------|--------------------|-----------------------|------------------|------------------|
| PROJECT:                |             |                        |  |      |                                     |                    |                       |                  |                  |
| PROJECT NUMBER:         |             |                        |  |      |                                     |                    |                       |                  |                  |
| RESPONSIBLE INDIVIDUAL: |             |                        |  |      |                                     |                    |                       |                  |                  |
|                         |             |                        |  |      |                                     |                    | UPDATE DATE:          |                  |                  |
| CONST #                 | Activity ID | CONSTRAINT DESCRIPTION |  | RFI# | RESPONSIBLE<br>ORG. &<br>INDIVIDUAL | DATE<br>IDENTIFIED | DATE NEED<br>RESOLVED | DATE<br>PROMISED | DATE<br>RESOLVED |
|                         |             |                        |  |      |                                     |                    |                       |                  |                  |
|                         |             |                        |  |      |                                     |                    |                       |                  |                  |

## Level 2: Look-ahead planning and scheduling – Constraint analysis

Constraint Analysis Worksheet, Benefits of the Constraint Analysis and Management Process

| <i>Item No.</i> | <i>Date</i> | <i>Requestor</i> | <i>Responsible Party</i> | <i>Description of Constraint</i>                                                                          | <i>Date Removal Required</i> | <i>Commit Date</i> | <i>Cost Impact?</i> | <i>Prerequisite Work Complete?</i> | <i>Resources Available</i> |
|-----------------|-------------|------------------|--------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------|--------------------|---------------------|------------------------------------|----------------------------|
| 1               | 3/11        | JB               | DB                       | Begin process of determining when control room floor plans will be available for planning electrical work | 4/7                          | 4/3                | None                | Yes                                | Yes                        |

## Level 2: Look-ahead planning and scheduling – Constraint analysis

- ❑ The Constraints Analysis Form, like the one shown, aids in systematically identifying and tracking the status of constraints on assignments.

Project:

Prepared by:

Date Prepared:

|   | Responsible Party       | Activity Description<br>Remember the Five Criteria for Release of Assignments<br>Defined - Sound - Proper Sequence - Right Size - Able to Learn | Make Ready Needs<br>Work That Must and Can Be Performed<br>Prior To Release of This Assignment | Period to Perform the Work |    |    |    |    |    |   | PPC Analysis |                                     |
|---|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------|----|----|----|----|----|---|--------------|-------------------------------------|
|   |                         |                                                                                                                                                 |                                                                                                | M                          | T  | W  | TH | F  | S  |   | Y            | N                                   |
|   |                         |                                                                                                                                                 |                                                                                                | 21                         | 22 | 23 | 24 | 25 | 26 |   |              | Reasons For Variance                |
| 1 | Structural designer     | Reevaluate Roof Design to support mechanical equipment                                                                                          | Mechanical equipment loads received                                                            | X                          | X  | X  | X  |    |    | X |              |                                     |
| 2 | Architect               | Internal layout drawings for 2nd floor                                                                                                          |                                                                                                | X                          | X  |    |    |    |    | X |              |                                     |
| 3 | Architect               | Reflected ceiling drawings for meeting rooms                                                                                                    | Finalize location of access panels                                                             |                            | X  | X  | X  | X  |    | X |              | Access panel location not finalized |
| 4 | Mechanical Engineer     | HVAC drawings for 2nd floor                                                                                                                     |                                                                                                |                            |    | X  | X  | X  |    | X |              |                                     |
| 5 | Electrical Engineer     | Low current drawings for 2nd floor                                                                                                              | Location of CCTV cameras                                                                       |                            |    | X  | X  | X  |    | X |              | Information not received            |
| 6 | Landscape architect     | Prepare schematic landscape design                                                                                                              |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
|   |                         |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
|   | <b>Workable Backlog</b> |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
| 1 | Architect               | Furnishing drawings for first floor                                                                                                             |                                                                                                |                            |    |    |    |    |    | X |              |                                     |
| 2 |                         |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
| 3 |                         |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
| 4 |                         |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |
| 5 |                         |                                                                                                                                                 |                                                                                                |                            |    |    |    |    |    |   |              |                                     |

## Level 2: Look-ahead planning and scheduling – Constraint analysis

| <b>BOLDT BUILDS</b><br>DESIGN & BUILD CONSTRUCTION COMPANY USA<br>Project: Same Day Surgery<br>Planner: Dana Deibert |                                         |                   | Six Week Lookahead / Constraints Analysis |          |          |          |          |          |          |          |          |          |         |          | Contract / C.O.'s |          |           |             |            |       |           |       |           |             | Week of 10-23-00 |                                                                                   |
|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------|-------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|-------------------|----------|-----------|-------------|------------|-------|-----------|-------|-----------|-------------|------------------|-----------------------------------------------------------------------------------|
| Week                                                                                                                 | Activity                                | Responsible Party | 10/24/00                                  | 10/31/00 | 11/07/00 | 11/14/00 | 11/21/00 | 11/28/00 | 12/05/00 | 12/12/00 | 12/19/00 | 12/26/00 | 1/02/01 | Contract | Space             | Planning | Budgeting | Engineering | Submittals | RFI's | Materials | Labor | Equipment | Prereq Work | Space            | Comments / Other                                                                  |
| 1                                                                                                                    | Build mock-up of room 11                | Boldt             | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       | x         |       |           |             |                  | Millwork & mirror                                                                 |
| 1                                                                                                                    | Microscope vibration study              | SLMC/STS          | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  | CD's will be issued prior to this info;<br>Isolation system will come as addendum |
| 1                                                                                                                    | Bid & award bid pack 3                  | Boldt             | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  | Review with Brad                                                                  |
| 1                                                                                                                    | Submit-review-approve roofing shopdrwng | Langer            | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             | x          |       |           |       |           |             |                  | Additional submittals required                                                    |
| 1                                                                                                                    | Release updated construction documents  | ARC               | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  | Coordinate with Ring & Du                                                         |
| 1                                                                                                                    | Demolition                              | Boldt             | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             |            |       |           |       |           |             |                  |                                                                                   |
| 1                                                                                                                    | Pour roof                               | Boldt             | x                                         |          |          |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           | x           |                  |                                                                                   |
| 1                                                                                                                    | Expedite stone production               | BDI               | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       | x        |                   |          |           |             | x          |       |           |       |           |             |                  | Stone was ordered 10-19-00                                                        |
| 1                                                                                                                    | Steel Shops: Curtainwall Support        | Dave              | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       | x         |             |                  | Klein Dickert will coordinate with Mike D                                         |
| 1                                                                                                                    | Roof detailing                          | Dave              | x                                         | x        | x        |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           | x           |                  |                                                                                   |
| 1                                                                                                                    | Phase 3 Millwork Shop Drwngs            | Precision         | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             |            |       |           |       |           |             |                  |                                                                                   |
| 1                                                                                                                    | Fabricate louvers                       | Air Flow          | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             | x          |       |           |       |           |             |                  | 5-6 week lead time - Ordered 10-19-00                                             |
| 1                                                                                                                    | Fabricate auto entrance doors           | Besam             | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             |            |       |           |       |           |             |                  | Shipping 11-3; Besam header to Dickert                                            |
| 1                                                                                                                    | Fabricate curtainwall                   | Klein Dickert     | x                                         | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             | x          |       | x         |       |           |             |                  | Waiting for framing materials-by October                                          |
| 2                                                                                                                    | Mock-up review                          | SLMC              |                                           |          | x        | x        |          |          |          |          |          |          |         |          |                   |          |           |             |            |       | x         |       | x         |             |                  | Millwork; Mirror                                                                  |
| 2                                                                                                                    | Masonry Work                            | BDI               |                                           | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           |             |            |       | x         |       |           |             |                  | Roger needs to confirm if brick is in                                             |
| 2                                                                                                                    | Penthouse framing & decking             | Dave              |                                           | x        | x        | x        |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       | x         |             |                  | Boldt to confirm placement of AHU's                                               |
| 2                                                                                                                    | Bid Pack 3 Submittals                   | TBD               |                                           | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       | x        |                   |          |           |             |            |       |           |       | x         |             |                  | Award contracts                                                                   |
| 2                                                                                                                    | Start work on patient rooms 3847 -49    | TBD               |                                           | x        | x        | x        | x        | x        | x        | x        | x        | x        | x       |          |                   |          |           | x           | x          |       |           |       |           |             |                  | Need to coordinate with Jan Keepers                                               |
|                                                                                                                      | Workable Backlog                        |                   |                                           |          |          |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  |                                                                                   |
|                                                                                                                      | Fabricate AHU's / ACCU                  | Trane             |                                           |          |          |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  | Shipping: 11-13-00                                                                |
|                                                                                                                      | Med Gas Equip. Lead-Time                | Squires           |                                           |          |          |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  | Delivery: 11-6-00                                                                 |
|                                                                                                                      | Demo shades at main entrance            | TBD               |                                           |          |          |          |          |          |          |          |          |          |         | x        |                   |          |           |             |            |       |           |       |           |             |                  |                                                                                   |
|                                                                                                                      | Review room numbering                   | ARC/ Luke         |                                           |          |          |          |          |          |          |          |          |          |         |          |                   |          |           |             |            |       |           |       |           |             |                  |                                                                                   |

How to use buffers to adapt the **JIT** concept to construction?

## Level 2: Look-ahead planning and scheduling – Use of buffers

- ❑ Ballard and Howell (1995) propose the use of **buffers** to adapt the **JIT concept** to **construction**.
- ❑ Three types of buffers may be used to **shield downstream** construction processes from flow variation.
  - a) **Inventory buffers**
    - ❖ Keep excess materials on or **near the site**
  - b) **Capacity buffers**
    - ❖ Build a **reserve capacity** in crew or operation
  - c) **Schedule buffers**
    - ❖ Also known as plan buffers or workable backlog
    - ❖ **Work not on the critical path** acts as a back up for planned work

## Level 2: Look-ahead planning and scheduling – Use of buffers

- ❑ In the application of the Last Planner® technique, **buffers** include a “**workable backlog**” of tasks that

are **available to be done** but do **not need to be done**;

that is, they are **not on the critical path**.

What does **workable backlog** mean in look-ahead schedule?

## Level 2: Look-ahead planning and scheduling – Workable backlog

- ❑ **Workable backlog** is used to **describe assignments** that have met **all quality criteria**, but may need other **prerequisite work** to be done **before they can be started**.
  - ❖ *For example, the paving of the tennis court for a new university sports center is scheduled for 3 months' time.*
    - ✓ It **can be done now**, as it is on a remote part of the site that has already been compacted and graded.
    - ✓ It is **not on the critical path**.
    - ✓ This assignment will be **maintained as workable backlog**.

**Workable backlog** enables crews to **continue working productively** if there is a **constraint** that prevents the **completion of an item** on the **WWP**.

## Level 2: Look-ahead planning and scheduling – Workable backlog

- ❑ This **backlog** allows crews to **do productive work** in case there are **interruptions** to the **WWP**.

**Plan buffers** are backlogs of **workable assignments**.

- ❑ This **varies from traditional project management** that insists on what **SHOULD** be done –

**without** fully considering whether it **CAN be done**.

## Level 2: Look-ahead planning and scheduling – Workable backlog

|      |                                     | Tasks                                     | Responsible Party | Weeks | Constraints |          |         |          |          |          |         |                   |                |           | Explanations |            |       |           |       |           |             |                  |                                                                                |
|------|-------------------------------------|-------------------------------------------|-------------------|-------|-------------|----------|---------|----------|----------|----------|---------|-------------------|----------------|-----------|--------------|------------|-------|-----------|-------|-----------|-------------|------------------|--------------------------------------------------------------------------------|
|      |                                     | Six Week Lookahead / Constraints Analysis |                   |       | 10/20/00    | 10/27/00 | 11/3/00 | 11/10/00 | 11/17/00 | 11/24/00 | 12/1/00 | Contract / C.O.'s |                |           |              |            |       |           |       |           |             | Week of 10-23-00 |                                                                                |
| Task | Notes                               | Activity                                  | Responsible Party |       |             |          |         |          |          |          |         | Safety            | Space Planning | Budgeting | Engineering  | Submittals | RFI's | Materials | Labor | Equipment | Prereq Work | Space            | Comments / Other                                                               |
| 1    |                                     | Build mock-up of room 11                  | NAID              | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Millwork & mirror                                                              |
| 1    | <input checked="" type="checkbox"/> | Microscope vibration study                | BLMC/STP          | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | CD's will be issued prior to this info; Isolation system will come as addendum |
| 1    |                                     | Bid & award bid pack 3                    | NAID              | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Review with Brad                                                               |
| 1    |                                     | Submit-review-approve roofing shopdrawing | Langer            | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Additional submittals required                                                 |
| 1    |                                     | Release updated construction documents    | AMC               | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Coordinate with Ring & Du                                                      |
| 1    |                                     | Demolition                                | NAID              | XXXX  | XXXX        | XXXX     | XXXX    | XXXX     | XXXX     | XXXX     | XXXX    |                   |                |           |              |            |       |           |       |           |             |                  |                                                                                |
| 1    |                                     | Pour roof                                 | NAID              | X     |             |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  |                                                                                |
| 1    |                                     | Expende                                   | ND                | XXXX  | XXXX        | XXXX     | XXXX    | XXXX     | XXXX     | XXXX     | XXXX    | X                 |                |           |              |            |       |           |       |           |             |                  | Stone was ordered 10-19-00                                                     |
| 1    |                                     | Steel Shop                                | Dave              | XXXX  | XXXX        | XXXX     |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             | X                | Klein Dickert will coordinate with Mike D                                      |
| 1    |                                     | Roof deta                                 | Dave              |       | X           | X        | X       |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  |                                                                                |
| 1    |                                     | Phase 3 Millwork Shop Drawngs             | Prevision         | XXXX  | XXXX        | XXXX     |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  |                                                                                |
| 1    |                                     | Fabricate louvers                         | Al Pave           | XXXX  | XXXX        | XXXX     | XXXX    | XXXX     | XXXX     | XXXX     | XXXX    |                   |                |           |              |            |       |           |       |           |             |                  | 5-6 week lead time - Ordered 10-19-00                                          |
| 1    | <input checked="" type="checkbox"/> | Fabricate auto entrance doors             | Besam             | XXXX  | XXXX        |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Shipping 11-3; Besam header to Dickert                                         |
| 1    | <input checked="" type="checkbox"/> | Fabricate curtainwall                     | King Dickert      | XXXX  | XXXX        | XXXX     | XXXX    |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Waiting for framing materials-by October                                       |
| 3    |                                     | Mock-up review                            | BLMC              |       | X           | X        |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             | X                | Millwork; Mirror                                                               |
| 3    |                                     | Masonry Work                              | ND                |       | X           | X        | XXXX    | XXXX     | XXXX     | XXXX     | XXXX    |                   |                |           |              |            |       |           |       |           |             |                  | Roger needs to confirm if brick is in                                          |
| 3    |                                     | Penthouse framing & decking               | Dave              |       | X           | X        |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             | X                | Boldt to confirm placement of AHU's                                            |
| 3    |                                     | Bid Pack 3 Submittals                     | TND               |       | XXXX        | XXXX     | XXXX    |          |          |          |         |                   |                |           |              |            |       |           |       |           |             | X                | Award contracts                                                                |
| 3    |                                     | Start work on patient rooms 3847 -49      | TND               |       | XXXX        | XXXX     | XXXX    |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Need to coordinate with Jan Keepers                                            |
|      |                                     | Workable Backlog                          |                   |       |             |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  |                                                                                |
|      |                                     | Fabricate AHU's / ACCU                    | Trane             |       |             |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Shipping: 11-13-00                                                             |
|      |                                     | Med Gas Equip. Lead-Time                  | Spokane           |       |             |          |         |          |          |          |         |                   |                |           |              |            |       |           |       |           |             |                  | Delivery: 11-6-00                                                              |

How to **update** the look-ahead schedule?

## Level 2: Look-ahead planning and scheduling – Update

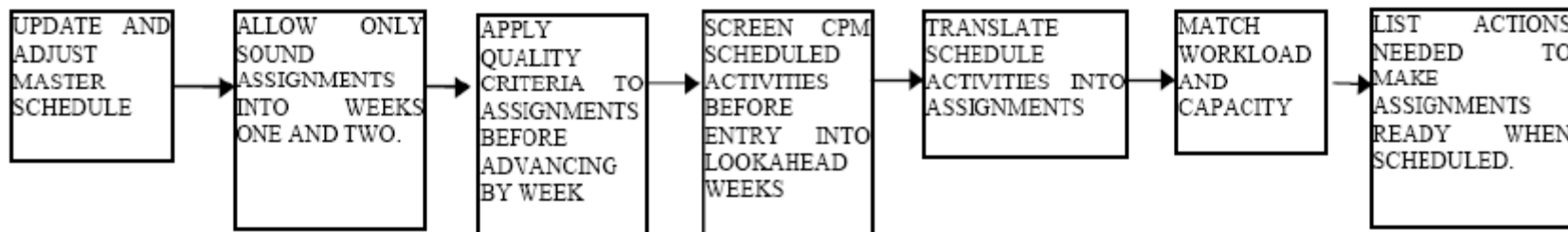
- ❑ **Each week**, the **project team** reviews the **upcoming items** to ensure that
  1. They are **not obstructed by constraints** and
  2. They **can be carried out** predictably.
- ❑ This **review includes**:
  1. **Incomplete** preparatory work,
    - a) **Insufficient** labor and/or materials, or
    - b) **Unsatisfied** requests for information (RFIs),

**such work assignments** are considered **defective** and should be **rejected**.
  2. Current progress,
  3. Remaining duration estimates,
  4. Forecasted deliveries of equipment and materials.

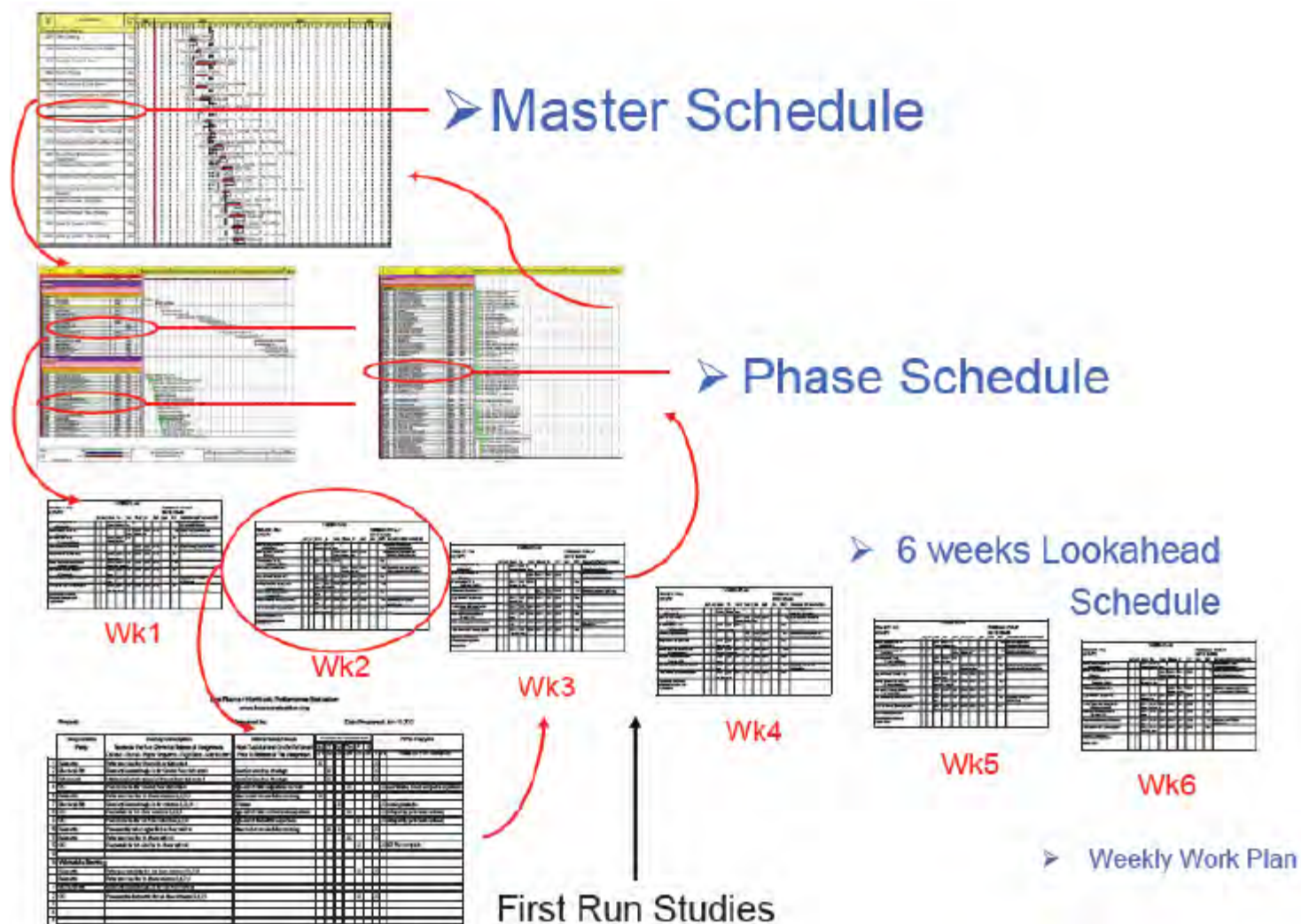
***It results in a continual update on a workflow plan that is realistic and credible to all project stakeholders.***

## Level 2: Look-ahead planning and scheduling – Specific steps

What are the **specific steps** to prepare look-ahead schedule?



## Update and revise



Look ahead schedule as part of the planning cycle.

## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

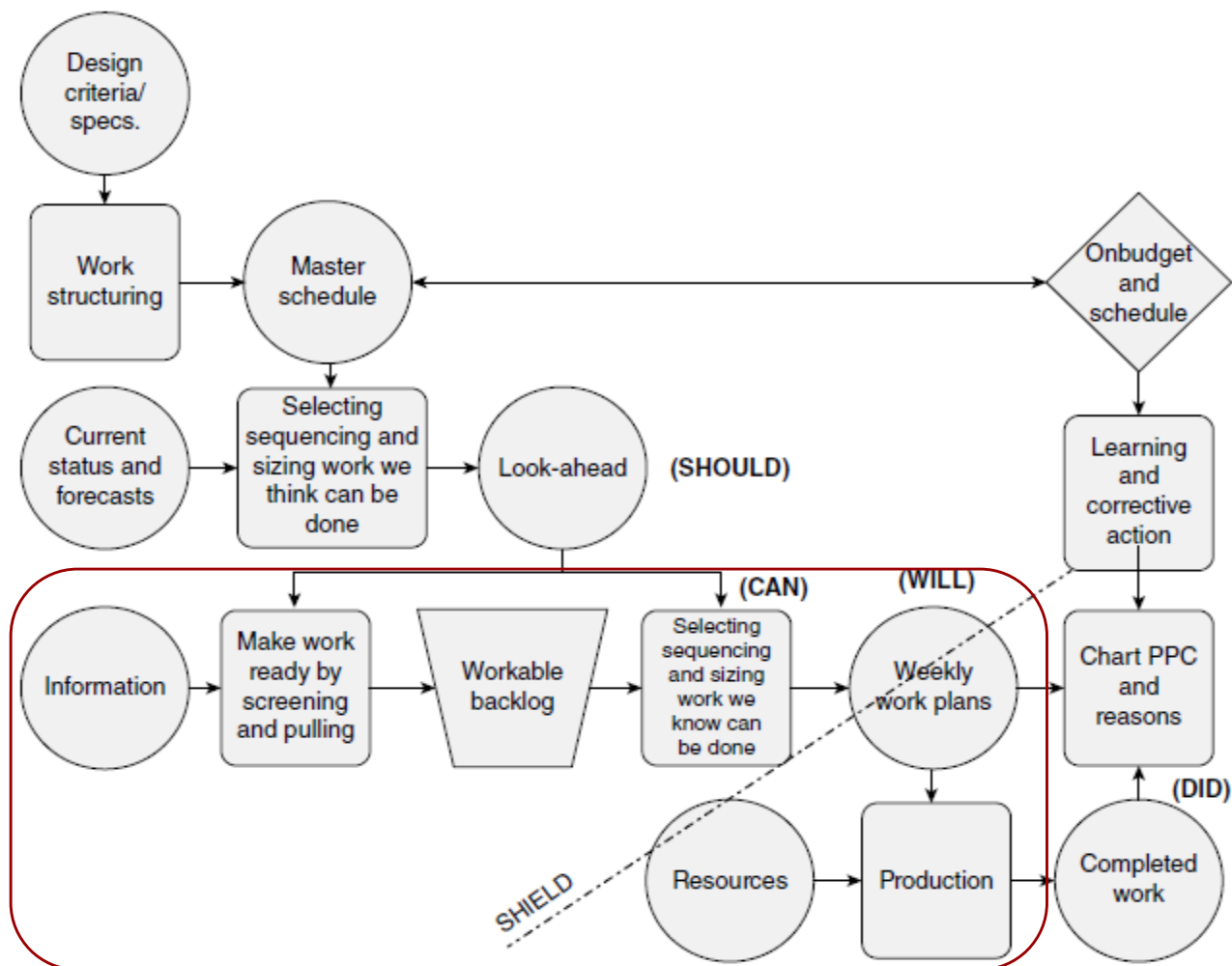
1. **Level 1: The master pull schedule**

2. **Level 2: The look-ahead schedule**

3. **Level 3: The WWP**

4. **Level 4: Certain projects may require a daily work plan**

## Last planner in construction



The Last Planner® System: process flow

## Level 3: Weekly work plan (WWP)

- ❑ Weekly work plan (WWP) meetings are held to **review the work accomplished** for the **past week** and plan the work for the **following week**.
- ❑ It is important to note that **planning is really a conversation,**  
**not just a written document.**
- ❑ **Each WWP meeting** is an essential part of the process  
it depends on **open and frank communication** between **all trades** and their last planners.
- ❑ In some projects, it is **appropriate to include suppliers** such as rebar and truss and concrete suppliers.
  - ❖ *The issues discussed include the actual schedule, site conditions, safety issues, construction methods, manpower needs, and capabilities.*

## Level 3: Weekly work plan (WWP)

- ❑ The **WWP** emphasizes what WILL be done in the **upcoming week** –  
from those tasks that **CAN** be done,  
based on the **informed commitment** by the involved trades.
- ❖ It considers “**workable backlog**” if it is needed as a **buffer**.
  - ✓ As a **rule of thumb** it is recommended in committing crews to **no more than 75% of their capacity** when developing the **WWP**.
    - *The crew can maintain its reliability in passing work on to the downstream crew, when called to do so as they “pull” activities, even if the weekly (or daily) schedule is interrupted.*
- ❖ It is imperative that the last planners **promise what they WILL do only when** they have **verified beyond a doubt** that they can carry them out.

## Level 3: Weekly work plan (WWP)

- ❑ The **WWP** is derived from the **look-ahead plan**.
- ❑ **Eligible activities** or **assignments** are those that have **no current constraints**, and that have **resources available** and **assigned**.
  - ❖ For example, responsible supervisors enhance the Level 2 activity into a detailed work-flow or plan.
- ❑ The **plan** is laid out by geographic area and the materials, sequence, and tasks are listed **for each area**.

## Level 3: Weekly work plan (WWP)

- Rule 3: Allow activities into weekly work plans only if all constraints have been removed. (Shielding)

What are the **specific steps** to prepare weekly work plan?

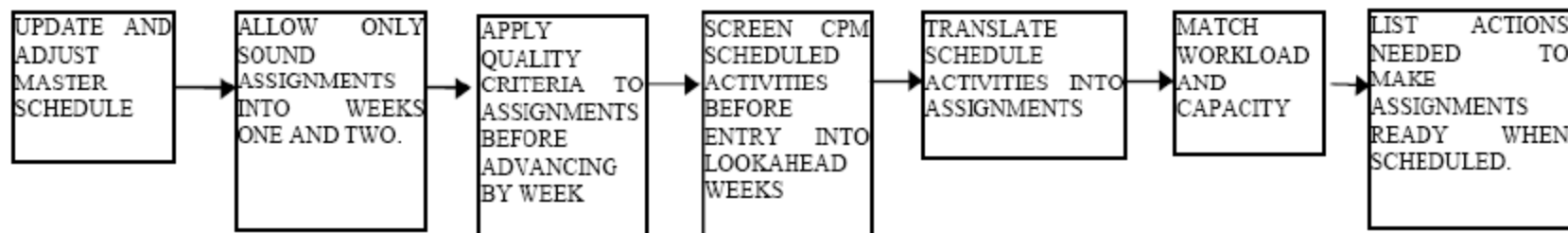
eps

- re review

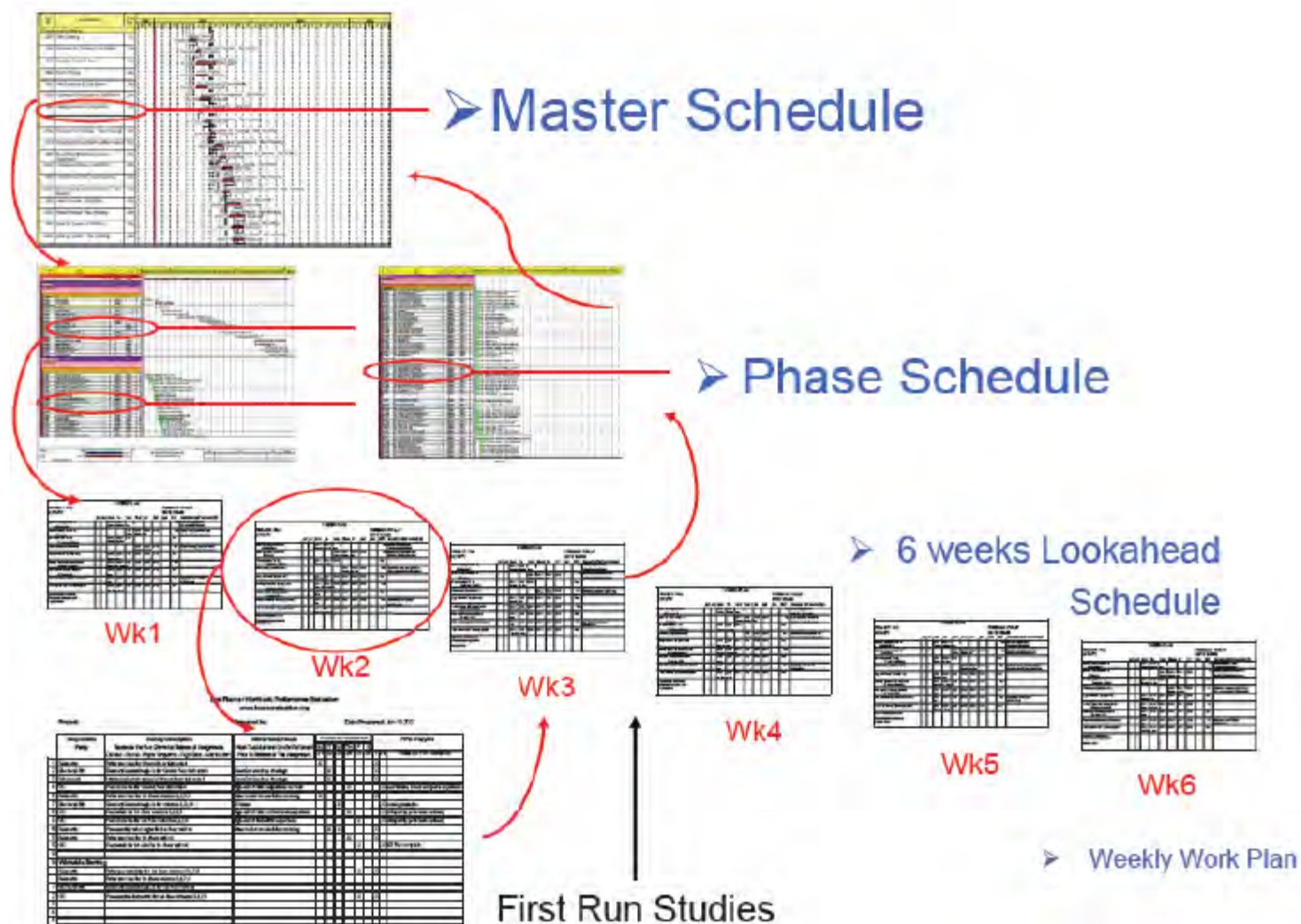


## Level 3: Weekly work plan (WWP) – Specific steps

- ❑ These are the steps involved in the process each week:



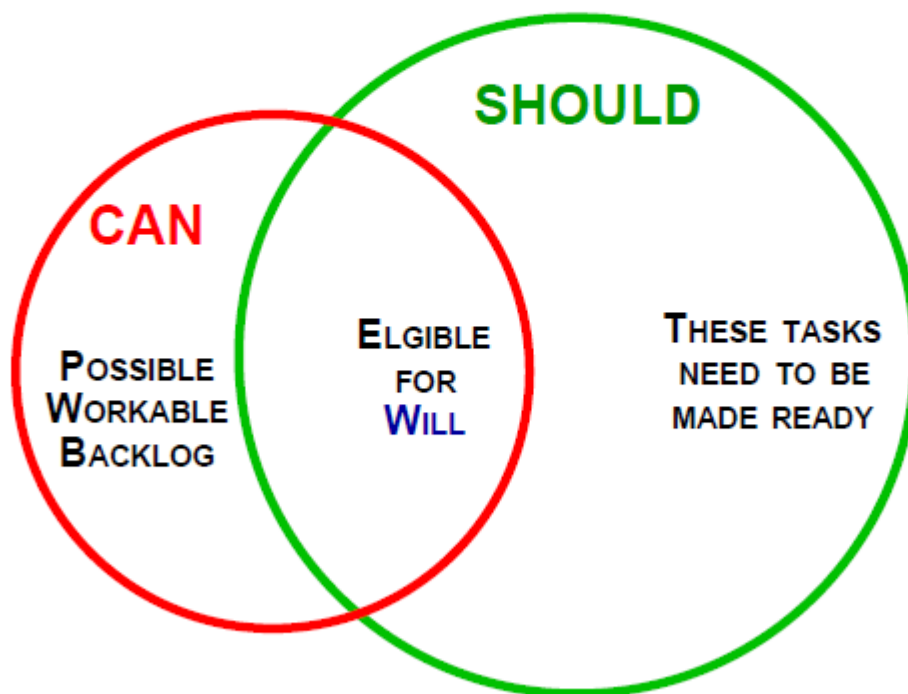
## Level 3: Weekly work plan (WWP) – Specific steps



Look ahead schedule as part of the planning cycle.

## Level 3: Weekly work plan (WWP) – Forming

# Forming the Weekly Work Plan



Unless commitment is made, there are only promises and hopes... but no plans. - Peter Drucker

## Level 3: Weekly work plan (WWP) – Criteria

❑ Required work attributes to move from should to will

- Definition
- Soundness
- Sequence
- Size
- Learning

Work meeting these only  
goes to workable backlog

©Lean Construction Institute, 2001

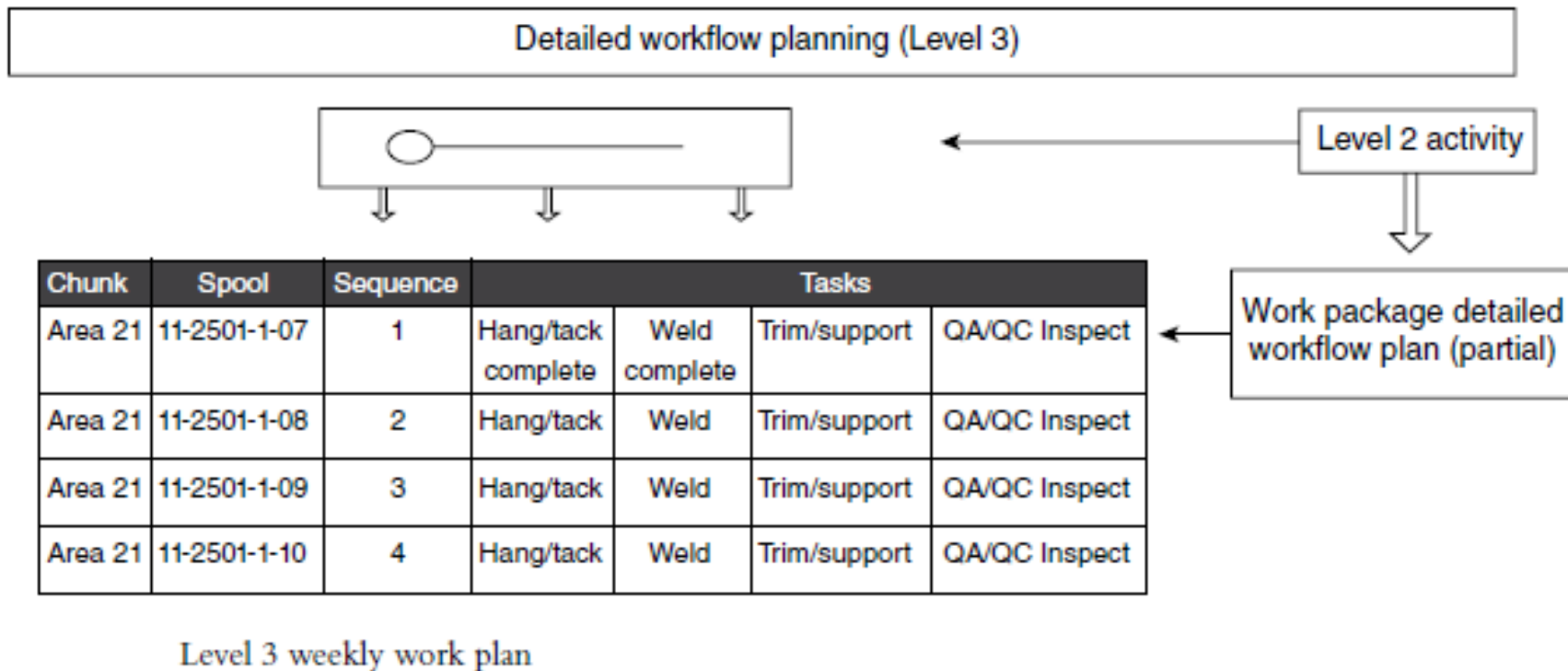
❑ Only assignments that meet these quality criteria may be put on a Weekly Work Plan.

When we reach the **work packages** in last planner system?

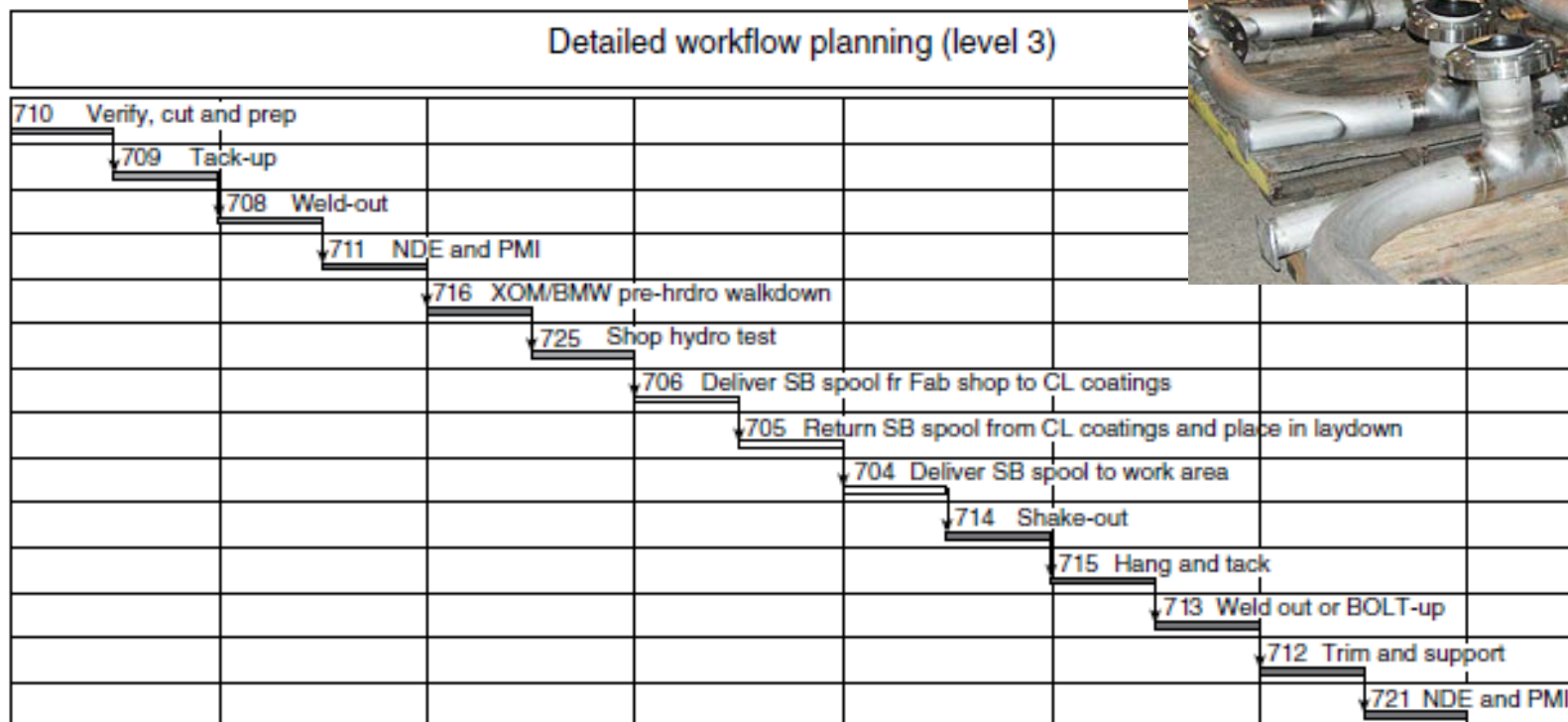
## Level 3: Weekly work plan (WWP) – Work packages

- ❑ Level 3 activity contains work packages for physical/geographic boundaries;
  - ❑ Packages are **small enough** to be
    1. Managed by one foreman,
    2. Rapidly re-planned
    3. When change occurs, and
    4. Updated quickly and accurately by the foreman for completion.

## Level 3: Weekly work plan (WWP) – Work packages



## Level 3: Weekly work plan (WWP) – Workflow planning



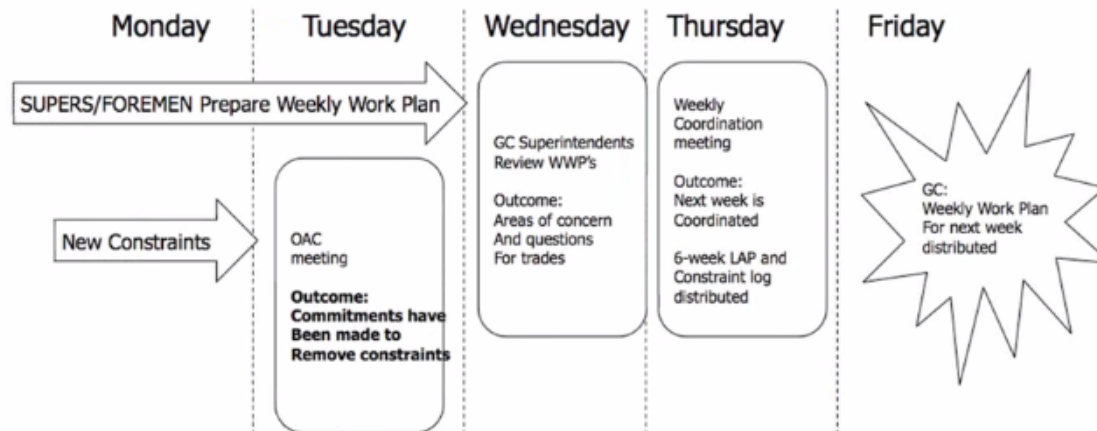
Detailed workflow planning. Detailed workflow planning using standard processes on a complex project involving ~5,000 engineered-to-order pipe spools. Standard workflow plan (Level 3) incorporating each of the ~5,000 pipe spools within appropriately defined work packages. In this standard process example, a pipe spool's workflow requires: 14 tasks, five teams, six hand-offs between teams, and transport between four site locations

## Level 3: Weekly work plan (WWP) – Sample

|                                                                                                                                                                                                                         |      |                                     |                                                                                                                          |                   |                                                                         |   |   |   |   |   |       |  |  |   |   |             |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------------------------------------------------------------|---|---|---|---|---|-------|--|--|---|---|-------------|--|
| <div><div><div><div><div><div></div><div><b>BOLDT BUILDS</b></div><div>OSCAR J. BOLDT CONSTRUCTION COMPANY, USA</div></div></div><div>Project: Same Day Surgery</div><div>Planner: Dena Delbert</div></div></div></div> |      |                                     |                                                                                                                          | Week of 10/23/00  |                                                                         |   |   |   |   |   |       |  |  |   |   |             |  |
| Weekly Work Plan                                                                                                                                                                                                        |      |                                     |                                                                                                                          |                   |                                                                         |   |   |   |   |   |       |  |  |   |   |             |  |
| Assignment Description                                                                                                                                                                                                  |      |                                     |                                                                                                                          | Make Ready Needs  |                                                                         |   |   |   |   |   | Done? |  |  |   |   |             |  |
| Deliber                                                                                                                                                                                                                 | Next | Repeat                              | Remember the Five Criteria for Release of Assignments<br>Defined - Sound - Proper Sequence - Right Size<br>Able to Learn | Responsible Party | Work that Must and Can Be Performed Prior to Release of this Assignment | M | T | W | T | F | S     |  |  | Y | N | Comments    |  |
| 1                                                                                                                                                                                                                       |      | <input checked="" type="checkbox"/> | Issue vibration study                                                                                                    | Brad/STS          |                                                                         | x | x | x | x |   |       |  |  |   |   |             |  |
| 1                                                                                                                                                                                                                       |      |                                     | Award Bid Pack 3                                                                                                         | Dena/Brad         |                                                                         | x | x | x | x | x |       |  |  |   |   |             |  |
| 1                                                                                                                                                                                                                       |      |                                     | Reissue construction documents                                                                                           | Jose              | Coordinate with Ring & DuChateau                                        | x | x | x | x |   |       |  |  |   |   |             |  |
| 2                                                                                                                                                                                                                       |      |                                     | Test Glycol Mains                                                                                                        | Jarosz            |                                                                         | x | x | x | x | x |       |  |  |   |   |             |  |
| 3                                                                                                                                                                                                                       |      |                                     | Pour Roof                                                                                                                | Randy             |                                                                         |   |   |   | x |   |       |  |  |   |   |             |  |
| 4                                                                                                                                                                                                                       |      |                                     | Confirm brick is ready                                                                                                   | Roger Spahr       |                                                                         | x |   |   |   |   |       |  |  |   |   |             |  |
| 4                                                                                                                                                                                                                       |      |                                     | Stone production                                                                                                         | Rossi             |                                                                         | x | x | x | x | x |       |  |  |   |   | Week 1 of 8 |  |
| 5                                                                                                                                                                                                                       |      |                                     | Complete roof framing                                                                                                    | Bob Brue          |                                                                         | x | x | x |   |   |       |  |  |   |   |             |  |
| 5                                                                                                                                                                                                                       |      |                                     | Begin roof detailing                                                                                                     | Bob Brue          |                                                                         |   |   |   | x | x |       |  |  |   |   |             |  |
| 5                                                                                                                                                                                                                       |      | <input checked="" type="checkbox"/> | Re-submit curtainwall support shops                                                                                      | Dick              |                                                                         | x | x | x | x |   |       |  |  |   |   |             |  |
| 5                                                                                                                                                                                                                       |      |                                     | Issue penthouse curb ASK's                                                                                               | Jose              |                                                                         | x | x | x | x |   |       |  |  |   |   |             |  |
| 6                                                                                                                                                                                                                       |      |                                     | Submit Phase 2 millwork shops                                                                                            | Precision         |                                                                         | x |   |   |   |   |       |  |  |   |   |             |  |
| 6                                                                                                                                                                                                                       |      |                                     | Deliver mock-up millwork                                                                                                 | Precision         |                                                                         |   |   |   |   | x |       |  |  |   |   |             |  |
| 7                                                                                                                                                                                                                       |      |                                     | Submit additional roofing shops                                                                                          | Scott Harms       |                                                                         | x | x |   |   |   |       |  |  |   |   |             |  |
| 8                                                                                                                                                                                                                       |      | <input checked="" type="checkbox"/> | Resubmit curtainwall shops                                                                                               | Jim L             |                                                                         |   |   | x |   |   |       |  |  |   |   |             |  |
| 8                                                                                                                                                                                                                       |      | <input checked="" type="checkbox"/> | Submit curtainwall Struct. Calcs                                                                                         | Jim L             |                                                                         |   |   | x |   |   |       |  |  |   |   |             |  |
| 8                                                                                                                                                                                                                       |      |                                     | Order Glass                                                                                                              | Jim L             | ARC verbally confirm dimensions                                         | x |   |   |   |   |       |  |  |   |   |             |  |
| 10                                                                                                                                                                                                                      |      |                                     | Fab. Louvers                                                                                                             | Alr Flow          |                                                                         | x | x | x | x | x |       |  |  |   |   | Week 1 of 8 |  |

## Level 3: Weekly work plan (WWP) – Weekly planning cycle

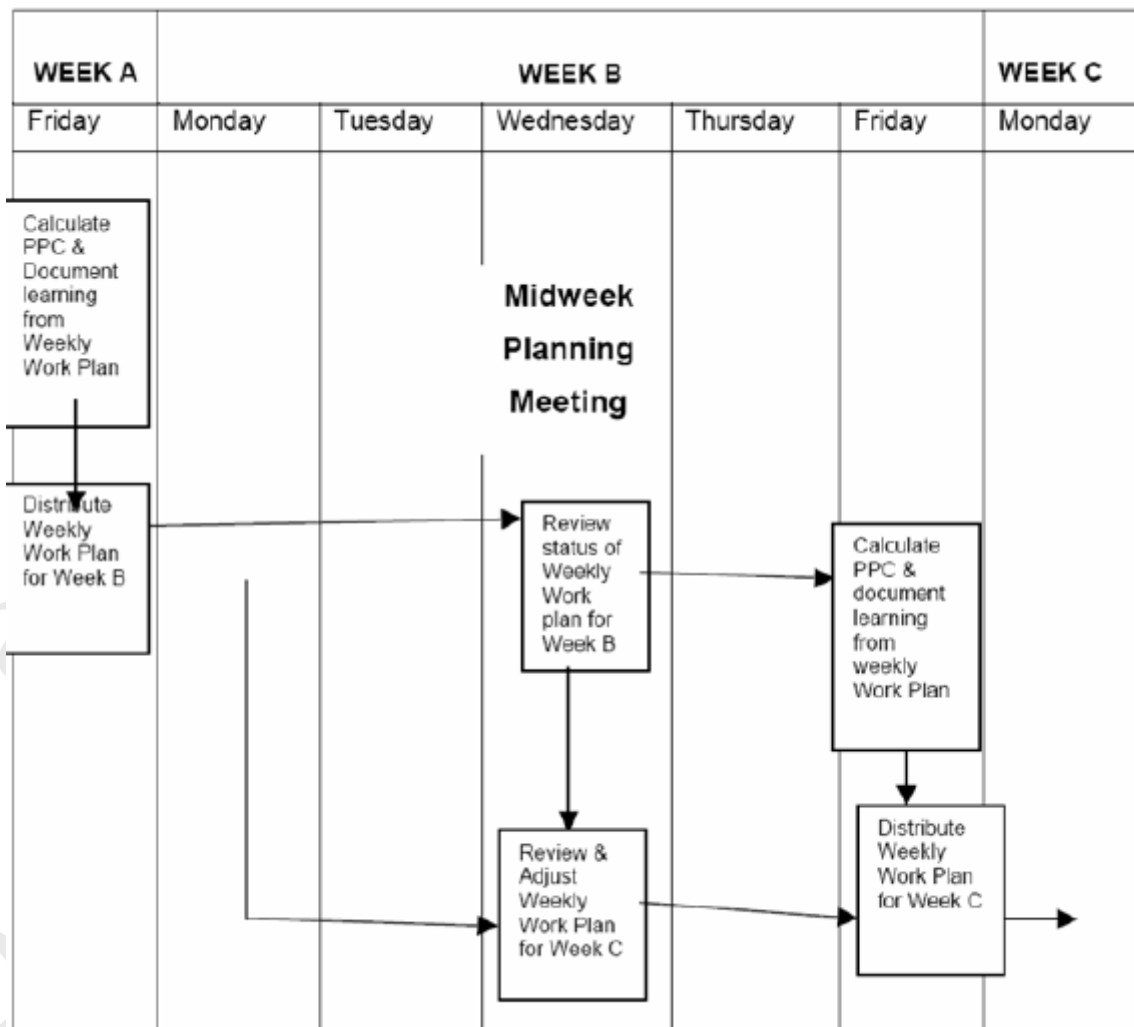
### Weekly Planning Cycle



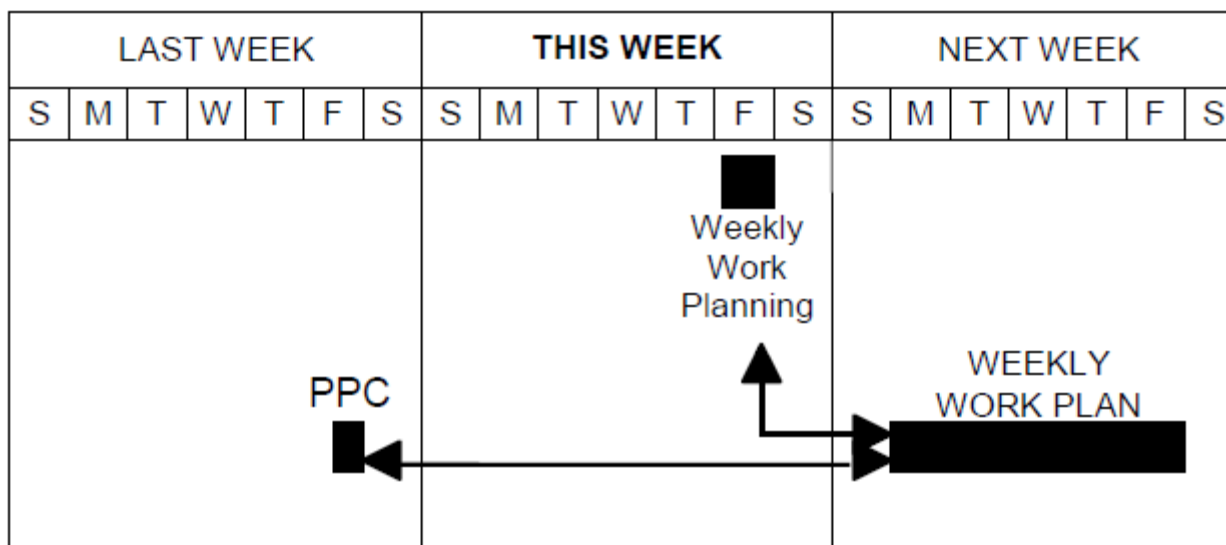
Daily Check-in Meeting to be done at the end of the shift – Foremen and Supers

| Monday                         | Tuesday                 | Wednesday                 | Thursday                    | Friday       |
|--------------------------------|-------------------------|---------------------------|-----------------------------|--------------|
|                                | Look-Ahead Plan Meeting |                           | Weekly Coordination Meeting |              |
| Check-In                       | Check-In                | Check-In                  | Check-In                    | Check-In     |
| Trades Submit Look-Ahead Plans |                         | Trades Submit WWP Updates |                             | Finalize WWP |

## Level 3: Weekly work plan (WWP) – Weekly planning cycle



## Level 3: Weekly work plan (WWP) – Weekly planning cycle





## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

1. Level 1: The master pull schedule
2. Level 2: The look-ahead schedule
3. Level 3: The WWP
4. Level 4: Certain projects may require a daily work plan

## Level 4: Daily work plan

- ❑ The **daily workflow plan (Level 4)** is appropriate for **projects where**
  1. There is **extensive prefabrication**
  2. There is **little or no interchangeability** of materials/equipment.
  
- ❑ The **Level 4 diagram** is **similar** to the **Level 3 weekly diagram**,  
but the **foremen commit daily** to completing tasks based on the **crew's capability and capacity**.



## Level 4: Daily work plan – Daily project schedule

☐ Sample

### DAILY PROJECT SCHEDULE

Tasks to Be Performed

Project: \_\_\_\_\_

Prepared by: \_\_\_\_\_

Date: \_\_\_\_\_

| Work Items Today | Foreman/Crew |
|------------------|--------------|
| 1.               |              |
| 2.               |              |
| 3.               |              |
| 4.               |              |
| 5.               |              |
| 6.               |              |
| 7.               |              |
| 8.               |              |
| 9.               |              |
| 10.              |              |

| Work Items Today | Subcontractor |
|------------------|---------------|
| 1.               |               |
| 2.               |               |
| 3.               |               |
| 4.               |               |
| 5.               |               |
| 6.               |               |
| 7.               |               |
| 8.               |               |
| 9.               |               |
| 10.              |               |

| Work Items Tomorrow |
|---------------------|
| 1.                  |
| 2.                  |
| 3.                  |

| Work Items Tomorrow |
|---------------------|
| 1.                  |
| 2.                  |
| 3.                  |

| Survey Tasks Today |
|--------------------|
| 1.                 |
| 2.                 |
| 3.                 |

| Engineering Tasks |
|-------------------|
| 1.                |
| 2.                |
| 3.                |

| Mat'ls Needed |    |
|---------------|----|
| 1.            | 5. |
| 2.            | 6. |
| 3.            | 7. |
| 4.            | 8. |

| General Notes |
|---------------|
| 1.            |
| 2.            |
| 3.            |
| 4.            |

| Equipment Description | Hrs 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 1-2 | 2-3 | 3-4 | 4-5 | Remarks |
|-----------------------|---------|-----|------|-------|-------|-----|-----|-----|-----|---------|
| 1.                    |         |     |      |       |       |     |     |     |     |         |
| 2.                    |         |     |      |       |       |     |     |     |     |         |
| 3.                    |         |     |      |       |       |     |     |     |     |         |
| 4.                    |         |     |      |       |       |     |     |     |     |         |
| 5.                    |         |     |      |       |       |     |     |     |     |         |
| 6.                    |         |     |      |       |       |     |     |     |     |         |



## Level 4: Daily work plan – Daily crew schedule

☐ Sample

### DAILY CREW PLANNING CHART

#### Tasks to Be Performed

Crew: \_\_\_\_\_

First Line Supervisor: \_\_\_\_\_

Prepared by: \_\_\_\_\_

Date: \_\_\_\_\_

| Worker | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-1 | 1-2 | 2-3 | 3-4 | 4-5 |
|--------|-----|-----|------|-------|-------|------|-----|-----|-----|-----|
| 1.     |     |     |      |       |       |      |     |     |     |     |
| 2.     |     |     |      |       |       |      |     |     |     |     |
| 3.     |     |     |      |       |       |      |     |     |     |     |
| 4.     |     |     |      |       |       |      |     |     |     |     |
| 5.     |     |     |      |       |       |      |     |     |     |     |
| 6.     |     |     |      |       |       |      |     |     |     |     |
| 7.     |     |     |      |       |       |      |     |     |     |     |
| 8.     |     |     |      |       |       |      |     |     |     |     |
| 9.     |     |     |      |       |       |      |     |     |     |     |
| 10.    |     |     |      |       |       |      |     |     |     |     |

| Materials Needed |
|------------------|
| 1.               |
| 2.               |
| 3.               |
| 4.               |
| 5.               |

| Major Tools Needed |
|--------------------|
| 1.                 |
| 2.                 |
| 3.                 |
| 4.                 |
| 5.                 |

| Equip. Plan | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-1 | 1-2 | 2-3 | 3-4 | 4-5 |
|-------------|-----|-----|------|-------|-------|------|-----|-----|-----|-----|
| 1.          |     |     |      |       |       |      |     |     |     |     |
| 2.          |     |     |      |       |       |      |     |     |     |     |
| 3.          |     |     |      |       |       |      |     |     |     |     |

| Contingency Tasks to Perform (when time is available) |
|-------------------------------------------------------|
| 1.                                                    |
| 2.                                                    |
| 3.                                                    |
| 4.                                                    |

| Comments and Notes |
|--------------------|
| 1.                 |
| 2.                 |
| 3.                 |
| 4.                 |

## Level 4: Daily work plan – Daily crew schedule – Pretask plan

Pretask Plan

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Foreman:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |          | <b>Hazard Elimination</b><br><b>Personal Protective Equipment</b><br><input type="checkbox"/> Safety harnesses <input type="checkbox"/> Special gloves<br><input type="checkbox"/> Protective clothing <input type="checkbox"/> Eye protection<br><input type="checkbox"/> Hearing protection <input type="checkbox"/> Face shields<br><input type="checkbox"/> Safety footwear <input type="checkbox"/> Respirators<br><input type="checkbox"/> Other: _____                                                                                                                                                                                                                         |  |
| Date:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Time: | AM or PM |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| Project:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| Location:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| Task: _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |          | <b>Specific Safety Measures</b><br><input type="checkbox"/> Toeboards, netting <input type="checkbox"/> Eyewash, shower<br><input type="checkbox"/> Use monitor <input type="checkbox"/> Housekeeping<br><input type="checkbox"/> Slope, shore, t-box <input type="checkbox"/> Scaffold<br><input type="checkbox"/> Set safe position <input type="checkbox"/> Contain sparks<br><input type="checkbox"/> Fire extinguisher <input type="checkbox"/> Erect barricades<br><input type="checkbox"/> Use proper tools <input type="checkbox"/> Get help<br><input type="checkbox"/> Change procedure <input type="checkbox"/> Contain materials<br><input type="checkbox"/> Other: _____ |  |
| _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| <b>Potential Hazards Present</b><br><input type="checkbox"/> Pinch points <input type="checkbox"/> Chemical burn<br><input type="checkbox"/> Materials/scrap <input type="checkbox"/> Thermal burn<br><input type="checkbox"/> Elevated work <input type="checkbox"/> Slips, trips, falls<br><input type="checkbox"/> Cave-in <input type="checkbox"/> Electrical shock<br><input type="checkbox"/> Cuts <input type="checkbox"/> Fire<br><input type="checkbox"/> Heat stress <input type="checkbox"/> Noise<br><input type="checkbox"/> Rigging <input type="checkbox"/> Overhead work<br><input type="checkbox"/> Strains, sprains <input type="checkbox"/> Harmful vapors<br><input type="checkbox"/> Abrasions <input type="checkbox"/> Overextension |       |          | <b>Items Verified</b><br><input type="checkbox"/> Permits obtained <input type="checkbox"/> Task reviewed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |

## Level 4: Daily work plan – Daily crew schedule – Pretask plan

| Potential Hazards Present (cont'd)                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Items Verified (cont'd)                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Particles in eye <input type="checkbox"/> Confined space<br><input type="checkbox"/> Lockout/tagout <input type="checkbox"/> Dropped items<br><input type="checkbox"/> Spill hazard <input type="checkbox"/> Open holes<br><input type="checkbox"/> Overhead work <input type="checkbox"/> Asbestos/lead/etc.<br><input type="checkbox"/> Other: _____<br>_____                                                                                                 | <input type="checkbox"/> Lines drained/purged <input type="checkbox"/> Others informed<br><input type="checkbox"/> Close drains/vents <input type="checkbox"/> Chemical burns<br><input type="checkbox"/> Safety gear present <input type="checkbox"/> MSDS reviewed<br><input type="checkbox"/> Check for low points <input type="checkbox"/> LOTO in place<br><input type="checkbox"/> Other: _____<br>_____ |
| <p>Description of procedure to perform task: _____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p><b>Signatures of persons performing the work</b></p> <p>(By signing this form, crew members indicate that they understand the task plan and feel fully prepared to proceed to perform the work safely.)</p> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;">           _____<br/>           _____<br/>           _____         </div> <div style="width: 45%;">           _____<br/>           _____<br/>           _____         </div> </div> |                                                                                                                                                                                                                                                                                                                                                                                                                |

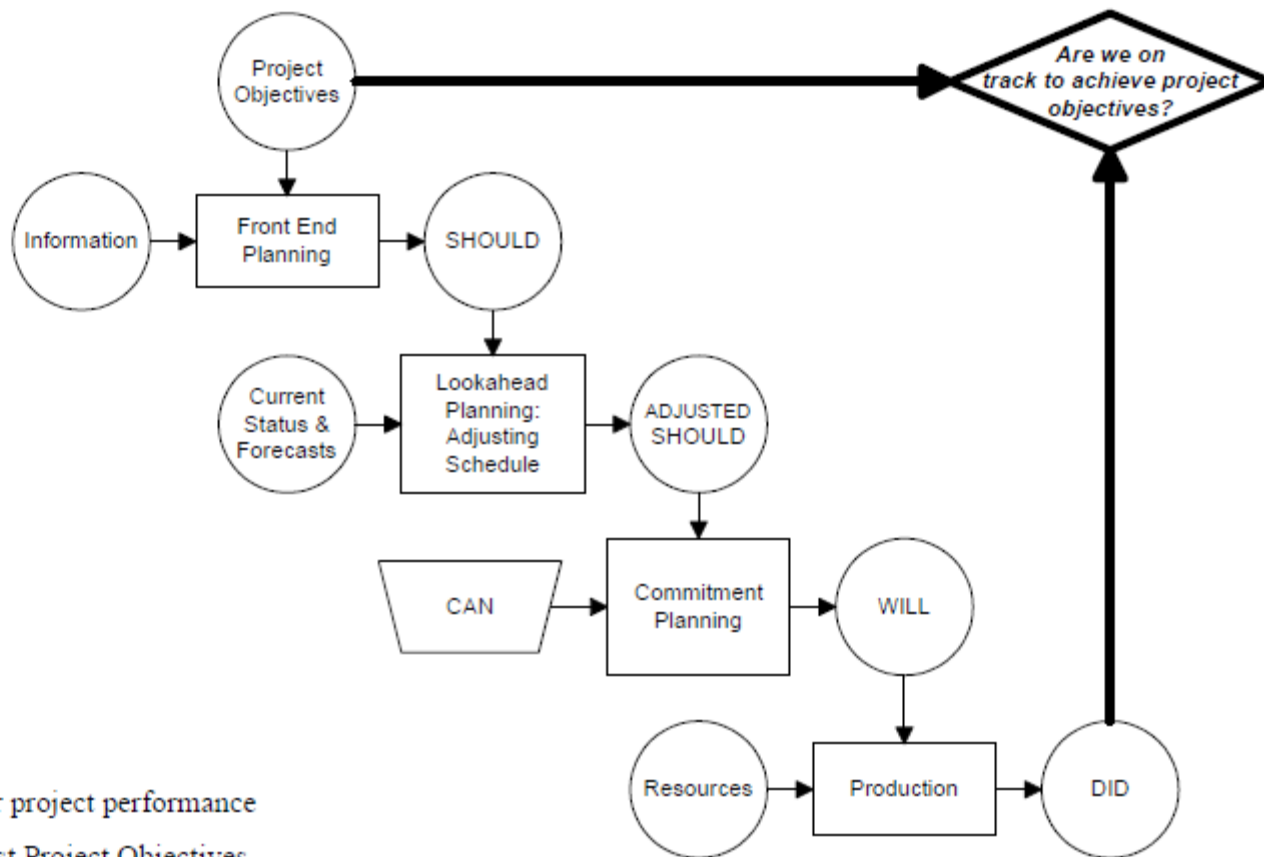
## Last planner in construction

❑ The LPS is based on **four levels** of schedules and planning tools:

1. Level 1: The master pull schedule
2. Level 2: The look-ahead schedule
3. Level 3: The WWP
4. Level 4: Certain projects may require a daily work plan

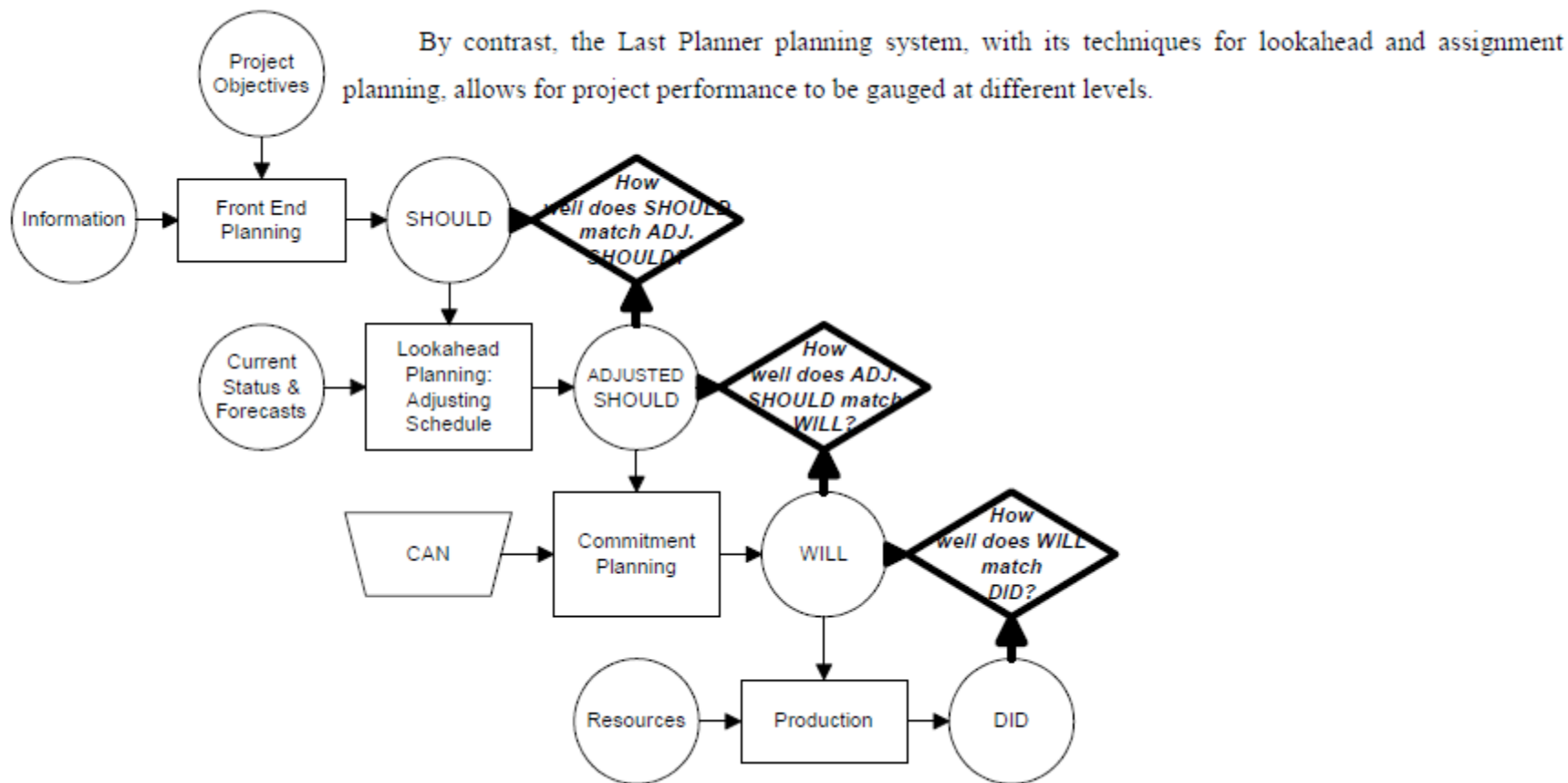
## The Last Planner® System: process flow

## Performance measurement – Traditional approach

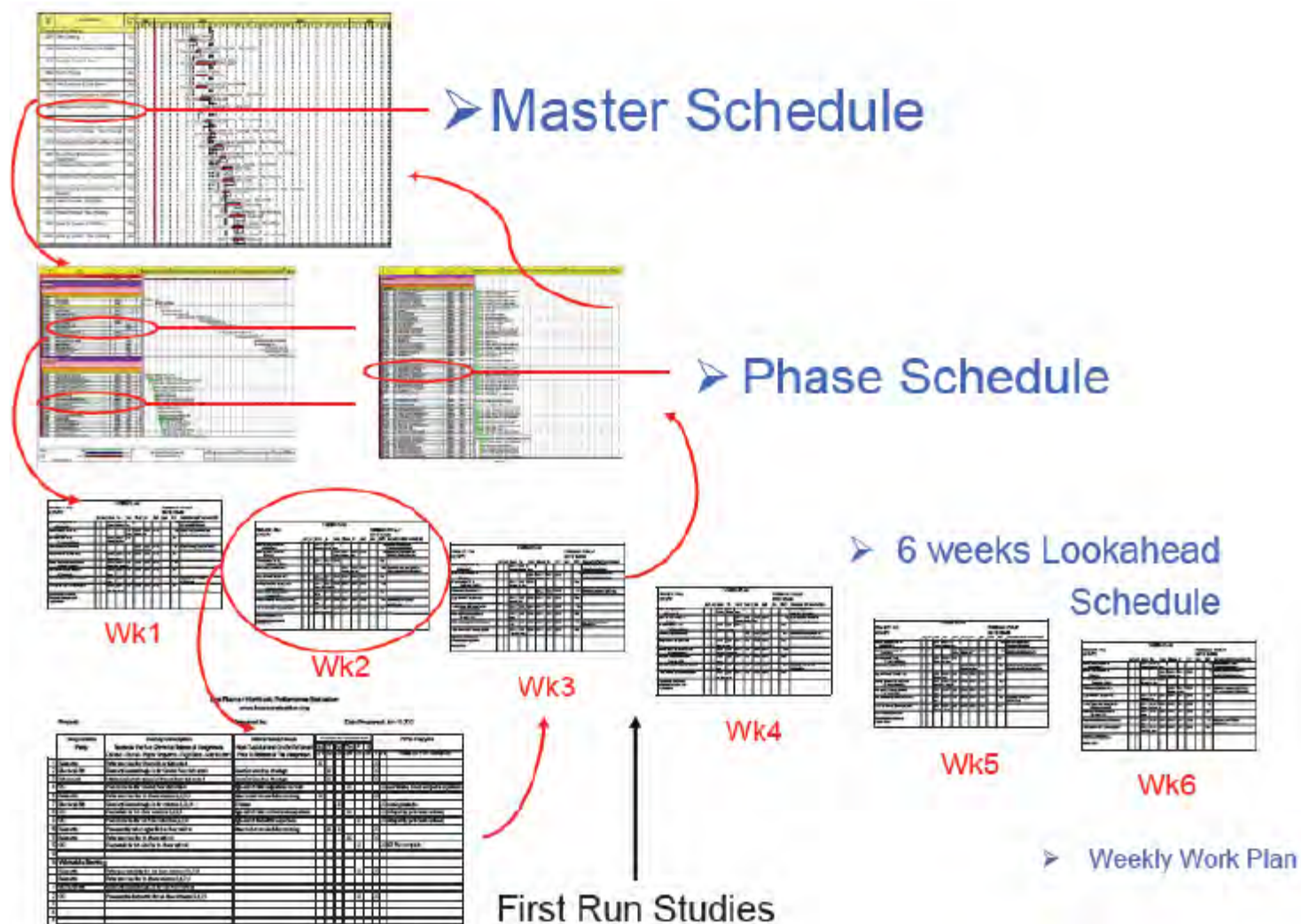


A traditional measure for project performance is to compare DID against Project Objectives.

## Performance measurement – Lean approach



## Performance measurement – Lean approach



Look ahead schedule as part of the planning cycle.

## Performance measurement – Completed work

Complete or Not Complete?  
That is the PPC Question.

- ❑ Whether or not an assignment has been **completed** requires a **YES or NO** answer.
  - ❑ The Last Planner does not give credit to assignments on the **Weekly Work Plan** that remain incomplete at the **end of the week**,  
**even though** they may have been **started**.
  - ❑ The rationale for this is that **only completed work** can be **handed off to the next production unit**,  
so if **any part remains incomplete**,  
**no clean handoff** can take place.
- In order to **create reliable flow** from one production unit to the next,  
end-of-week completion commitments **must be met**.

## Performance measurement – Completed work: PPC or PPC1

❑ In **weekly work planning**, the last planner tracks the **number of actual completions** divided by the **number of planned completions**.

❖ We refer to this performance measure as percent plan complete, **PPC**, or also **PPC1**

as it assesses the **reliability of planning work** that is one week out into the future.

$$\text{PPC} = \text{Did} / \text{Will}$$

*Example Lookahead Process Measurements*

| Completed | Week 1 | Week 2 |
|-----------|--------|--------|
| A         | A      | A      |
| D         | B      | B      |
|           | D      | C      |
|           | E      |        |

$$\text{PPC}_1 = \frac{AD}{ABDE} = 50\%$$

## Performance measurement – Completed work: PPC or PPC1

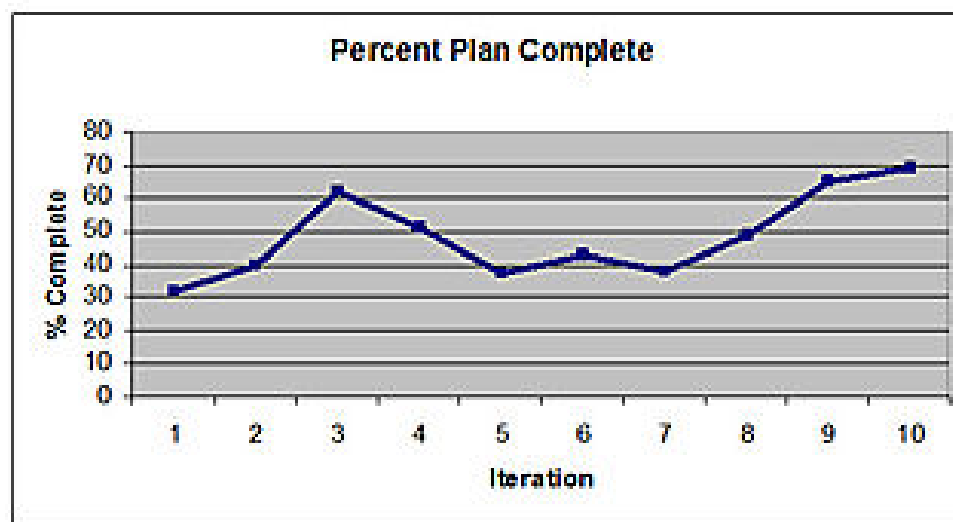
|                                                                                                                     |                                                                                                                         |  |  |                   |  |   |   |   |   |   |   |  |   |                  |                                    |              |  |
|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--|--|-------------------|--|---|---|---|---|---|---|--|---|------------------|------------------------------------|--------------|--|
| <b>BOLDT BUILDS</b><br>OSCAR J. BOLDT CONSTRUCTION COMPANY USA<br>Project: Same Day Sugery<br>Planner: Dena Deibert |                                                                                                                         |  |  |                   |  |   |   |   |   |   |   |  |   | Week of 10/16/00 |                                    |              |  |
|                                                                                                                     |                                                                                                                         |  |  | PPC = 69%         |  |   |   |   |   |   |   |  |   |                  |                                    |              |  |
| Assignment Description                                                                                              |                                                                                                                         |  |  |                   |  |   |   |   |   |   |   |  |   | Done?            |                                    | PPC Analysis |  |
| Repeat                                                                                                              | Remember the Five Criteria for Release of Assignments<br>Defined - Sound - Proper Sequence - Right Size - Able to Learn |  |  | Responsible Party |  | M | T | W | T | F | S |  | Y | N                | Reasons For Variance / Comments    |              |  |
|                                                                                                                     | Review mock-up drywall dimensions                                                                                       |  |  | Randy             |  | x | x | x | x | x |   |  | Y |                  | Wardrobe dimensions changed        |              |  |
|                                                                                                                     | Review microscope vibration Study                                                                                       |  |  | David             |  | x | x | x | x | x |   |  |   | N                |                                    |              |  |
|                                                                                                                     | Review bids - Bid Pack 3                                                                                                |  |  | Dena/ Brad        |  | x | x | x | x | x |   |  | Y |                  | Will award next week.              |              |  |
|                                                                                                                     | Review roofing shops                                                                                                    |  |  | Jose'             |  | x | x | x | x | x |   |  | Y |                  | Week 1 of 2                        |              |  |
|                                                                                                                     | Complete concrete haunches                                                                                              |  |  | Randy             |  | x | x | x |   |   |   |  | Y |                  |                                    |              |  |
|                                                                                                                     | Release order on limestone                                                                                              |  |  | Dena              |  | x |   |   |   |   |   |  | Y |                  |                                    |              |  |
|                                                                                                                     | Re-submit curtainwall support shops                                                                                     |  |  | Dick              |  | x | x | x | x | x |   |  |   | N                | Waiting for curtainwall shop drwg. |              |  |
|                                                                                                                     | Roof framing: 75% complete                                                                                              |  |  | Bob Brue          |  | x | x | x | x | x |   |  | Y |                  |                                    |              |  |
|                                                                                                                     | Submit Phase 2 Millwork Shops                                                                                           |  |  | Precision         |  | x | x | x | x |   |   |  |   | N                |                                    |              |  |
|                                                                                                                     | Fabricate mock-up millwork                                                                                              |  |  | Precision         |  | x | x | x | x | x |   |  | Y |                  | Week 2 of 3                        |              |  |
|                                                                                                                     | Re-submit curtainwall shops & structural calcs                                                                          |  |  | Jim Leicht        |  | x | x | x |   |   |   |  |   | N                | Middle of next week                |              |  |
|                                                                                                                     | Finalize review of louver shops                                                                                         |  |  | Tony/ David       |  | x | x | x | x |   |   |  | Y |                  |                                    |              |  |
|                                                                                                                     | Review GL-1 and GL-2                                                                                                    |  |  | ARC/Jim Leight    |  | x | x | x |   |   |   |  | Y |                  |                                    |              |  |
|                                                                                                                     |                                                                                                                         |  |  |                   |  |   |   |   |   |   |   |  |   |                  |                                    |              |  |
|                                                                                                                     |                                                                                                                         |  |  |                   |  |   |   |   |   |   |   |  |   |                  |                                    |              |  |

## Performance measurement – Completed work: PPC or PPC1

Tracking progress via Percent Plan Complete (PPC)

$$\text{PPC} = \frac{\text{number of planned activities completed}}{\text{number of planned activities}}$$

E.g. 10 features planned, 8 features delivered  $\text{PPC} = 8/10 = 80\%$



## Performance measurement – Completed work: PPC2

- ❑ **PPC2** Divides the number of **assignments completed** in the **plan week** by the number of **assignments listed** in the **Week Two plan**.

❖ Answers the question:

*How good a predictor of work flow are plans made two weeks in advance?*

- ❑ More advanced: Tasks made ready (TMR): Checks the whole look-ahead **Did / Can**

### Example Lookahead Process Measurements

| Completed | Week 1 | Week 2 |
|-----------|--------|--------|
| A         | A      | A      |
| D         | B      | B      |
|           | D      | C      |
|           | E      |        |

$$PPC_1 = \frac{AD}{ABDE} = 50\% \quad PPC_2 = \frac{A}{ABC} = 33\%$$

## Performance measurement – Completed work: PPC2

- ❑ The **PPC** is the most **commonly used metric** associated with the LPS to reflect **planning reliability on projects**.
  - ❖ However, perceiving the **PPC metric in isolation** will lead to an **incomplete understanding** of the overall planning process.
    - ✓ Therefore, recent research expressed the **need to complement PPC** with **other metrics to measure performance**.

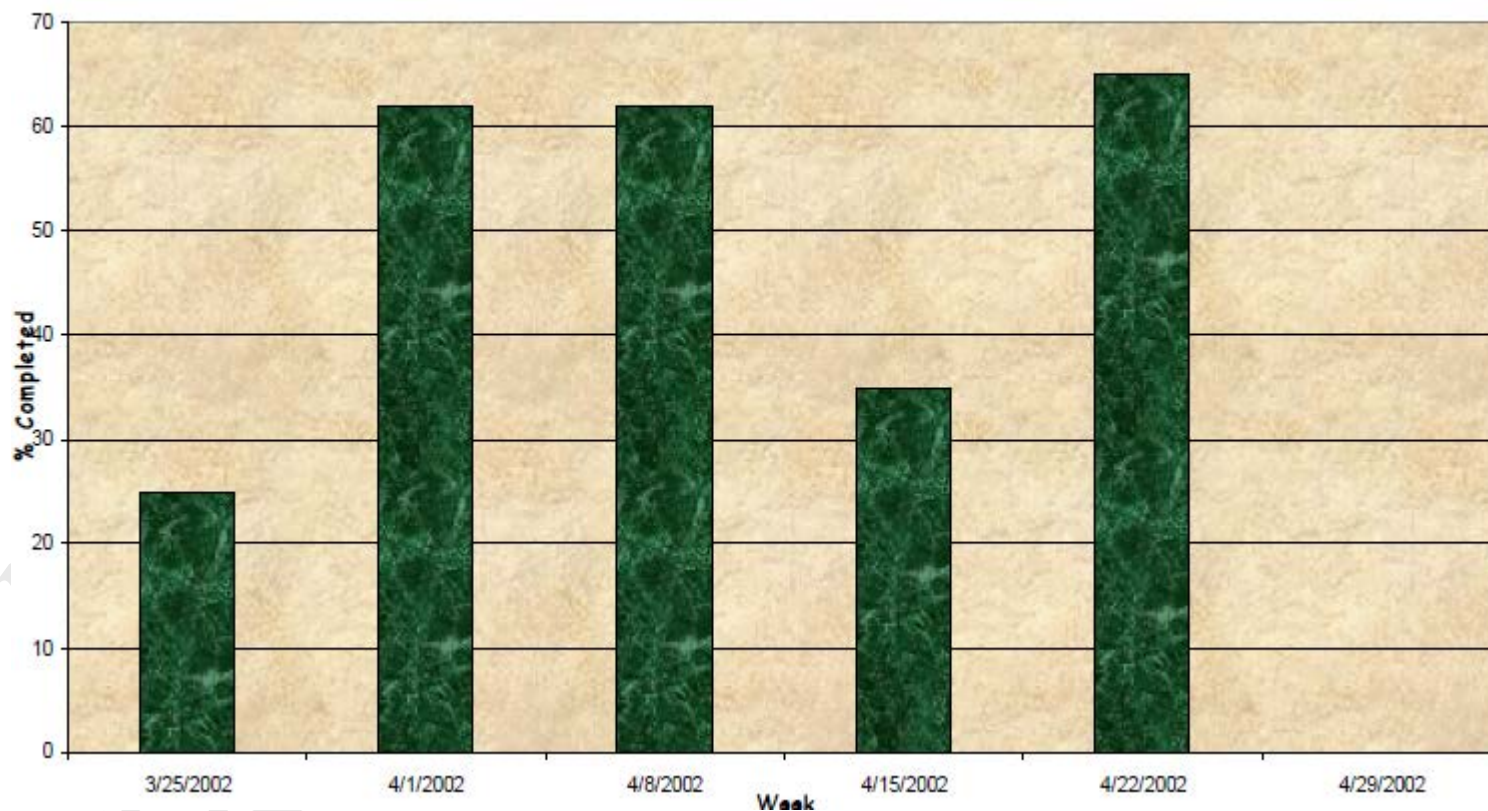
**You will learn later in this course!**

## Chart PPC and reasons

- ❑ After WWP have been **implemented and completed** through the “production” block, **completed work** is analyzed in the “Chart PPC and Reasons.”
  - ❖ Where assignments have **not been completed**, they are **examined and studied** through **root cause analysis** in order to improve future assignments.
- ❑ Completed work (DID) is compared with **planned work (WILL)**.
- ❑ The **PPC values** are calculated.
  - ✓ The **reasons** for **non-completion** are recorded and analyzed in order to improve the process.
  - ✓ **Learning** should be a **positive experience**.
    - It should **not be an occasion** for casting **blame**!

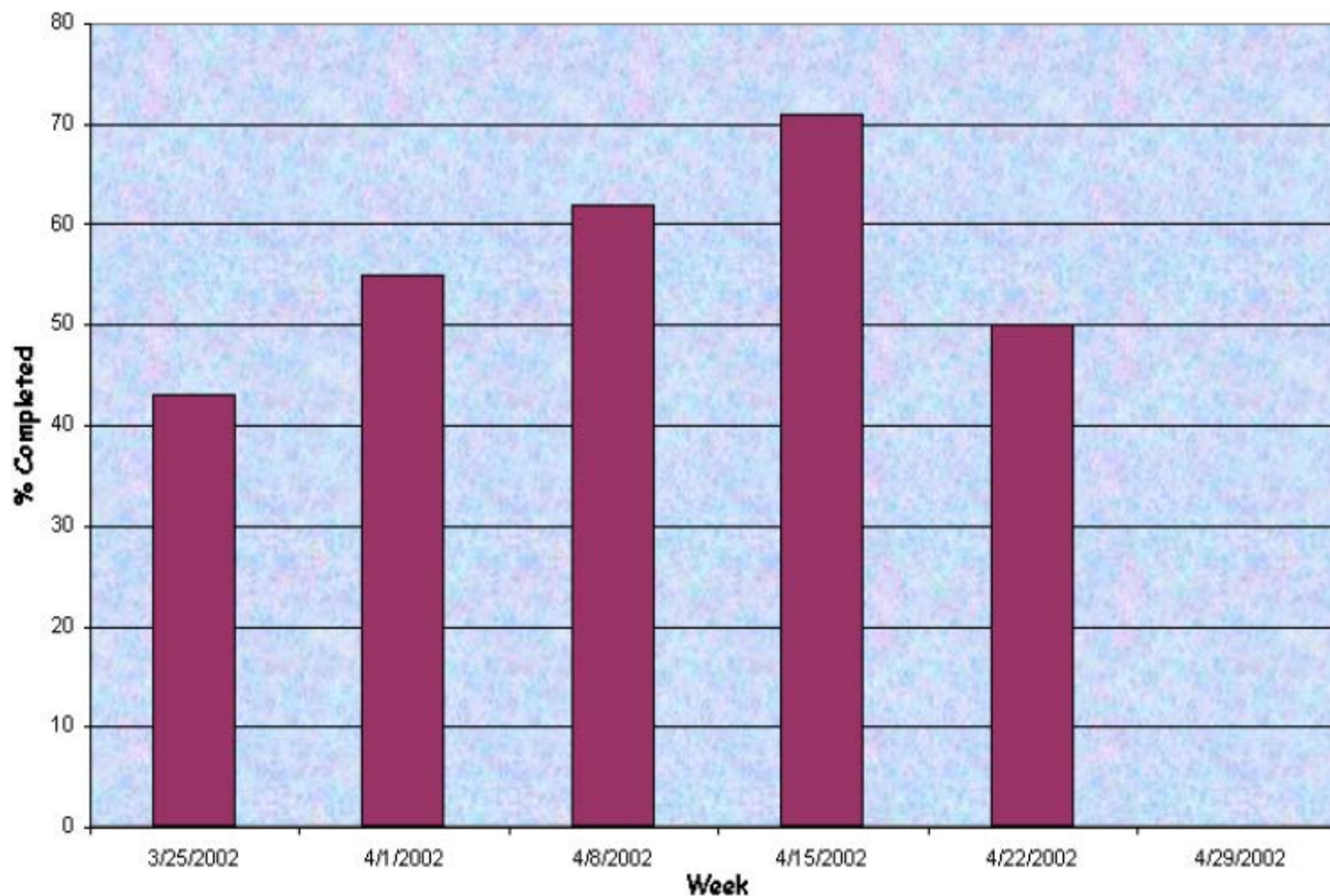
## Chart PPC and reasons – Chart PPC

Percent of Planned Completed - DRYWALLERS



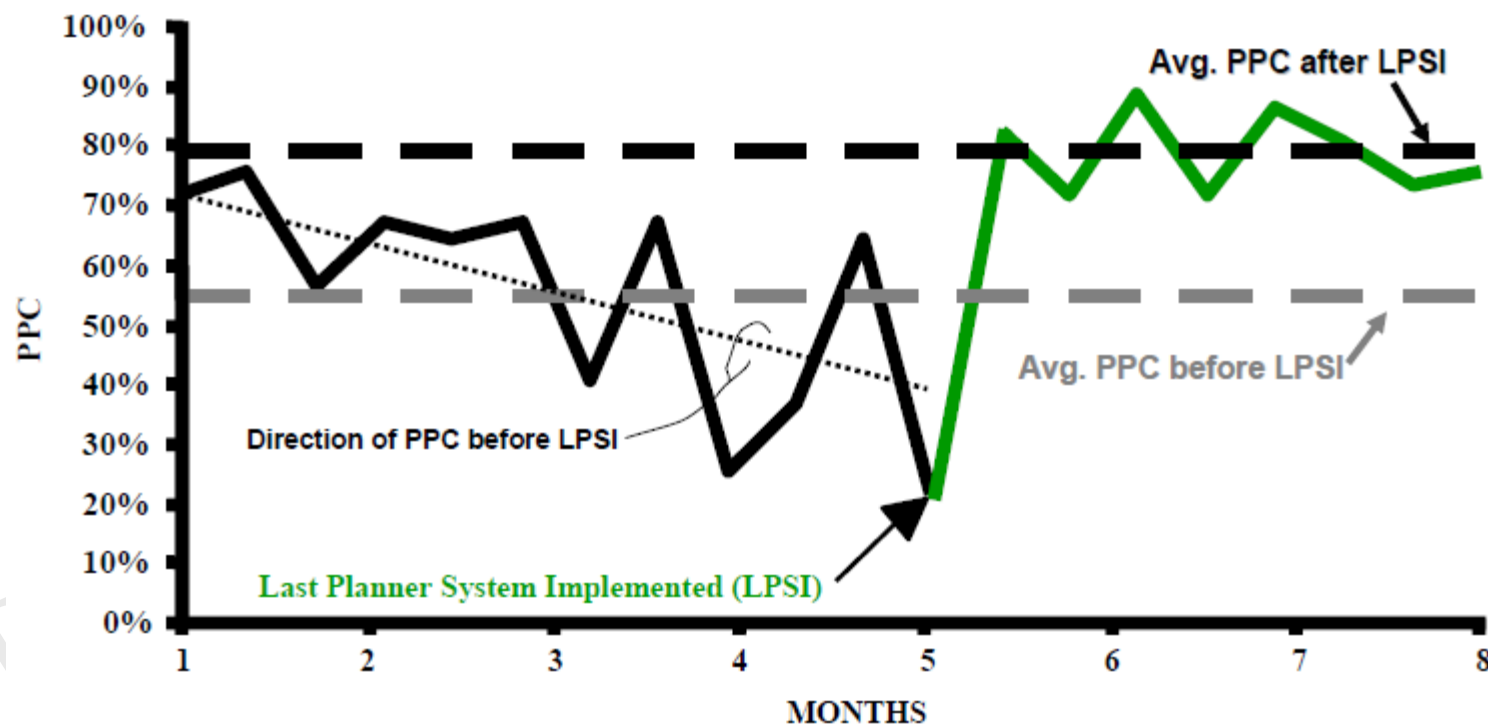
## Chart PPC and reasons – Chart PPC

Percent of Planned Completed - PLUMBERS



## Chart PPC and reasons – Chart PPC

- ❑ Comparing the results-evolution of PPC



## Chart PPC and reasons – Reasons for plan failure

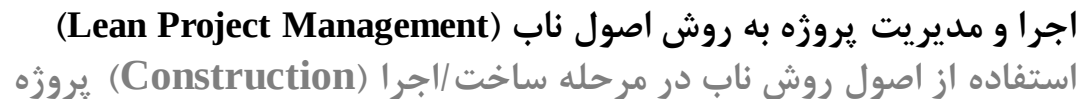
- ❑ When an **assignment is not completed** by the end of the plan week,  
Last Planner must **record the reasons** for non-completion.
  - ❖ Reasons for plan failure **fall into categories** pertaining to directives, prerequisite work, resources, and process or output failures.
- ❑ Designers and contractors may recognize some of those **commonly mentioned**:

|                          | DESIGN                                                                 | CONSTRUCTION                                                                                                                                          |
|--------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Directives</b>        | changes in design criteria<br>unaware of code requirements             | changes in directives from superintendent<br>not informed of performance standard                                                                     |
| <b>Prerequisite Work</b> | information needed from owner<br>waiting for vendor confirmation       | need submittal approval<br>materials did not arrive<br>request for information unanswered<br>other contractor still in area<br>no access to work area |
| <b>Resources</b>         | equipment failure<br>unavailability of lead designer to grant approval | lack of tools and equipment<br>labor shortage                                                                                                         |
| <b>Process or Output</b> | insufficient time<br>discovered calculation error                      | insufficient time<br>no craft coordination<br>weather<br>emergency                                                                                    |

## Chart PPC and reasons – Reasons for plan failure

### Reasons For Not Achieving 100% PPC - DRYWALL INSTALLERS

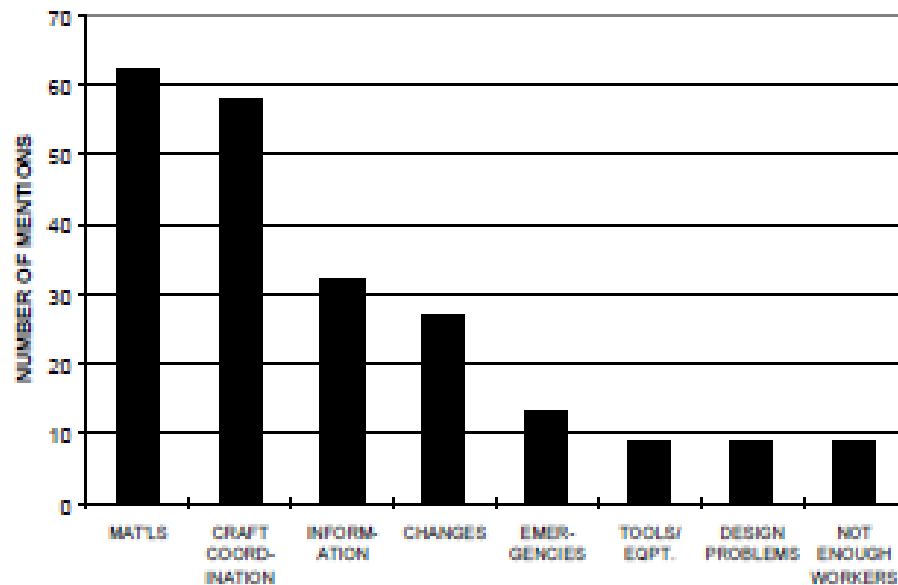
| Week            | 3/25/2002 | 4/1/2002 | 4/8/2002 | 4/15/2002 | 4/22/2002 | 4/29/2002 |
|-----------------|-----------|----------|----------|-----------|-----------|-----------|
| PPC             | 25%       | 62%      | 62%      | 35%       | 65%       |           |
| Tasks Completed | 1         | 8        | 13       | 7         | 13        |           |
| Tasks Planned   | 4         | 13       | 21       | 20        | 20        |           |
|                 |           |          |          |           |           |           |
| Coordination    | 3         | 1        | 3        | 8         | 2         |           |
| Engineering     |           |          | 1        |           | 1         |           |
| Owner Decision  |           |          |          |           |           |           |
| Weather         |           |          |          |           |           |           |
| Pre-Requisite   |           | 1        | 3        | 1         | 2         |           |
| Labor           |           |          |          | 4         |           |           |
| Materials       |           |          |          |           |           |           |
| Contract        |           |          |          |           |           |           |
| Submittals      |           |          |          |           |           |           |
| Equipment       |           |          |          |           |           |           |
| RFI's           |           |          |          |           |           |           |
| Space           |           | 3        | 1        |           | 2         |           |



## Variance Analysis - Reasons and Categorization

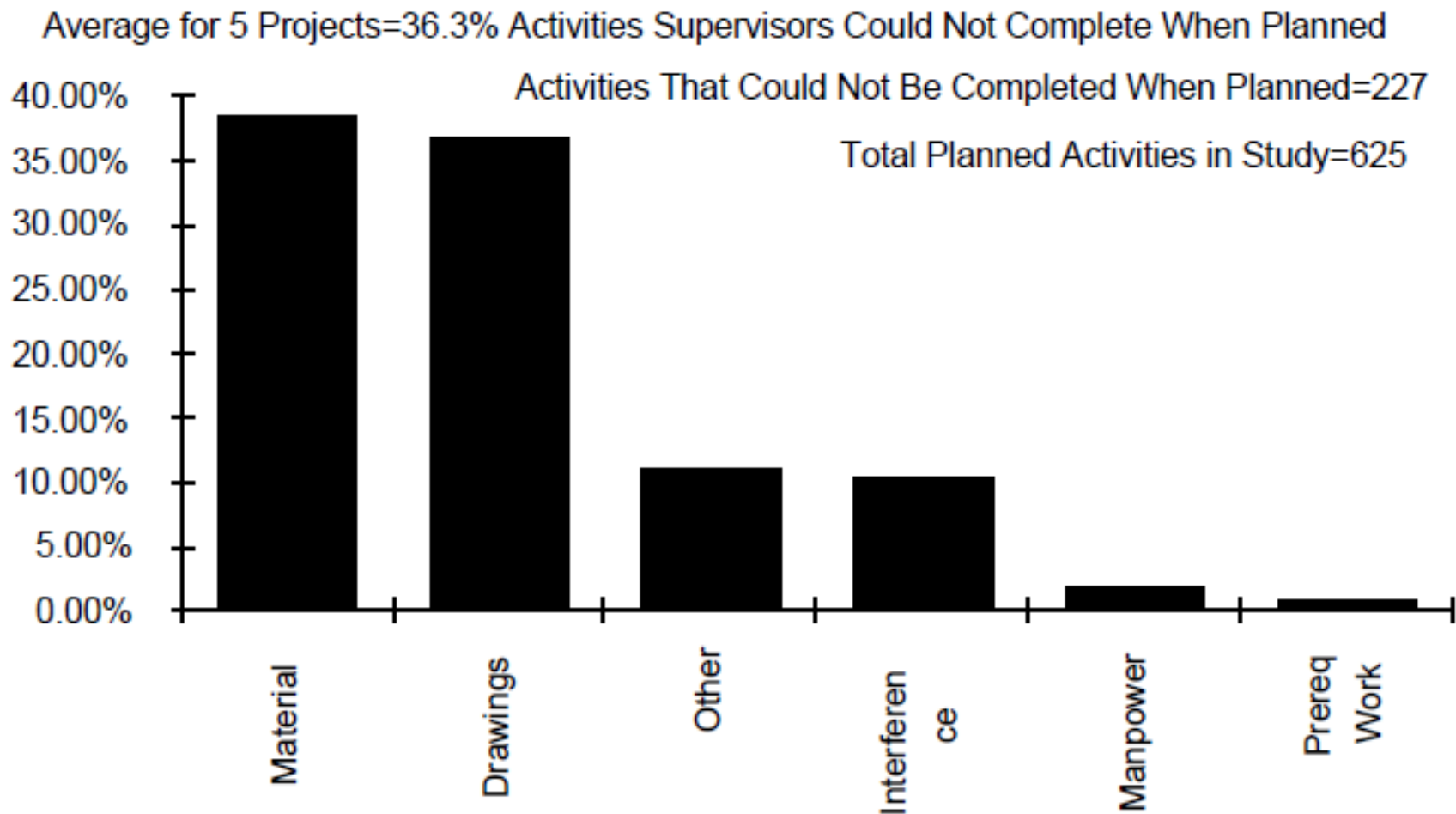
By: Alavipour, PhD, PMP, CMIT  
Kambiz Kordani, M.Sc., PMP

## Chart PPC and reasons – Reasons for plan failure

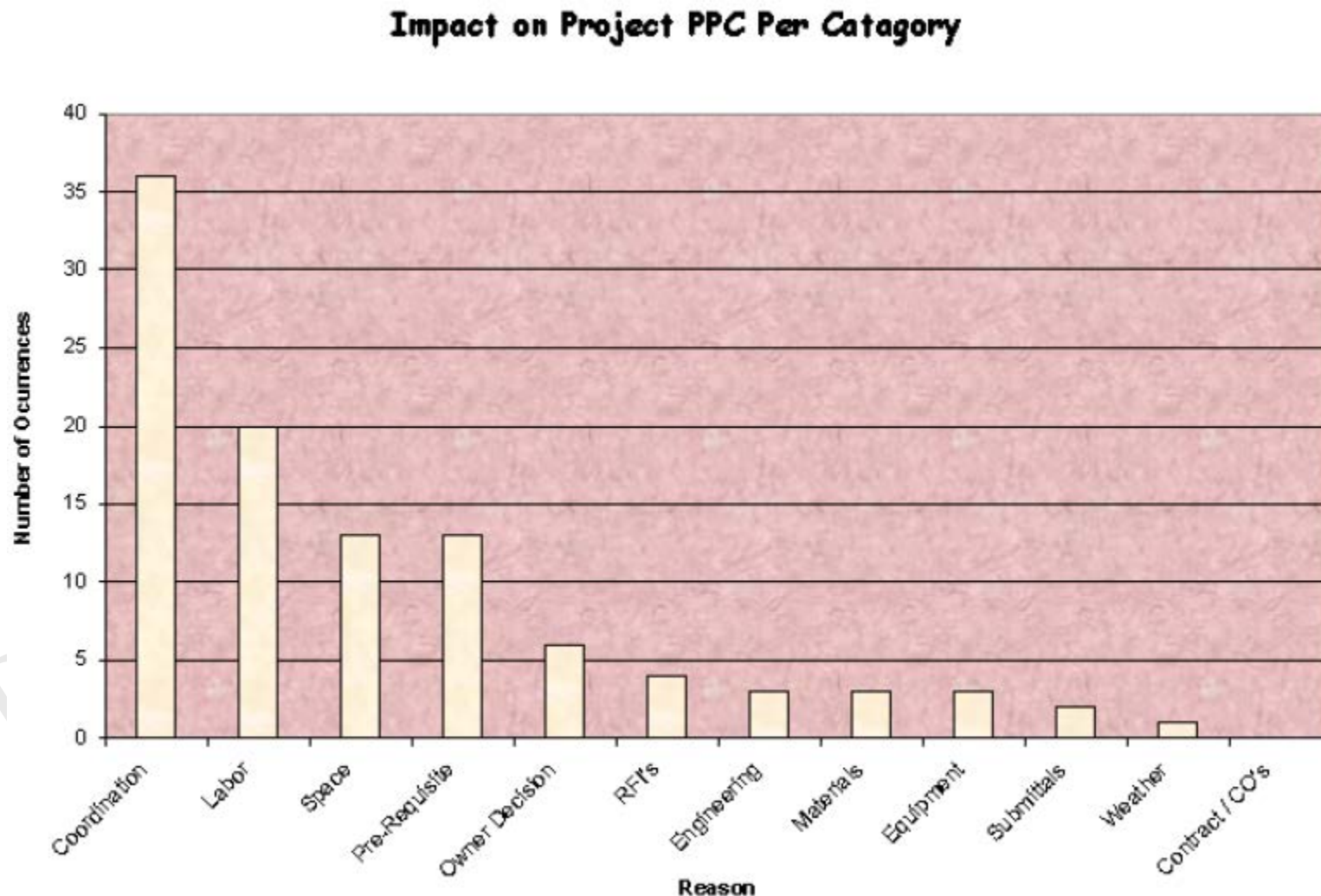


Reasons for plan failure can be plotted based on their frequency of occurrence. This highlights which failures are predominant and where process improvement efforts may be most beneficial.

## Chart PPC and reasons – Reasons for plan failure

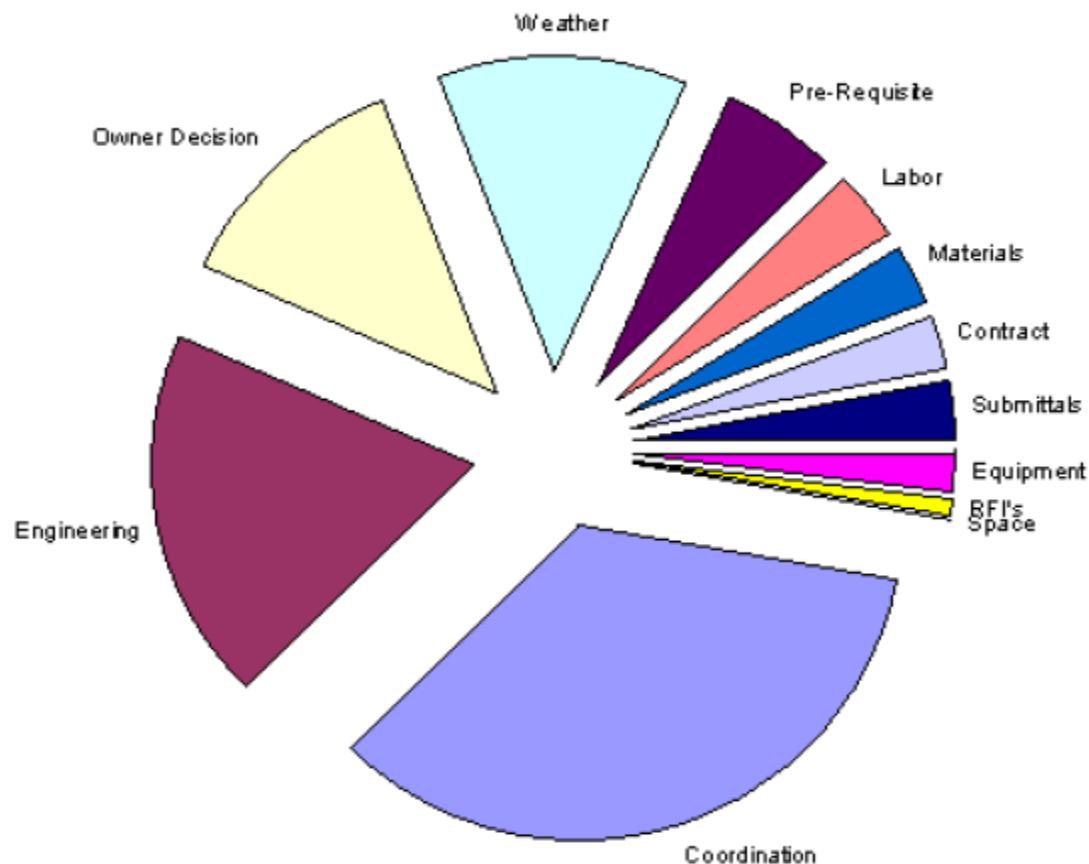


## Chart PPC and reasons – Reasons for plan failure



## Chart PPC and reasons – Reasons for plan failure

Categories Responsible for Incomplete PPC

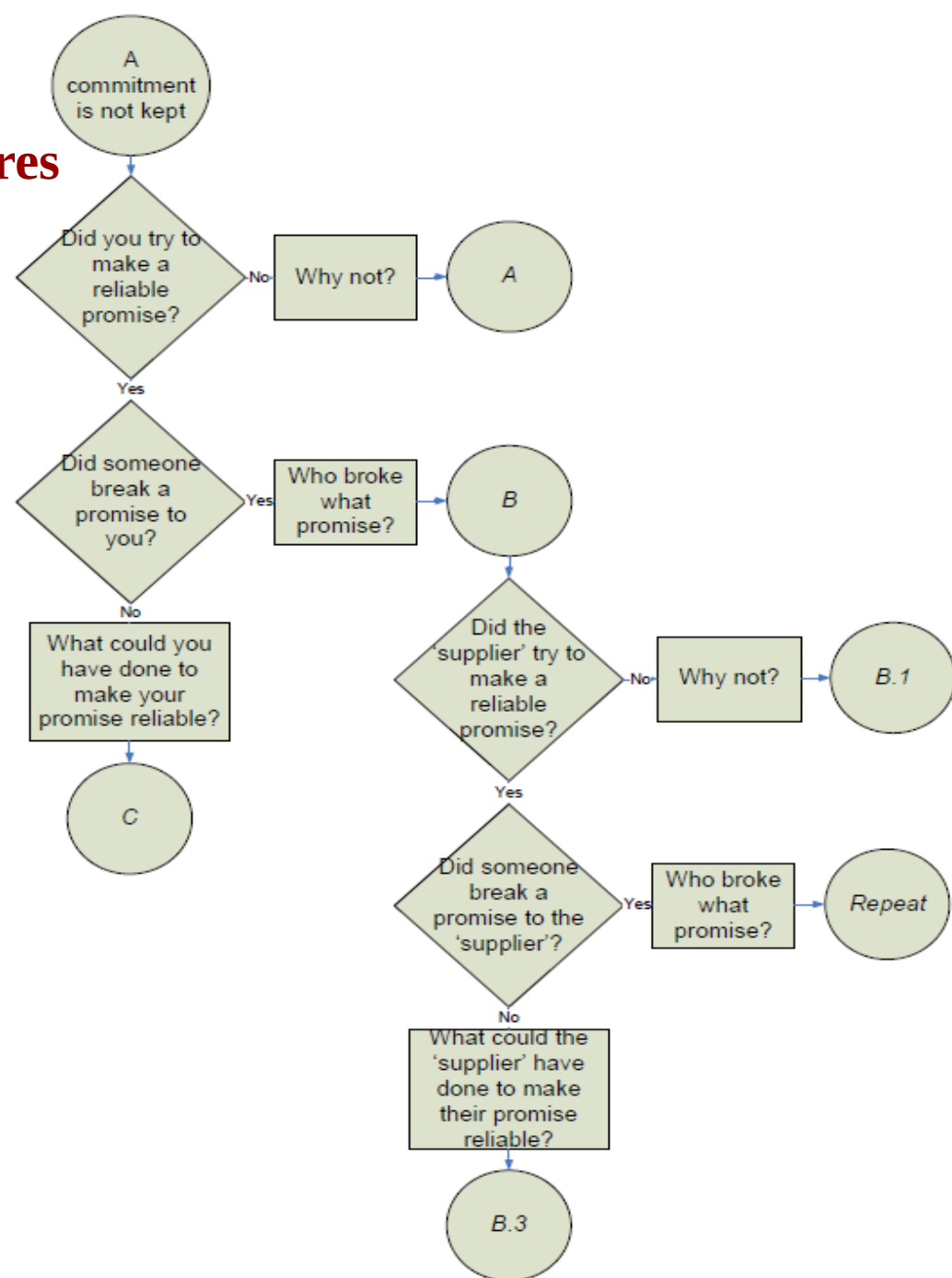


## Learning from plan failures

- ❑ After noting **reasons for non-completion**, the Last Planner must perform a root cause analysis.
  - ❖ The reason that is **first apparent** may in fact be a consequence of other actions that took place on the project.
  - ❖ The Last Planner **must get to the source** of the action or event chain in order to **learn how repeat failures** can be **prevented**.
  - ❖ The purpose is **not to assign blame** to any individual, but rather to **help people understand how a change** in their action might help **prevent future plan failures**.

## Learning from plan failures

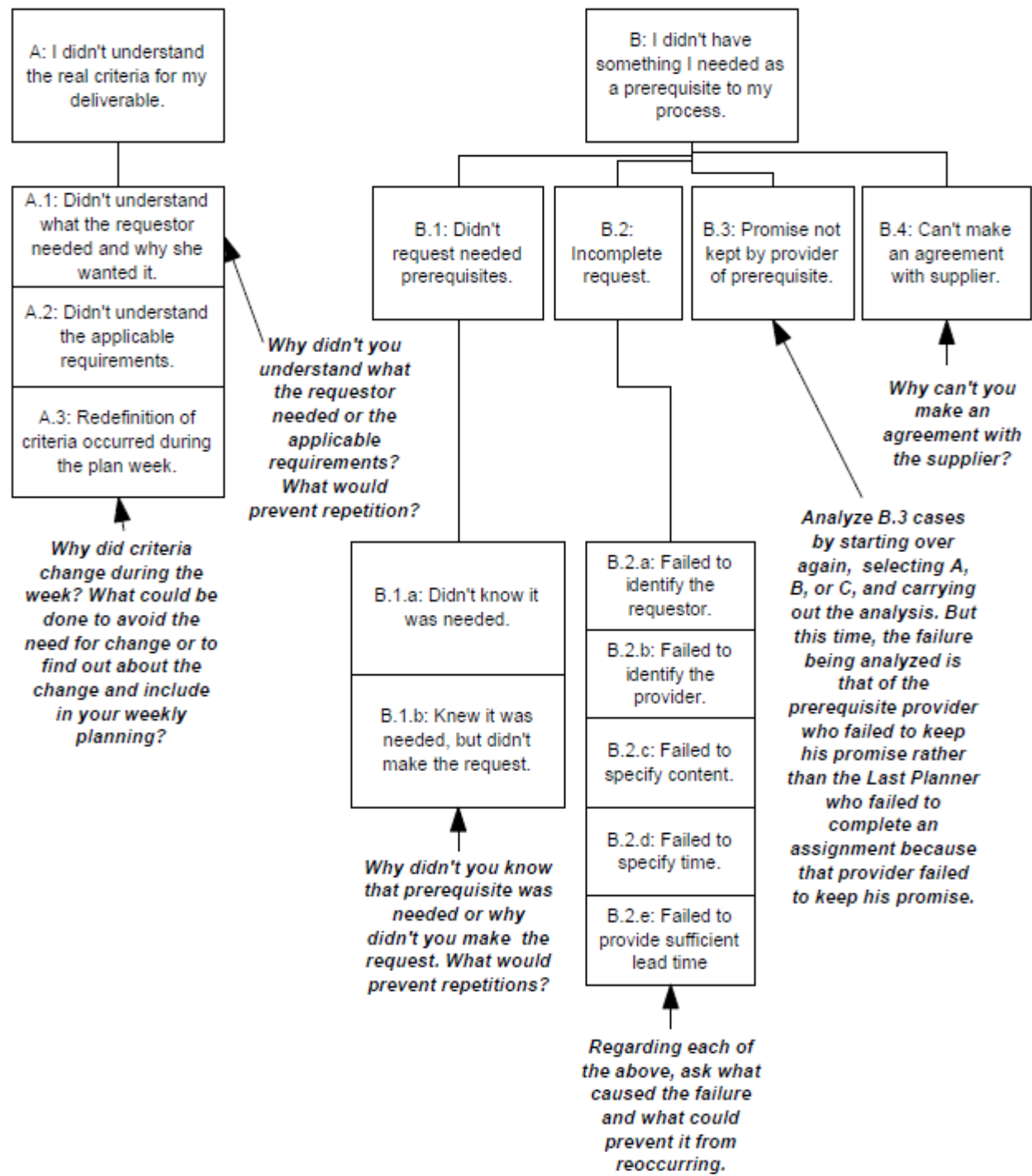
- ❑ Analysis for reasons of plan failure





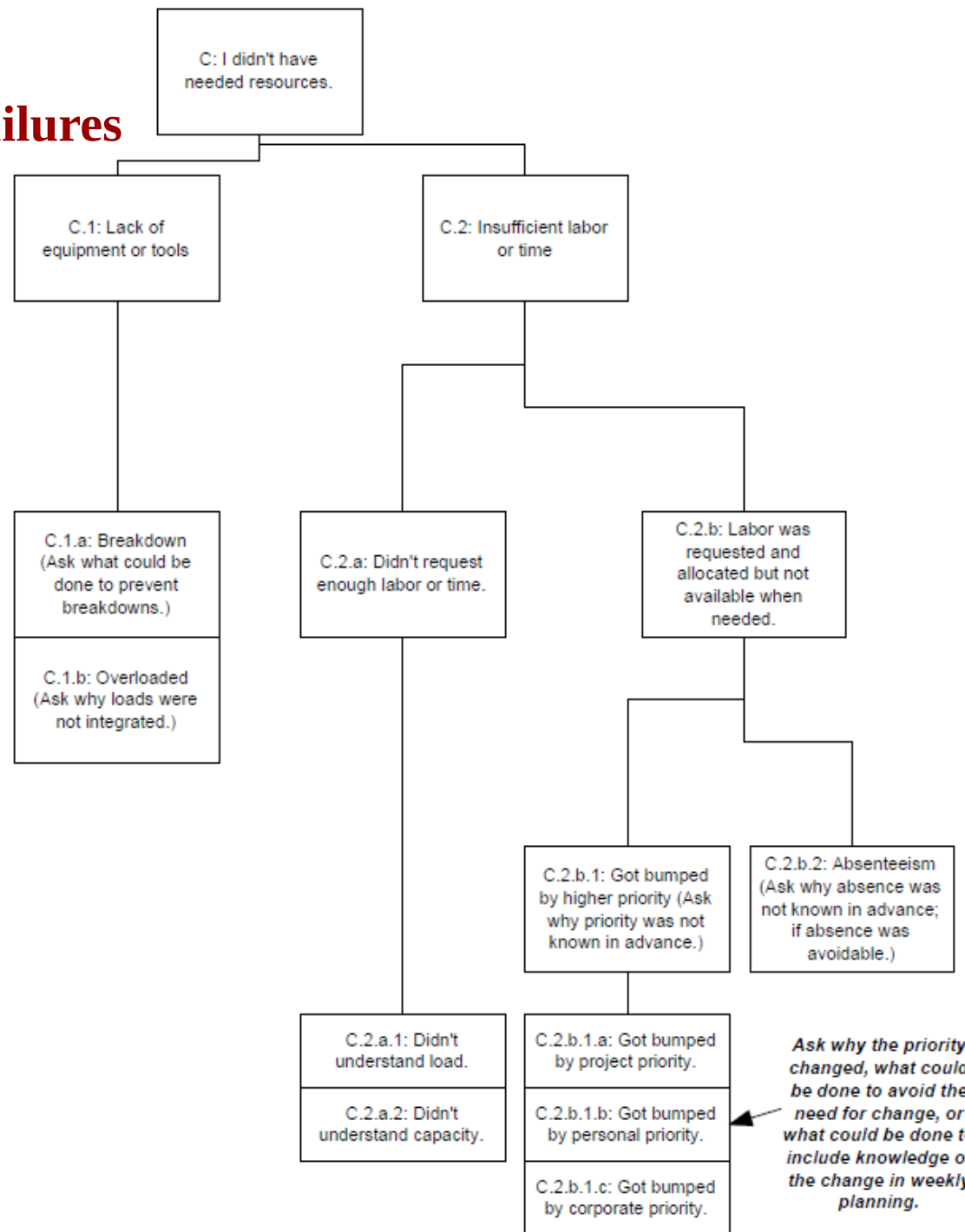
# Learning from plan failures

- Reasons analysis hierarchy – criteria and prerequisite

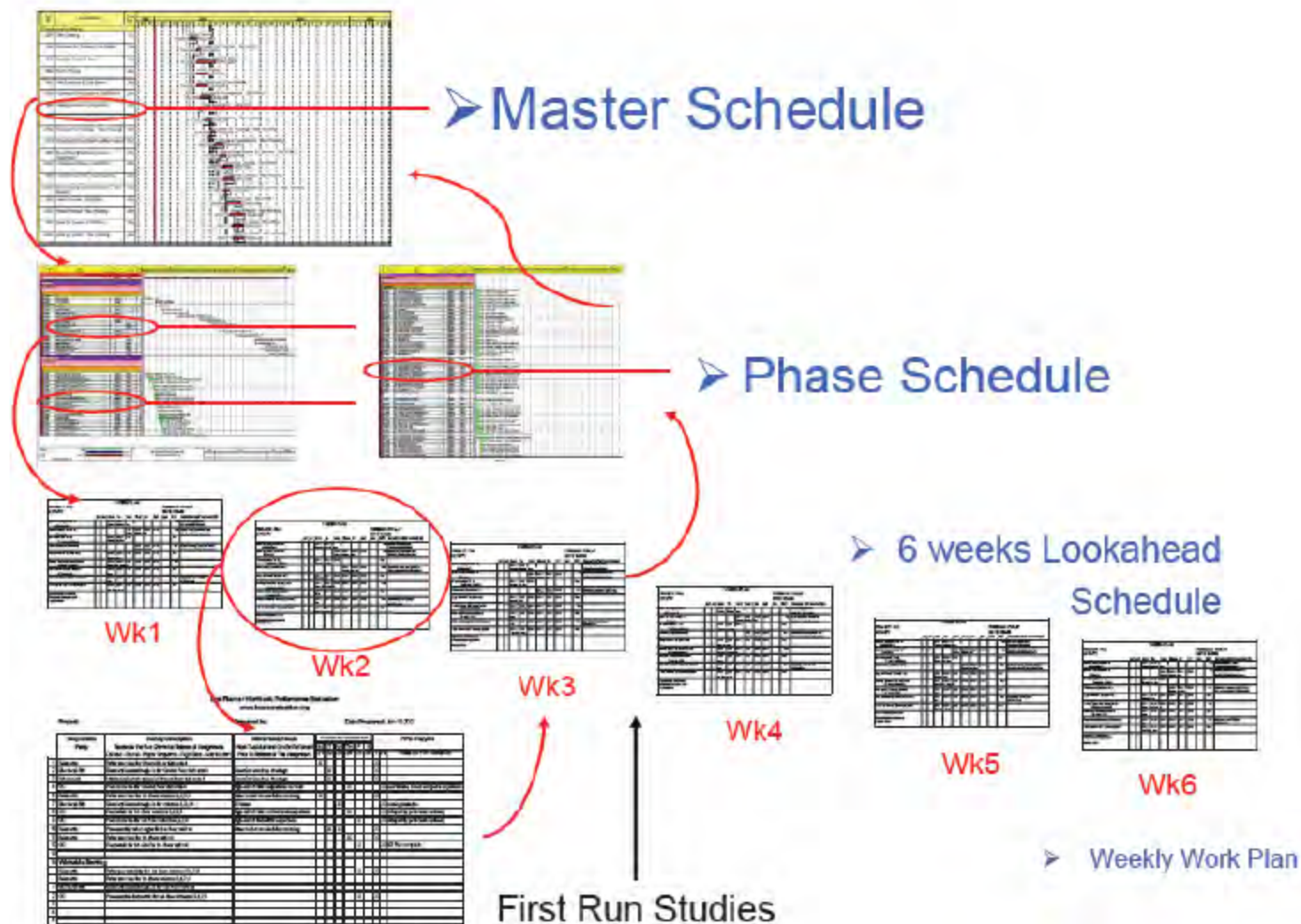


# Learning from plan failures

Reasons analysis  
hierarchy – Resources



## Learning and corrective actions



Look ahead schedule as part of the planning cycle.

## Who is the last planner?

- ☐ The **Last Planner** is the **person directly overseeing** the work done by a production unit.
- ☐ The Last Planner typically is **responsible and accountable** for the **unit's ability to produce** and for the **output they produce**.
- ☐ The Last Planner **may self-perform some of the work**.
- ☐ The **Last Planner** in **design** may be the **design lead**.
- ☐ The **Last Planner** for the **general contractor** may be a **project engineer** or an **area superintendent**.
- ☐ The **Last Planner** for the **specialty contractor** may be the **crew foreman**.

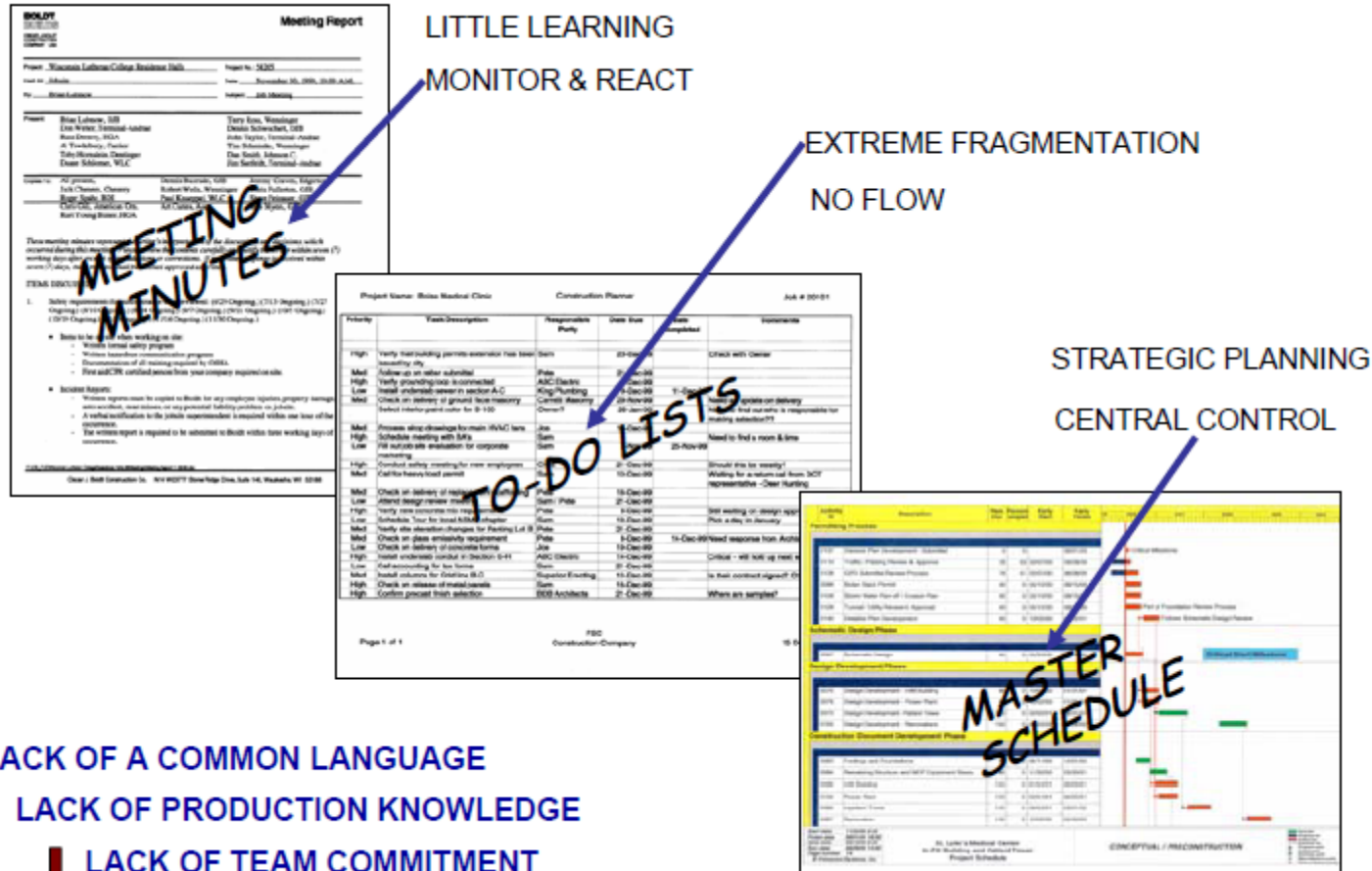
**You can be a Last Planner!**

## When to use?

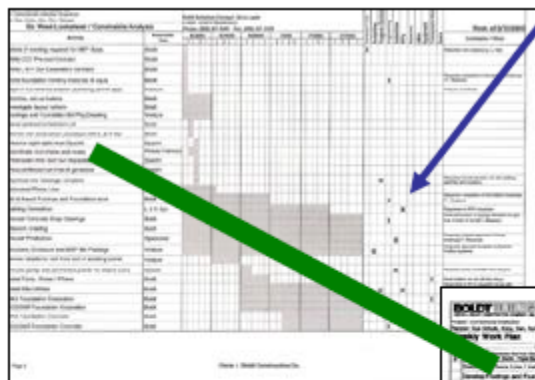
- ☐ The Last Planner can be **implemented from the start** of a project or

it may be **implemented on a project** that **already is underway**.

## Traditional schedule management



## Last planner system



SHAPING WORK FLOW

IDENTIFYING & REMOVING CONSTRAINTS

DECENTRALIZED PLANNING

EXPLICIT QUALITY ASSIGNMENTS



RAPID LEARNING

MEASUREMENT



BUILDING RELIABILITY

MANAGING WORK FLOW

PRODUCTION MANAGEMENT SYSTEM

COLLABORATIVE TEAM COMMITMENT

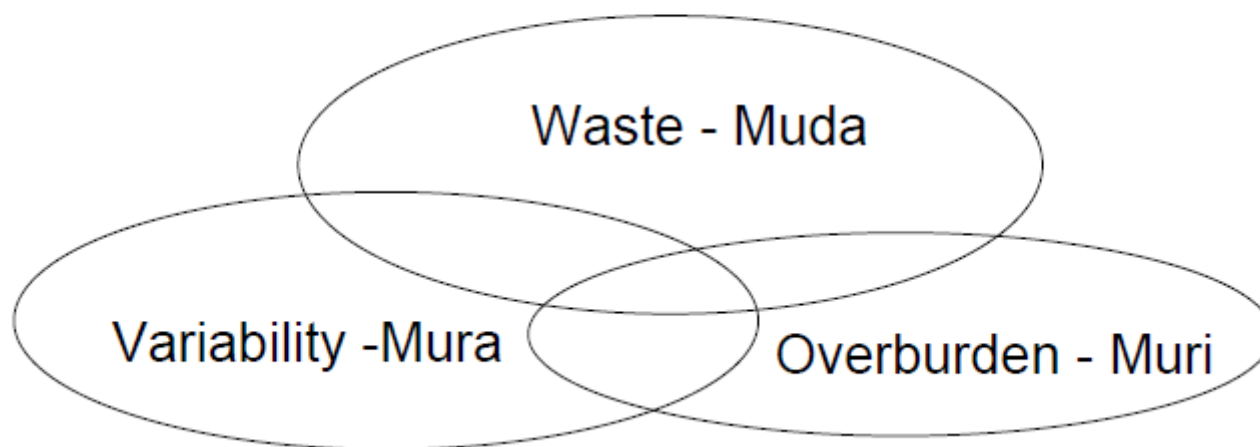
FLOW

# **Lean in Construction Phase of the LPDS**

## **(Lean Construction Implementation)**

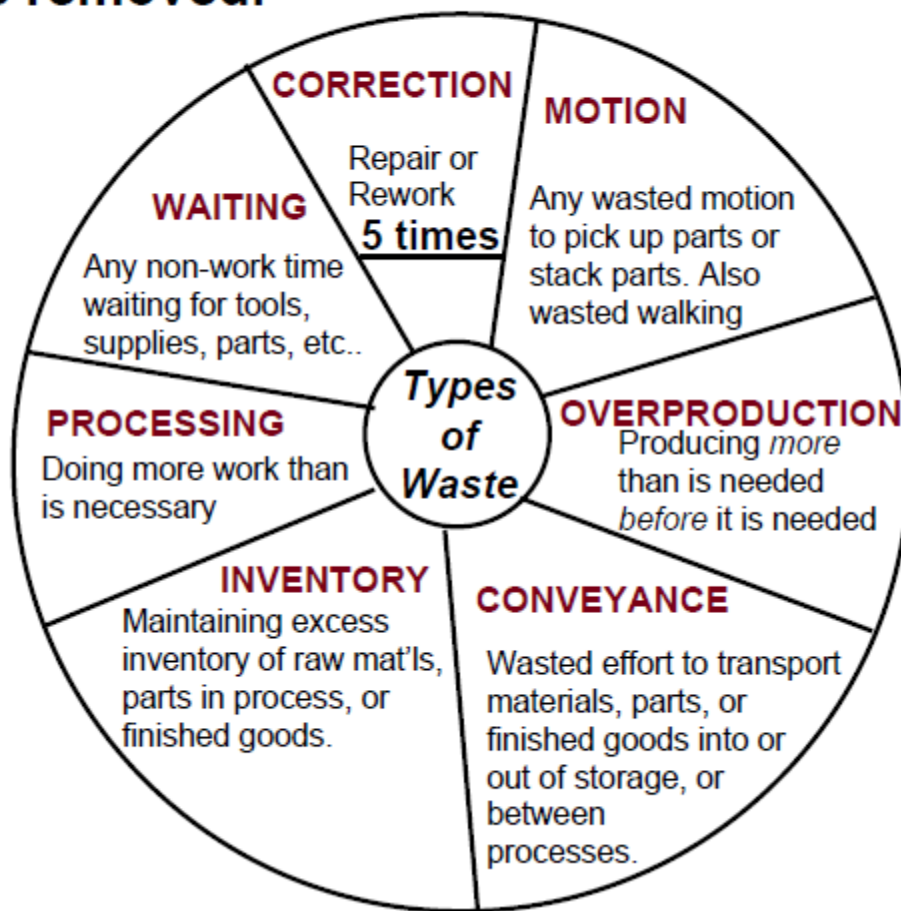
## Lean construction management

**IMPROVE WORKFLOW RELIABILITY ON  
YOUR SITE!!!!!!!!!!!!**



## Lean construction management

✱ Anywhere work is performed, waste is being generated and must be removed.



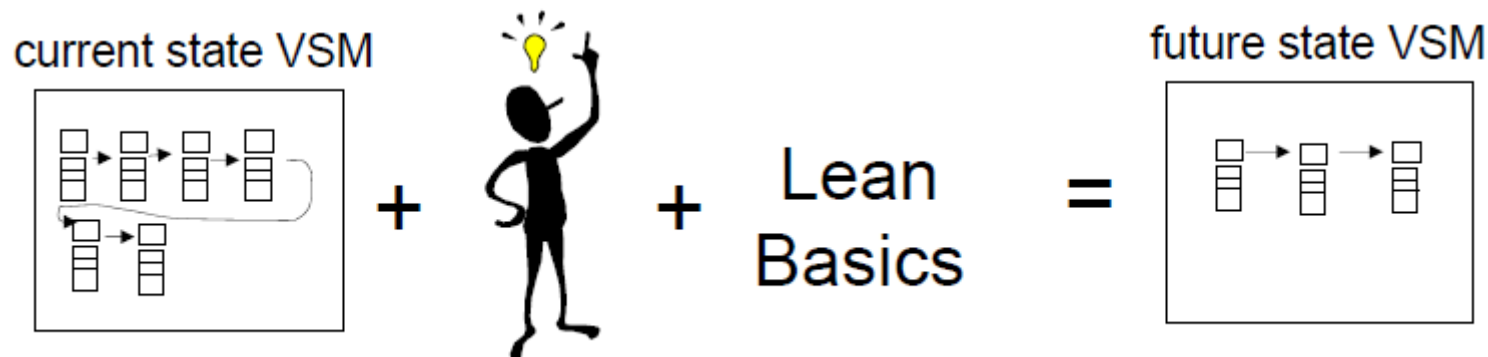
## Lean construction management

### Walbridge Aldinger Examples of Construction Waste

|   | Form of Waste                                                                                                 | Example                                                                                                         |
|---|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 1 | <b>Over-Production:</b> Producing over the customer requirements, producing unnecessary materials/products    | Producing more pipe spools than required                                                                        |
| 2 | <b>Inventory:</b> Holding or purchasing unnecessary raw supplies, work-in-progress inventory, finishing goods | Stockpiling too much dry wall in area well before it is needed and in the way of other trades                   |
| 3 | <b>Transportation:</b> Multiple handling, delay in material handling, unnecessary handling                    | Locating materials too far from the point of installation                                                       |
| 4 | <b>Waiting:</b> Time delays, idle time                                                                        | Crew B waiting for an activity to be completed as promised by Crew A                                            |
| 5 | <b>Motion:</b> Actions of people or equipment that do not add value to the product                            | Double and triple handling of material when planning could have reduced it to one move                          |
| 6 | <b>Over Processing:</b> Unnecessary processing steps or work elements                                         | Rubbing a concrete foundation wall to well when it will be backfilled or covered                                |
| 7 | <b>Correction:</b> Producing a part that is scrapped or requires rework /procedures                           | Punchlist items or items of work that are deficient and do not meet requirements which require rework           |
| 8 | <b>Not Utilizing Human Resources:</b> Not following-up/implementing ideas/suggestions                         | Not considering someone's idea to improve a process or work task particularly if that person performs that work |

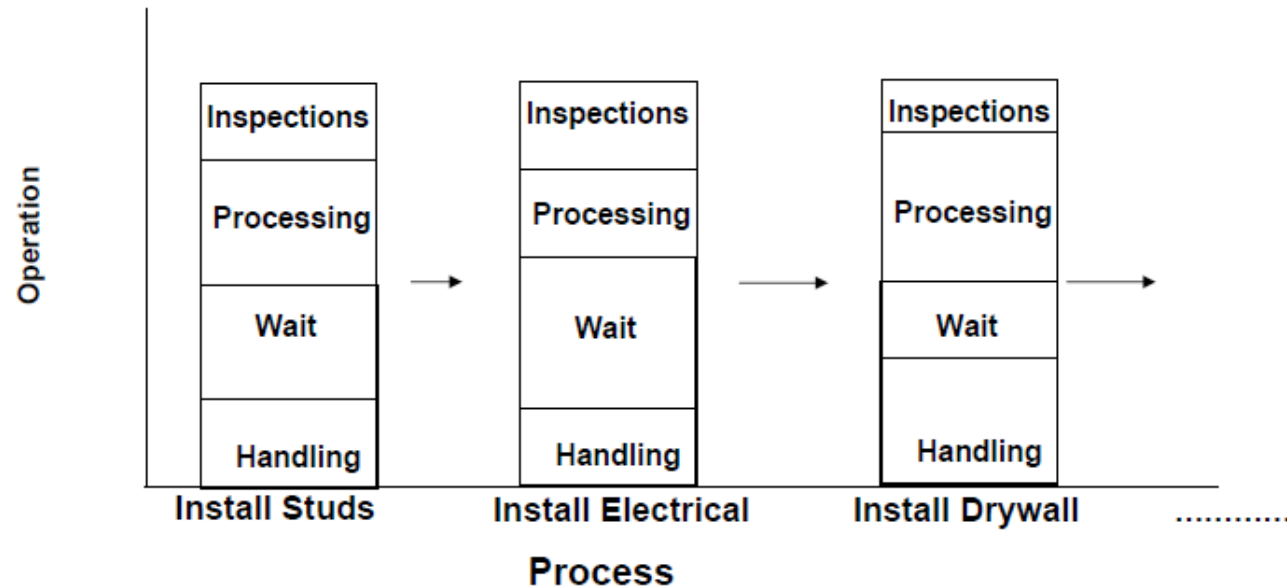
## Value stream mapping

# Planning tool to optimize results of eliminating waste



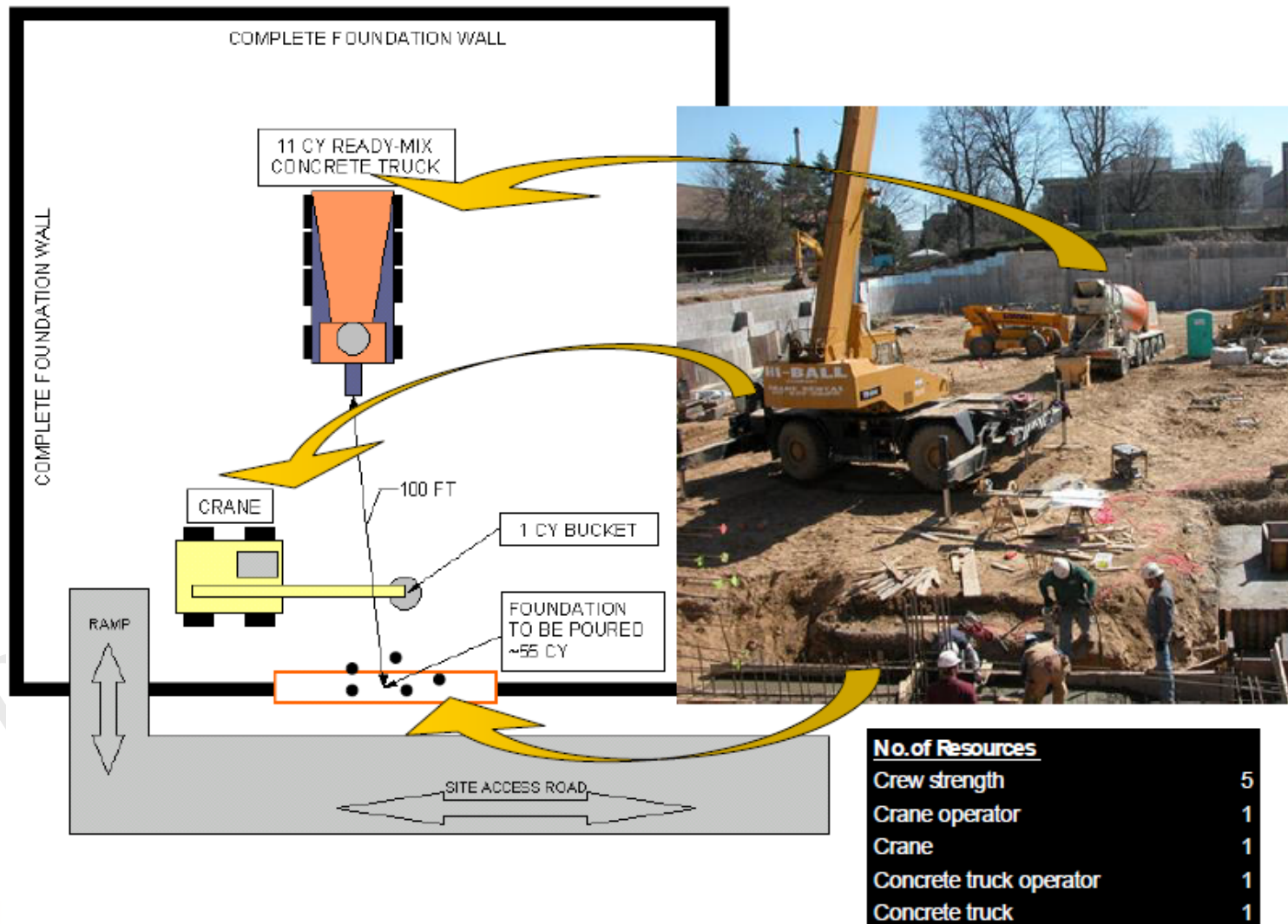
## Value stream mapping

### Process and Operation (Shingo 1990-adapted)



- An operation represent the work performed to complete the transformation of materials
- A process represent flow of material/info in time and space as it is being transformed
- Note that construction processes do not necessarily have operations occurring in the discrete fashion shown above

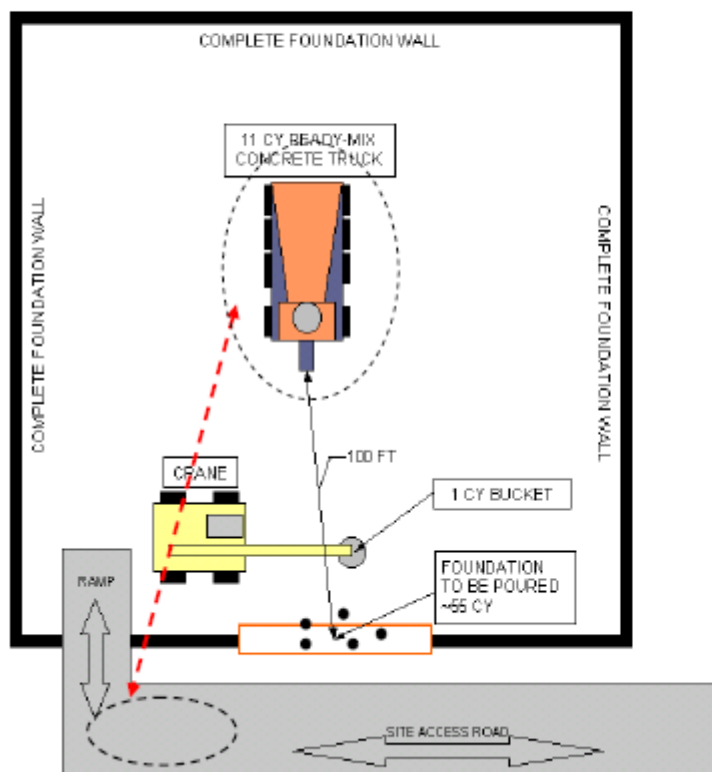
## Value stream mapping



## Value stream mapping

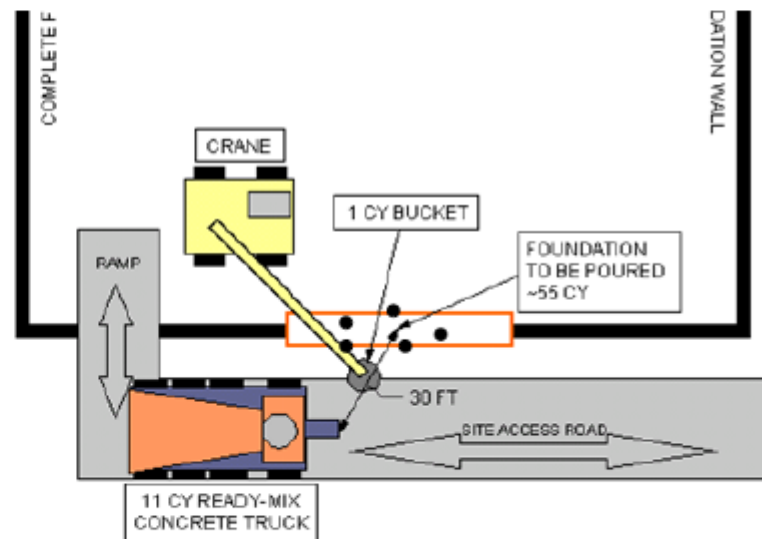
Why should the truck go into the site?

Is there any value added?



### Suggested Modification #1

Let the truck be parked outside, the crane can swing the bucket in the same manner from the truck to the crew pouring concrete.



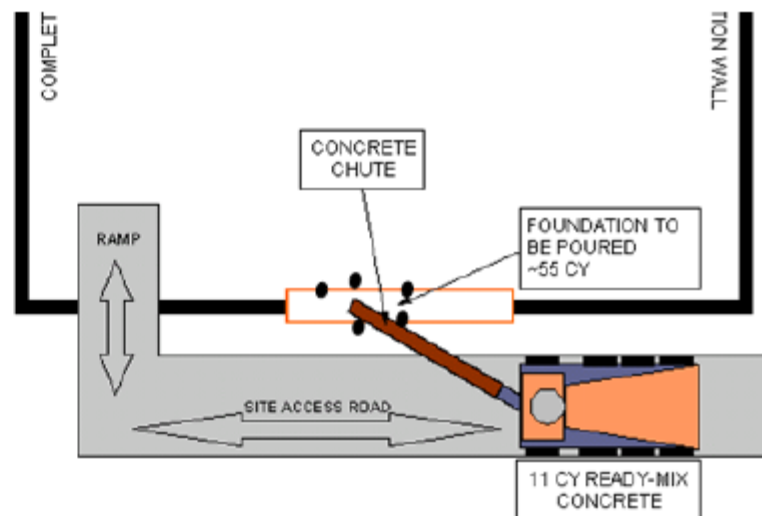
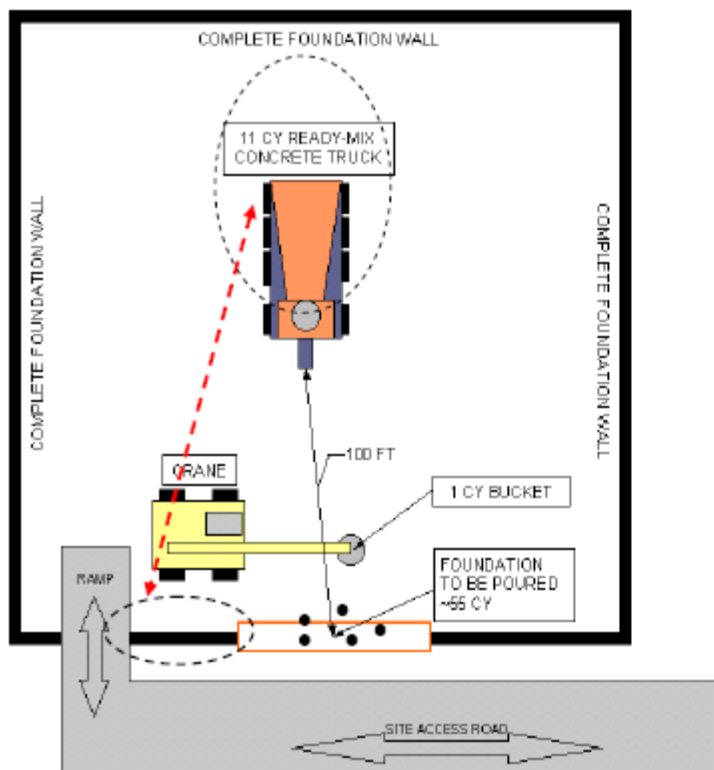
## Value stream mapping

What is the crane's role? It basically is a facilitator – helps transfer concrete from truck to casting crew!

Can the truck deliver concrete directly?

### Suggested Modification #2

The crane is omitted from the operation. The concrete mix truck is equipped with a chute, one that is flexible and can adjust in length and its angle. The truck can also move as per the location for casting.



# **Lean in Construction Phase of the LPDS**

## **(LC Levels of Implementation )**

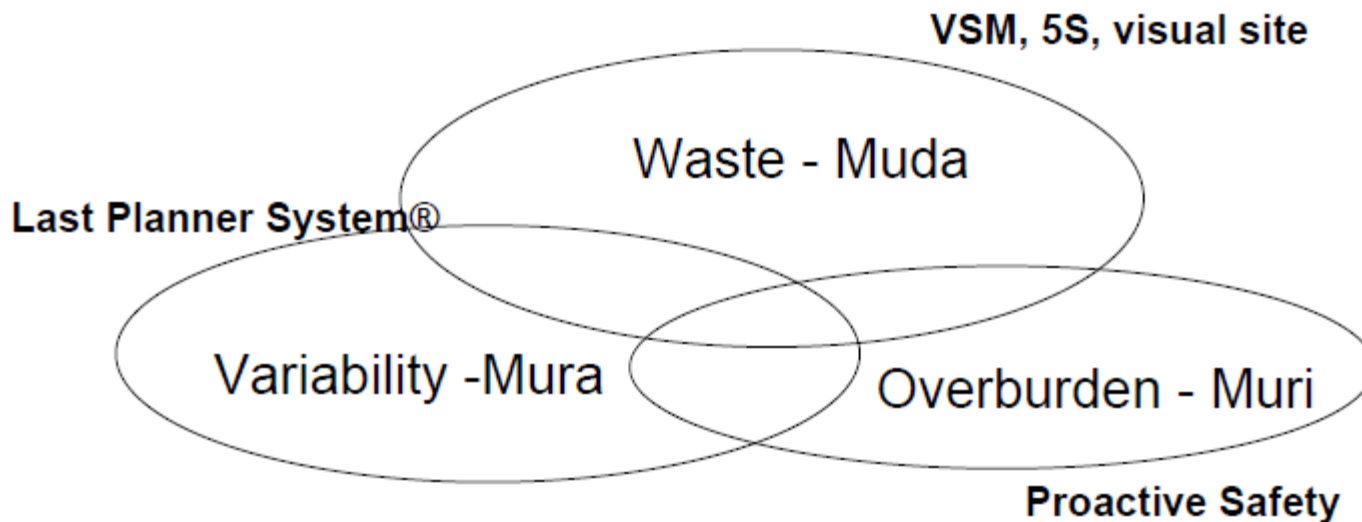
## Three levels model

| Level | Features                                               | Tools                                       | Involved/<br>Benefiting Party               |
|-------|--------------------------------------------------------|---------------------------------------------|---------------------------------------------|
| 1     | Improved Work Coordination                             | LPDS: LPS®                                  | Contractor and/or Sub-contractor            |
| 2     | Production System Design:<br>Reliable workflow on site | LPDS: LWS,<br>LPS®                          | Architect/Contractors/Suppliers             |
| 3     | <u>Align interests, define value, and share wealth</u> | <u>LPDS: Relational Contract, LWS, LPS®</u> | <u>Owner/Architect/Contractors/Supplier</u> |

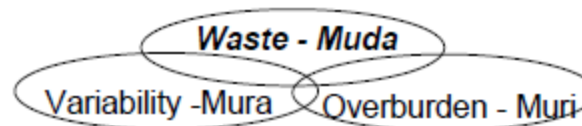
## Level 1

### Level 1

# IMPROVE WORKFLOW RELIABILITY ON YOUR SITE!!!!!!!!!!!!!!!!!!!!!!



### Level 2



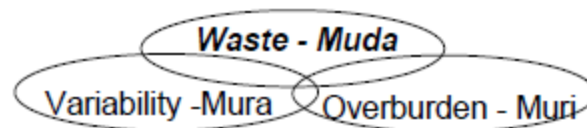
- **The Lean way – Production System Design to Increase Workflow Reliability**

- Lean work structuring will reduce waste caused by scope changes and design errors/ omissions,
  - Understand and challenge customer requirements (BIM)
  - Shift design responsibilities to suppliers (BIM, SCM)

SCM = Supply Chain Management

Lean  
Design  
and  
Supply

### Level 2



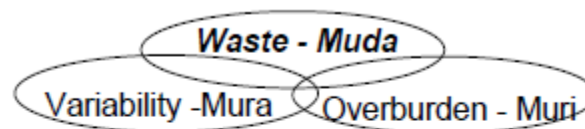
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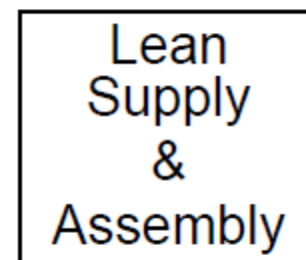
- Design product and process together using cross-functional teams
  - Simulation
  - First-run studies

Lean  
Design  
and  
Supply

### Level 2



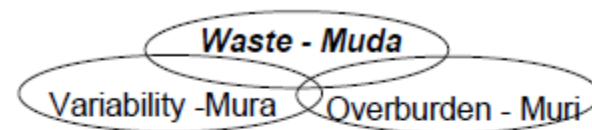
- **The Lean way – Production System Design to Increase Workflow Reliability**



- Lean work structuring will reduce waste caused by excess inventories

- Establish strategic alliances with suppliers
  - Allows pulling inventories/material to site; concrete
  - Standardize and industrialize (prefab) wherever possible

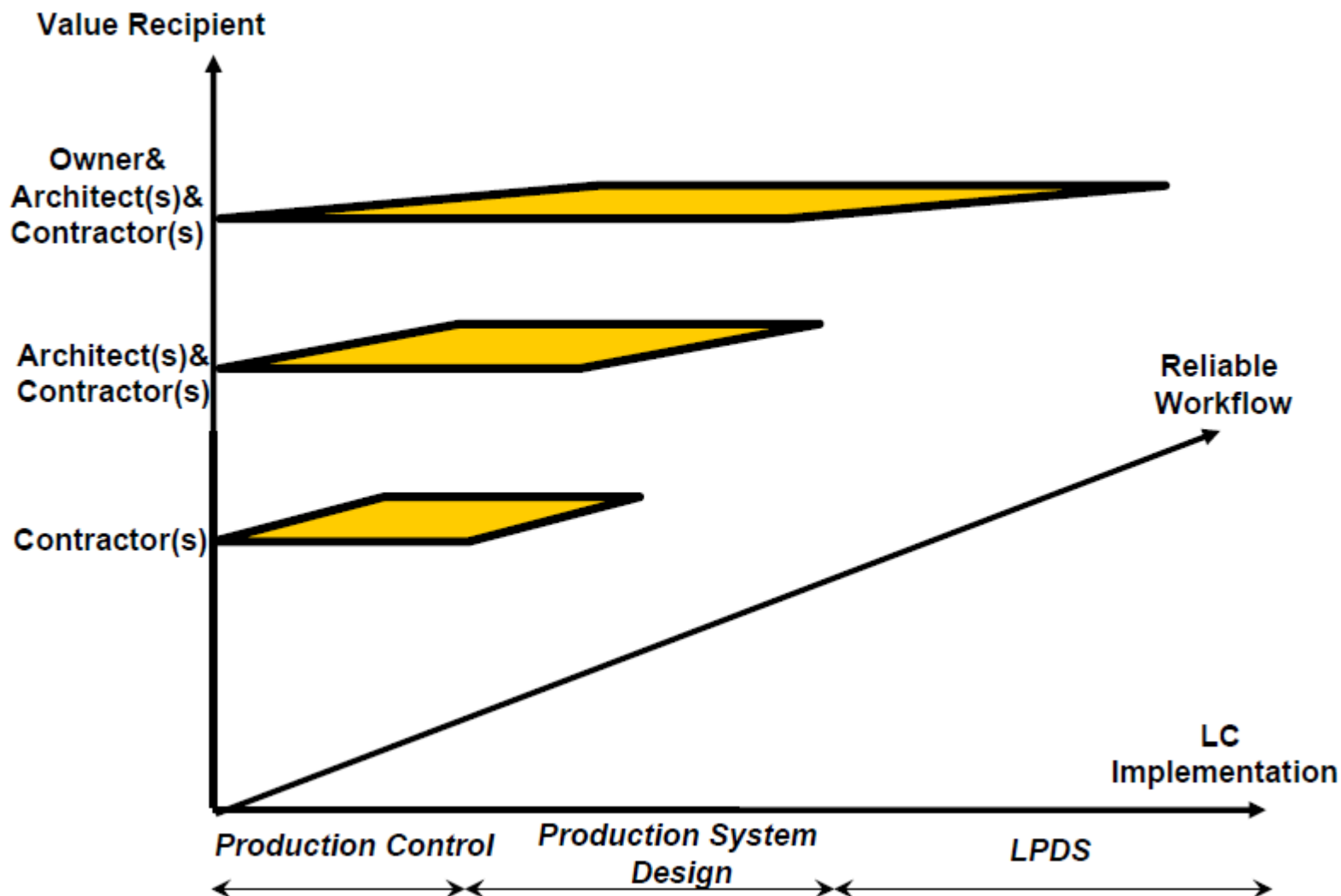
## Level 3



- **The Lean Way - Integrated Project Delivery Or Relational Contracting to Increase Workflow Reliability**

- This will allow the Architect and CM/GC and Subs to impact the programming (Project Definition) phase.

## Whole system at a glance



## Lean Design and Construction

### ASSIGNMENT 2-3-1:

1. Read the questions below with your team members to discuss the following questions together.
  - a) How can one ensure that the weekly work plan represents the most appropriate work to be performed in a given week?
  - b) What role does constraint analysis play in The Last Planner® System?
  - c) What is work structuring? What steps does it involve?
2. Try to answer the above questions together in one or two pages.
3. Send your paper (in PDF format) to [ralavipour@gmail.com](mailto:ralavipour@gmail.com)

**Due on the next week (next week with similar day)**

## موسسه مهندسی و مدیریت ساخت علوی پور

تهران، بلوار فردوس شرق، بعد از خیابان حسن آباد، مجتمع آبگینه، طبقه سوم اداری، واحد C42

+۹۸۲۱۴۶۱۰۰۴۴۵



+۹۸۲۱۴۶۱۰۰۴۵۰



info@dralavipour.com



www.dralavipour.com



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