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FUNDAMENTALS OF PRODUCTION CONTROL

CPE LEVEL THREE TRAINING MODULE

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INTRODUCTION

Scope

With a constantly increasing number of variants, shorter lifecycles, and unpredictable demand fluctuations: The manufacturing industry has to cope with many complex challenges as they strive to meet increasingly individualized customer demands – and to stay competitive over the long term. That's why, increasingly, flexible production control is crucial for success.

Production control is the activities involved in handling materials, parts, assemblies and sub-assemblies, from their raw or initial stage to the finished product stage in an organized and efficient manner. It may also include activities such as planning, scheduling, routing, dispatching, storage. Production planning and control has become an important issue in production as well as design process of products to be manufactured. Both of the fields require as accurate as possible computational model to control and predict manufacturing processes.

This training module assist in the understanding of the fundamentals of production control. Applications of proposed models should facilitate and simplify the product design and production control.

General Consideration

Production Management Model

Production is a process whereby raw material is converted into semi finished products and thereby adds to the value of utility of products, which can be measured as the difference between the value of inputs and value of outputs. Production function encompasses the activities of procurement, allocation and utilization of resources. The main objective of production function is to produce the goods and services demanded by the customers in the most efficient and economical way.

The functions of production management systems are planning and control. Planning establishes goals and a desired sequence of events for achieving goals. Control causes events to approximate the desired sequence, initiates re-planning when the established sequence is either no longer feasible or no longer desirable, and initiates learning when events fail to conform to plan.

When environments are dynamic and the production system is uncertain and variable, reliable planning may not be performed in detail. Consequently, deciding what and how much work is to be done next by a design squad or a construction crew is rarely a matter of simply following a master schedule established at the beginning of the project.

A key early finding was that only about half of the assignments made to construction crews at the beginning of a week were completed when planned. Experiments were performed to test the hypothesis that failures were in large part a result of lack of adequate work selection rules (these might also be called work release rules). Quality criteria were proposed for assignments regarding definition, sequence, soundness, and size. In addition, the percentage of assignments completed was tracked (PPC: Percent Plant Complete) and reasons for non-completion were identified, which amounted to a requirement that learning be incorporated in the control process.

The first measure after negotiation was the development of a schedule. Based on the data consolidated in the Executive Planning, which had already been developed and assimilated by everyone involved, especially the engineer responsible for contract management. To do so, the activities necessary to execute the construction were listed, as well as the precedence relations and the respective terms, which constituted a service program based on the Critical Path Method (CPM) technique.

According to the model, it was assumed that the uncertainty generated by the fact that a CPM technique does not reflect the flow difficulties to feedback the different productive processes would be compensated for by the use of Look Ahead Tables and Daily Plan. These were updated every week and permitted the complete control of the needs for each front of work by the responsible engineer and the foreman, with the following advantages:

- Monitoring of the desired rhythm of each job
- Optimization of working teams available in each stage of the construction
- Stabilization of the operational environment, decreasing the number of surprises during the activities.
- Decreasing quantity of raw material stored in the site.

Due to the fact that the construction had a short term, approximately three months for the example case. This schedule was executed with daily precision, and was sub-divided into areas of control, external, building, facade and general items.

In the sub-item building, the sub-division of services made after the application of mass in the walls was made per environment, that is, details for each environment, floor, walls, lining, electrical services, plumbing, HVAC, equipment, etc.

The cycle of production management for this construction can be summarized through the weekly meetings called by the site manager, with the support of the foreman and occasionally with the participation of representatives of sub-contractors. The following stages are executed:

- Look Ahead

Based on the CPM technique that had been reviewed the previous week, the services to be executed during the next two weeks are determined, being that daily details are given for the following two weeks. The main objective of this document is to allow that future needs of material, equipment and labor are anticipated, avoiding to increase the level of stock and occasional stop due to lack of input.

- Daily Plan

Based on Look ahead, the site manager, together with the foreman, executes the Daily Plan, which basically consists in listing the works to be performed during the following week, indicating the dates of execution and the team to be used for each work.

- PPC (Percent Planned Completed)

When the Daily Plan is executed, an analysis of the report of the report of the previous week is made, and the PPC is calculated by dividing the quantity of works effectively executed by the total quantity of works that had been foreseen. A note explaining the reasons justifies any work that had been foreseen but was not executed.

When the PPC is calculated, a re-programming of the services is made, indicating the services that had already been executed and those that had been foreseen but were not executed. The immediate result of this re-programming is the calculation of a new date for finishing the construction.

New Model of Production Management

In the development of a new model of production management, the first concern is to make the operational environment stable, through a new design of the organization and valorization of the function of planning and control.

In this scenario, the contract manager began to be responsible by the operational performance of the enterprise under his responsibility, as well as the management of the planning, services schedule and the logistic of the fronts of work. The foreman is responsible for guaranteeing the rhythm and quality of the services, systematically aiming the optimization of allocation of the available recourses (labor, materials, and service suppliers) for the different fronts of work under development.

According to the new concept, the enterprise begins during the phase of budgeting, when our planning and logistic manager, together with the contract manager and budget team, define the following points:

- Project of the site
- Definition of the infrastructure necessary to execute the construction, including:
    - Energy, water and sewerage systems
    - Infrastructure for communications in the site
    - Trustful and qualified local suppliers
- Access and flow of materials inside the site.
- Arrangements to conform the site to the ideal conditions of work safety and hygiene
- Execution methodology aiming the requirements for term and quality

Execution plans of the construction with the objective of budgeting according to the execution, as well as of giving consistency to the compromise of everybody with the term foreseen for the work.

Production process can be conceived in at least three different ways :

1) As a process of converting inputs to outputs
2) As a flow of materials and information through time and space
3) As a process for generating value for the customers.

All three conceptions are appropriate and necessary. However, the conversion model has been dominant in the AEC (Architectural/Engineering/Construction) industry until very recently.

Table 1. Conversion/Flow/Value

	Conversion View	Flow View	Value Generation
Nature of Construction	A series of activities which convert inputs to outputs.	The flows of information & resources, which release work: composed of conversion, inspection, moving, and waiting.	A value creating process which defines and meets customer requirements.
Main Principle	Hierarchical decomposition of activities; control and optimization by activity.	Decomposition at joints. Elimination of waste (unnecessary activities), time reduction.	Elimination of value loss-the gap between achieved and possible value.
Methods and practice	Work breakdown structure, critical path method. Planning concerned with timing start and responsibility for activities through contracting or assigning.	Team approach, rapid reduction of uncertainty, shielding, belancing, decoupling, plannig concerned, with timing, quality and release of work.	Development and testing of ends against means to determine requirements. Planning concerned with work structure, process and participation.
Practical contribution	Taking care to do necessary things.	Taking care that the unnecessary is done as little as possible.	Taking care that customer requirements are met in the best possible manner.

The design and construction of AEC facilities (buildings, process plants, airport terminals, highways, etc.) poses difficult management problems to which the models and techniques based on the conversion view have proven inadequate. Tradeoffs between competing design criteria must be made throughout the design process, often with incomplete information and under intense budget and schedule pressure. Increasingly, projects are subject to uncertainty because of the pace of technological change and the rapid shifting of market opportunities and competitor actions.

Production management concepts and techniques based on the conversion model hae not proven capable of solving these difficult problems. The heart of the conversion model is the assumption that the work to be done can be divided into parts and managed as if those parts were independent one from another. Management techinques such as work breakdown structures and earned value analysis belong to this conversion model. Work breakdown structures are driven by scoping and budget concern and have the objectives of insuring that all the work scope is included in one of the parts, insuring that no work scopes overlap, and allocating costs to each to allocate responsibility to internal or external work centers, which can subsequently be controlled against scope, budget, and schedule commitments.

This fundamentally a contracting mentality, which facilities the management of contracts rather than the management of production or work flow. Producton management is the “local” responsibility of those to whom the various parts are asigned or contracted. If everyone meets their contractual obligations, the project performs successfully. Unfortunately, this approach is the opposite of robust. When something goes wrong, as it very often does, the entire structure is prone to collapse.

If a management philosophy and tools are needed that fully integrate the conversion, flow and value models, we might consider the product development processes employed by firms designing and manufacturing consumer products (automobiles, printers, toasters, etc.) such processes have developed potentially useful concepts especially in the area of value, identification of customer needs and translation into engineering specifications (Ulrich and Eppinger 1993). Product development processes also are struggling with other issues relevant to the design of AEC facilities, including design decomposition, organizational means for integration, etc.

Manufacturing Planning and Control (MPC)

One of the more pervasive and least well forecast changes in the manufacturing environment is the implementation of enterprise resoursce planning (ERP) systems. Many of the ERP systems were based on the material requirements planning (MRP) logic and factory integration that MRP systems already had in place. Nevertheless, they often displaced the existing manufacturing planning and control systems or were implemented alongside of them. The result is that MPC systems are now imbedded in ERP systems in a great number of organizations.

The MPC system is concerned with planning and controlling all aspects of manufacturing, including managing materials, scheduling machines and people, and coordinating suppliers and key customers. Since these activities change over time and respond differently to different markets and company strategies. The development of an effective manufacturing planning and control system is key to the success of any company. Moreover, truly effective MPC systems design is not a one-time effort, MPC systems need to continuously adapt and respond to changes in the company environment, strategy, customer requirements, particular problems and new supply chain opportunities.

The most important aspect of the context for development and maintenance of a manufacturing planning and control system is the continual change in its competitive environment. Changes range from technological to political and strategic. Three key areas of influence on MPC system design are the degree of internalization, the role of the customer in the system, and the increasing use of information technology.

The MPC System Defined

The essential task of the MPC system is to manage efficiently the flow of material, the utilization of people and equipment, and to respond to customer requirements by utilizing the capacity of our suppliers, that of our internal facilities, and that of our customers to meet customer demand. Important ancillary activities involve the acquisition of information from customers on product needs and providing customers with information on delivery dates and product status. An important distinction here is that the MPC system provides the information upon which managers make effective decisions. The MPC system does not make decisions nor manage the operations – managers perform those activities. The MPC system provides the support for them to do so wisely.

The support activities of the MPC system can be broken roughly into three time horizons: long term, medium term, and short term. In the long term, the system is responsible for providing information to make decisions on the appropriate amount of capacity (including equipment, buildings, suppliers, and so forth) to meet the market demands of the future. This is particularly important in that these decisions set the parameters within which the firm responds to current demands and copes with short-term shifts in customer preferences.

Moreover, long-term planning is necessary for the firm to provide the appropriate mix of human resource capabilities, technology, and geographical locations to meet the firm's future needs. In the case of supply chain planning of supplier capacity can be more critical than internal capacity planning for the key suppliers.

For companies that outsource their manufacturing to outside companies, the planning of supplier capacity can be more critical than internal capacity planning. Moreover, the choice of outsourcing partners has to consider their capabilities to ramp up and adjust capacities to the actual dictates of the marketplace.

In the intermediate term, the fundamental issue addressed by the MPC system is matching supply and demand in terms of both volume and product mix. Although this is also true in the longer term, in the intermediate term, the focus is more on providing the exact material and production capacity needed to meet customer needs. This means planning for the right quantities of material to arrive at the right time and place to support product production and distribution. It also means maintaining appropriate levels of raw material, work in process, and finished goods inventories in the correct locations to meet market needs.

Another aspect of the intermediate term tasks is providing customers with information on expected delivery times and communicating to suppliers the correct quantities and delivery times for the material they supply. Planning of capacity may require determining employment levels, overtime frame that specific coordinated plans, including corporate budgets, sales plans and quotas, and output objectives, are set. The MPC system has an important role in meeting these objectives.

In the short term, detailed scheduling of resources is required to meet production requirements. This involves time, people, material, equipment, and facilities. Key to this activity is people working on the right things. As the day-to-day activates continue, the MPC system must track the use of resources and execution results to report on material consumption, labor utilization, equipment utilization, completion of customer orders, and other important measures of manufacturing performance.

Moreover, as customers change their minds, things go wrong, and other changes occur, the MPC system must provide the information to managers, customers, and suppliers on what happened, provide problem-solving support, and report on the resolution of the problems. Throughout this process, communication with customers on production status and changes in expectations must be maintained.

In order to effectively manage the manufacturing processes, a number of manufacturing performance indicators need to be compiled. Among these are output results, equipment utilization, and cost associated with different departments, products, labor utilization, and project completions. Also, measures of customer satisfaction such as late deliveries, product returns, quantity errors, and other mistakes are needed. The implications physically and financially of the activities on the manufacturing floor are collected, summarized, and reported through the MPC system.

The initial costs for a material planning and control system can be substantial. Moreover, the ongoing operational cost are also significant. An effective MPC system requires a large number of professionals and all their supporting resources, including computers, training, maintenance, and space. It's not uncommon to find the largest number of indirect employees at a manufacturing firm to be involved in the MPC area. These symptoms of an inappropriate or ineffective MPC are the bane of many managers. In fact, poor MPC performance has often been a major cause of firm bankruptcy. Many instances of failed mergers in China have been attributed to substantial mismatches in the MPC capabilities of the firms in China and their partners. Other examples abound of companies that have missed major opportunities because of their inability to respond because of their inability to respond quickly.

It is most typical now to find the MPC system imbedded in an enterprise resource planning (ERP) system. Many essential activities that need to be performed in the MPC system have not changed. However, the details have evolved as changes in our knowledge, technology, and markets have occurred. The MPC activities are now carried out in more areas of the firm and differ to meet the strategic requirements of the company. In this section, well provide out framework for understanding the MPC system.

MPC has been defined as a system that "provides information to efficiently manage the flow of materials, effectively utilize people and equipment, coordinate internal activities with those of suppliers, and communicate with customers about market requirements". The MPC system undertakes several activities to fulfill the information requirements of this definition. These activities are linked internally through various departments and hierarchies.

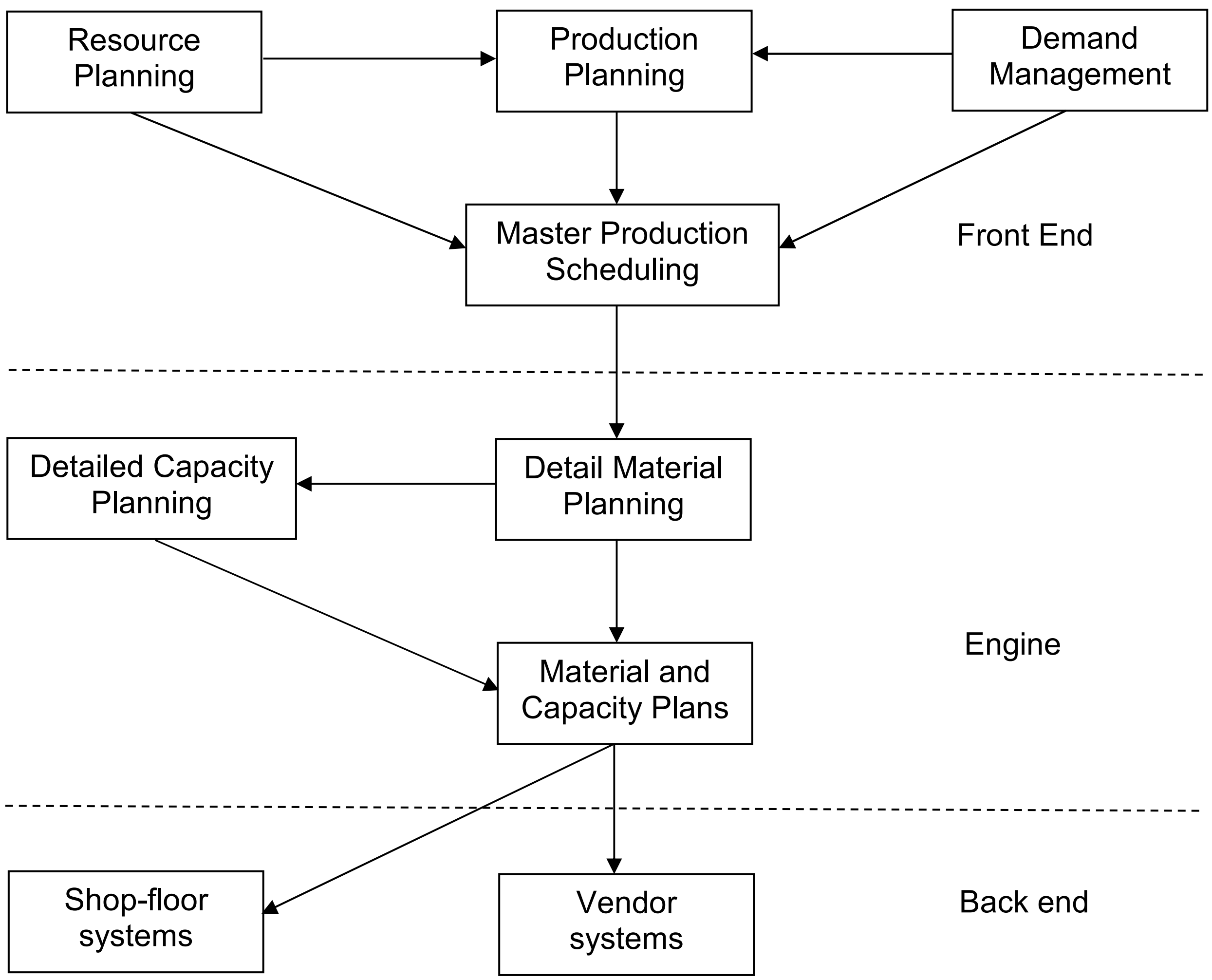

Figure 1: Manufacturing Planning and Control System (simplified)

Within the “front end”, demand management includes activities to determine external (customer) demand and internal demands: forecasting, order entry, order promising and determining branch warehouse requirements, interplant orders, and service parts requirements. Forecasting supports planning at all planning levels – long, mid, and the forecast. Basically, until a firm order is placed by a customer or a firm requirement is made known for an internal need, all demands are estimated. Demand management is combined with resource planning to create aggregate production plans, and that planning data is disaggregated to create the master production schedule (MPS).

The MPS then drives the materials requirement planning (MRP) and capacity requirements planning (CRP) by exploding demand requirements through product specifications, like bill of materials (BOM) and routing files. Material needs are determined by netting the scheduled receipts. In time-phased planning, net requirements are used to determine when an order needs to be received and, on lead-time data, when it needs to be released to the shop floor or to a supplier. The material plans are sent to capacity requirements planning (CRP) to determine how much and when capacity is needed to carry out required manufacturing activities.

The MPC Classification Schema

Figure 2 below shows the relationship between MPC system approaches, the complexity of the manufactured product as expressed in the number of subparts, and the repetitive nature of production, expressed as the time between successive units. Figure 2 also shows some example products that fit these time and complexity scales.

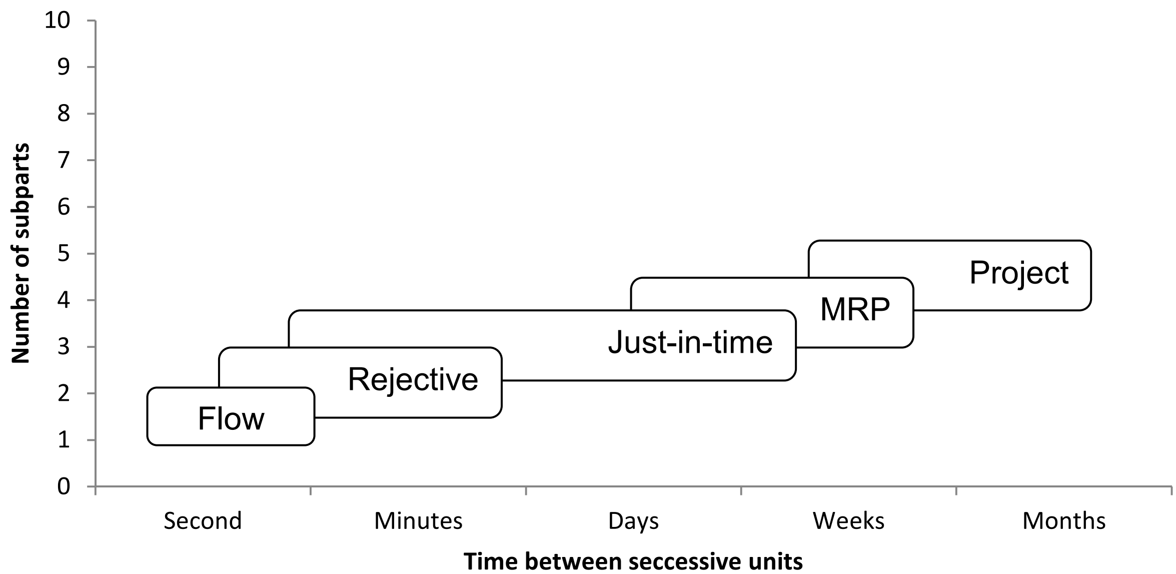

Figure 2: MPC Classification Schema

Several MPC approaches presented in Figure 2 are appropriate for products that fit in various points in the schema. The Figure 2 demonstrates that the MPC emphasis changes as the nature of the product, process, or both change. For example, as a product’s sales volume grows over time, the MPC emphasis might shift from right to left.

Evolution of the MPC System

Figure 3: are performed in every manufacturing company, whether large or small, MPC system configuration depends strongly on the company attributes at a particular point in time. The key to keeping the MPC system matched to evolving company needs is to ensure system activities are synchronized and focused on the firm’s strategy. This ensures that detailed MPC decision making is in harmony with the company’s game plan. But the process is not static – the need for matching is ongoing.

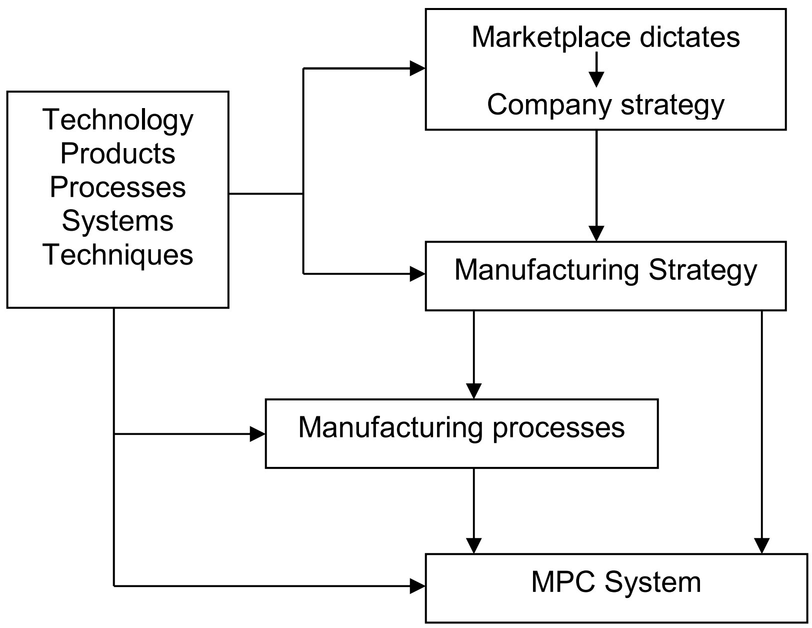

Figure 3: Evolutionary Response to Forces for Change

Meaning of Production Control

Production has been an explicit topic of study primarily in industrial engineering, which has dealt almost entirely with one type of production, namely, manufacturing (in the sense of “making”), with only occasional forays into construction, plant maintenance, building maintenance, agriculture, forestry, mining, fishing, etc. Design and engineering have infrequently been conceived as production processes; the focus almost entirely being placed on making things rather than designing them. Defining production as the designing and making of artifacts allows us to understand how construction is a type of production and also that design is an essential component in production generally and in construction specifically.

Industrial process control introduces feedback and feedforward mechanisms for regulating a process. Feedback is initiated by a comparison of actual with target outputs. Feedforward is initiated by a comparison of actual with target inputs. Production control theorists working in manufacturing distinguish two primary ways of regulating work flow in manufacturing systems: push and pull. Push systems release materials or information into a system based on preassigned due dates (from a master production schedule, for example) for the products of which they are parts. Pull systems release materials or information into a systems based on the state of the system (the amount of work in process, the quality of available assignments, etc) in addition to due dates. In factory systems, pull may be derivate ultimately from customer orders. In construction, pull is ultimately derivative from target completion dates, but specifically applies to the internal customer of each process.

Criteria for a Design Production Control System

The preceding review and critique of the literature suggest the following guidelines and criteria for an effective design production control system:

- Variability must be mitigated and remaining variability managed. Variability is virtually disregarded in current control systems. But the construction industry certainly has its share of variability: variability in quality, variability in processing times, variability in deliveries, etc. Neglect of variability causes greater variability, and there is always an associated penalty.

  According to Hopp and Spearman (1996), variability results in some or all of the following:

  - Buffering of flows, which increases lead times and work-in-process
  - Lower resource utilization
  - Lost throughput

- Assignments are sound regarding their prerequisites.
- The realization of assignments is measured and monitored.
- Causes for failing to complete planned work are investigated and those causes are removed.
- A buffer of sound assignments is maintained for each crew or production units.
- The prerequisites of upcoming assignments are actively made ready.
- The traditional schedule-push system is supplemented with pull techniques. Not only do pull systems usually perform better than push systems (Hopp and Spearman, 1996), but pull systems are especially needed in conditions of variability.
- Production control facilities work flow and value generation. Production thinking and practice in all areas has focused primarily on the task goals of production and neglected flow and value (Huovila and Koskela, 1997). The object of traditional project control has been behaviour. What needs to be controlled is work flow.

- The project is conceived as a temporary production system. The model for corrective action in traditional project control is course correction, drawn by analogy from the path of a vehicle bound for a specific destination with a target arrival time and a specified spending budget or otherwise limited resources. If the project is to be conceived rather as a temporary production systems, the course correction model is radically oversimplified and inappropriate. The flow of materials and information is what is to be controlled. They flow through very complex networks of temporary and permanent production systems. Corrective action must be taken within an understanding of these networks and of the impact of changes in sequence, processing methodologies, buffer location and sizing, local control strategies.
- Decision making is distributed in production control systems. Traditional project control assumes the necessity and possibility of central control. The underlying image is that of a single mind and many hands. Arguably, dynamics production systems cannot be controlled centrally, but rather are adaptive creatures driven by decision making at their periphery.

Definition

Control – The monitoring of performance through a feedback by comparing the results achieved with planned targets so that performance can be improved.

Estimating – Decides the quantity of products to be produced and cost involved on the basis of sales forecast

Lead time – The continuous process normally yield faster deliveries as compared to batch process.

Loading – Loading facility or work center & deciding or machine which job is assigned to which work center

Operations – Performance in accordance with details set out in production plan.

Planning – The choice from several alternatives of the best utilizing the available resources to achieve the desired objective.

Production – process whereby raw material is converted into semi-finished products and thereby adds to the value of utility of products, which can be measured as the difference between the value of inputs and value of outputs.

Production control – activities involved in handling materials, parts, assemblies and subassemblies, from their raw or initial stage to the finished product stage in an organized and efficient manner.

Pulling– a method of introducing materials or information into a production process.

Routing – This is process of determining sequence of operations to be performed in the production process.

Scheduling – Involves fixing priorities for each job and determining the starting time and finishing time.

The Last Planner – the person or group accountable for production unit control, that is, the completion of individual assignments at the operational level.