theory of constraints

a self learning program

# TOC on Project Management and Engineering

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By Eliyahu M. Goldratt

TOC theory of constraints GOLDRATT

# TOC

## Self Learning Program

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# TOC
# on Project Management and Engineering

## A Self Learning Program

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# TOC / Enterprise Wide

## A Complete Self Learning Program

# TOC
# on Project Management and Engineering

## A Self Learning Program

By Eliyahu M. Goldratt

# Contents

# TOC
# on Project Management and Engineering

## A Self Learning Program

## What is the problem?

## What to change?

## Common complaints

1. Usually original due dates are not met.

2. There are too many changes.

3. Too often resources are not available when needed (even when promised).

4. Necessary things are not available on-time (information, specifications, materials, designs authorizations, etc.)

5. There are fights about priorities between projects.

6. There are budget over-runs.

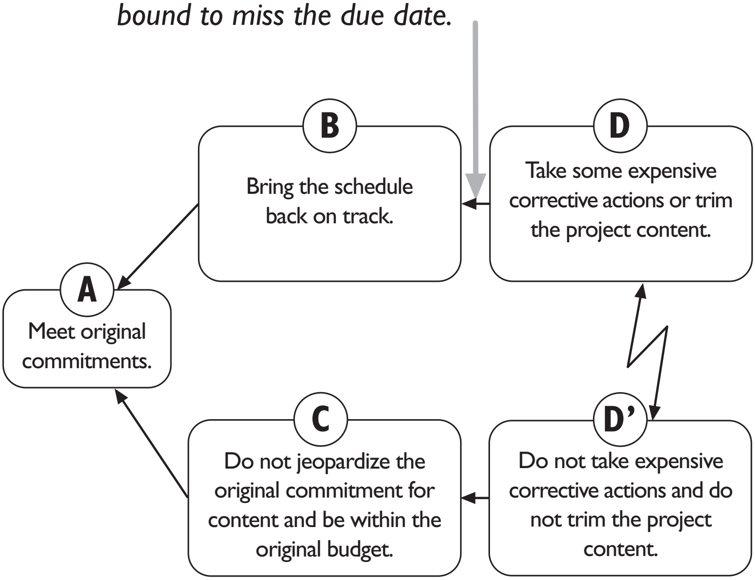
7. There is too much re-work.

## Cloud of complaint #1.

## Usually original due dates are not met.

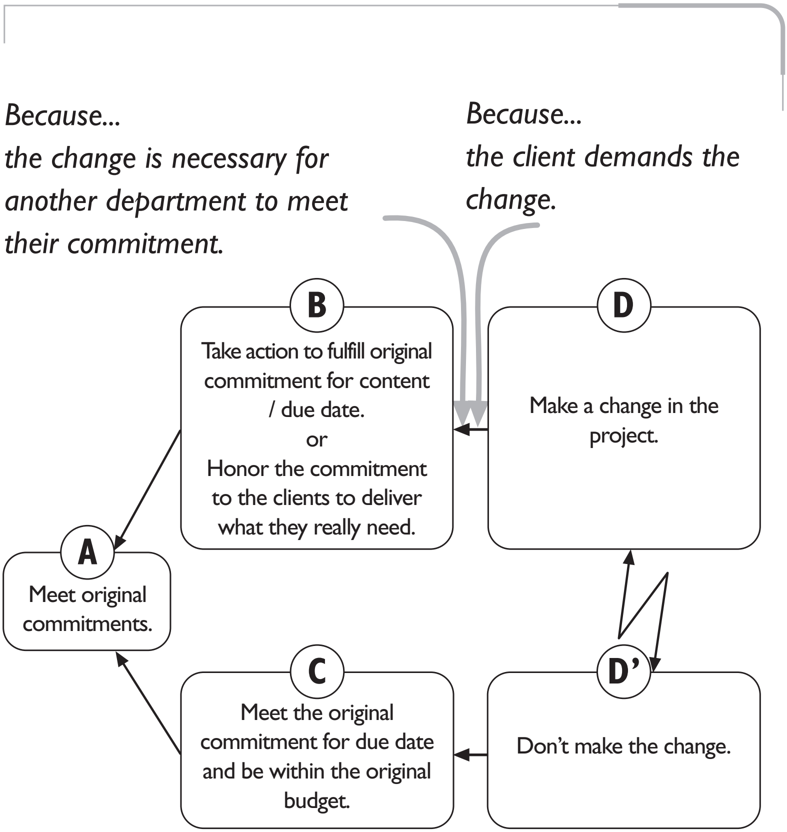
*Because...*

*without these actions we are bound to miss the due date.*



## Cloud of complaint #2

## There are too many changes.

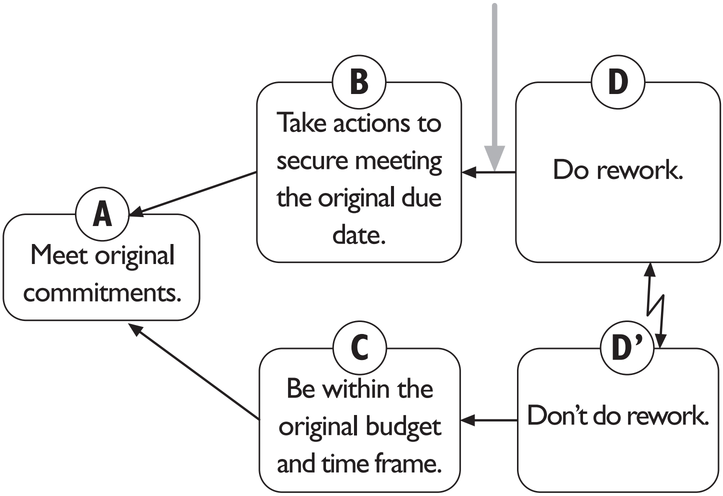


## Cloud of complaint #7.

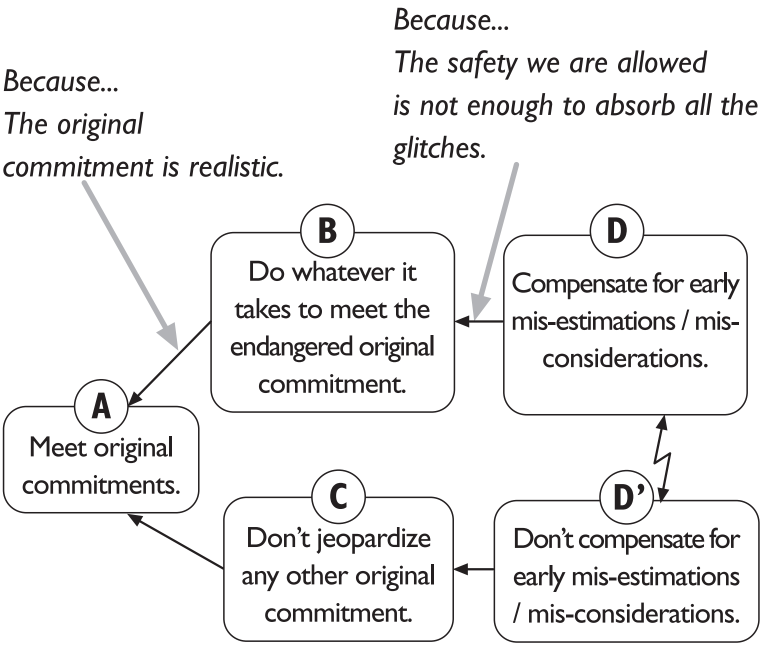
## There is too much re-work.

*Because...*

*to be on time we must start without final specs, which is bound to result in rework.*



# Project Management Cloud

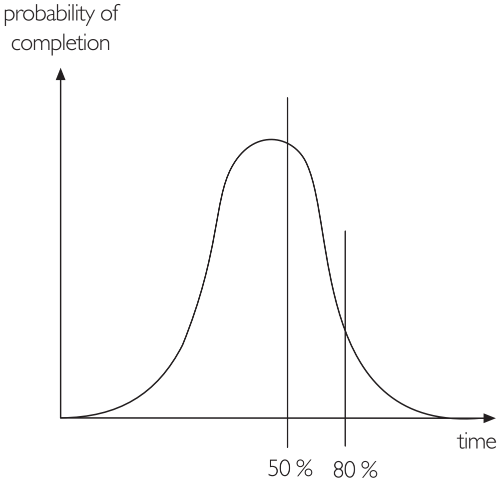


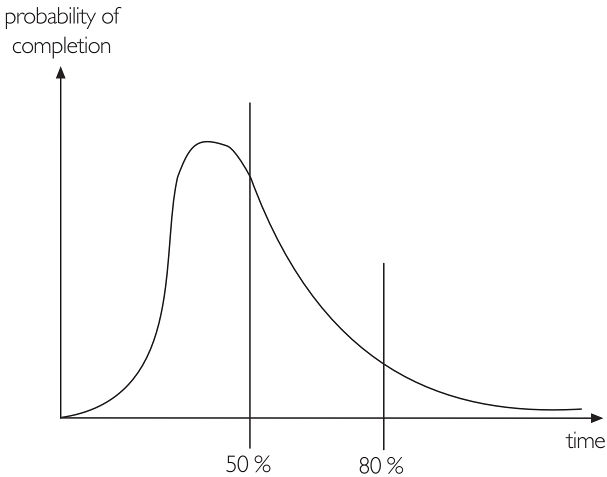
## Current mode of operation

The way to improve the performance of the organization is by inducing local improvements everywhere.

The way to have the project finish on time is by putting pressure on each task to finish on time.

## What is the difference between a "realistic estimate" and a "50% chance" estimate?

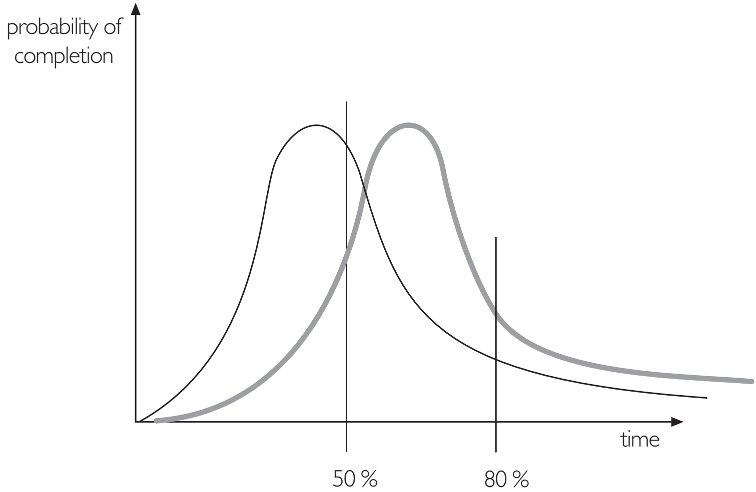



**The higher the uncertainty the bigger the tail!**

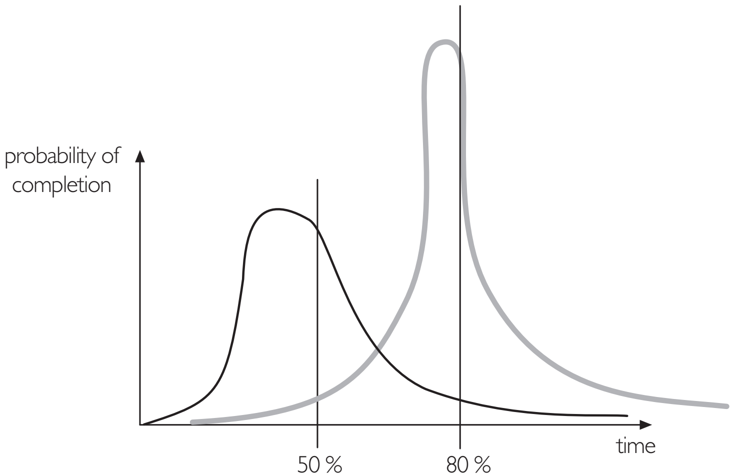
# Do statistical deviations average out?

Student Syndrome



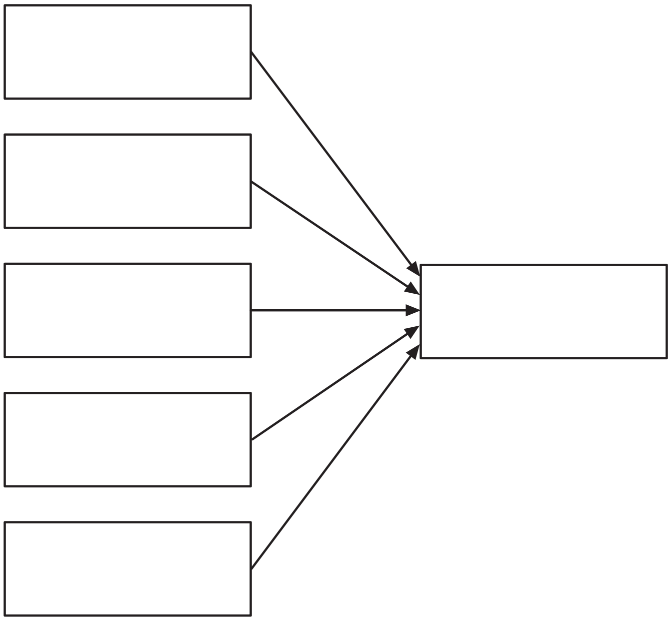
# Do statistical deviations average out?

Parkinson law: Work expands to fill up the available time.



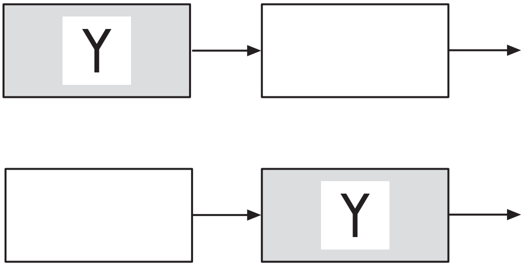
# Do statistical deviations average out?

## Integration

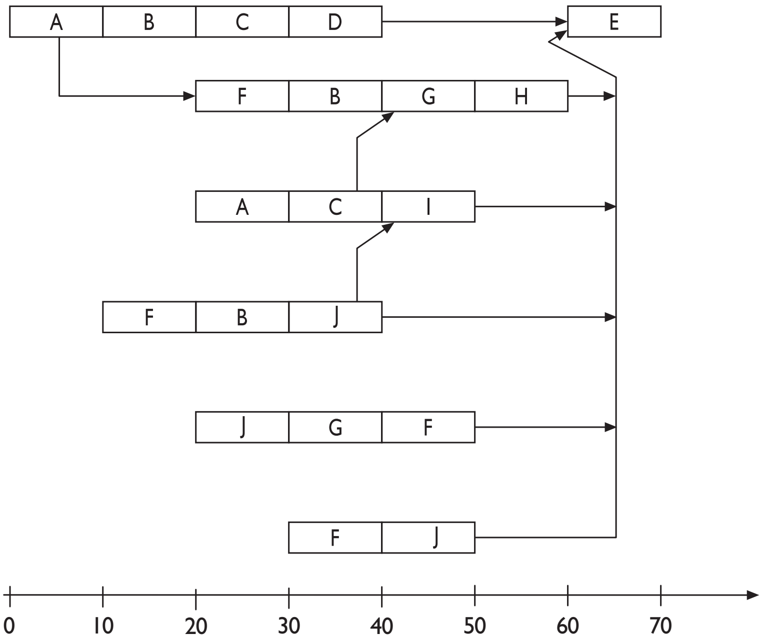


# Do statistical deviations average out?

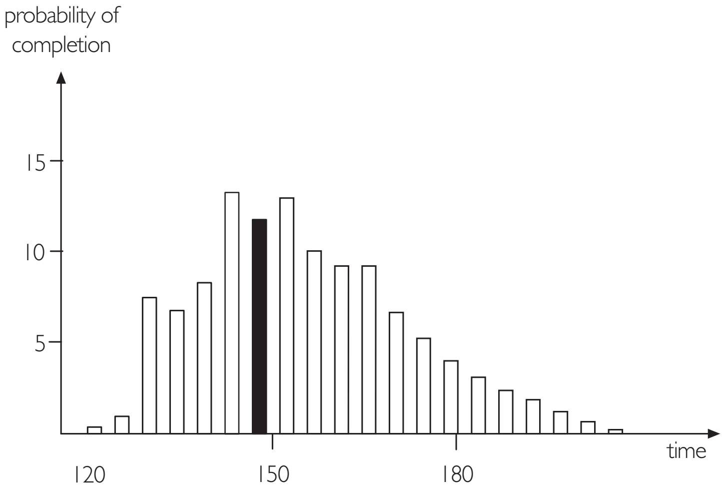
Resources with multi-tasks



# A typical project



# Project completion times

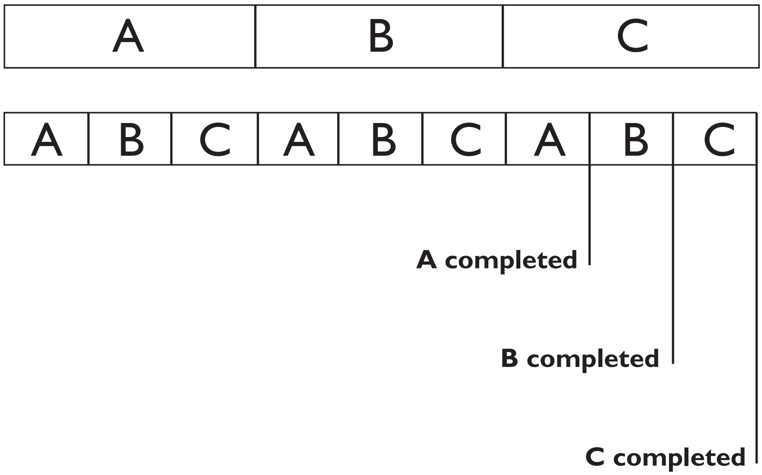


## Multi-projects environments

Project manager: All the responsibility, no authority.
Resource manager: A servant to many masters.

## Bad multi-tasking

Many suffer, nobody gains.



## In a multi-tasking environment, what is the reliability of time estimations?

# Simulated project results

| | 10% chance to complete | 50% chance to complete | 90% chance to complete |
|---|---|---|---|
| Days until project completion: | | | |
| Project 1 | 315 | 370 | 425 |
| Project 2 | 315 | 375 | 430 |
| Project 3 | 315 | 375 | 430 |

There is plenty of safety embedded
in projects but it is masked and wasted due
to our mode of operation.

## What is the solution?

## What to change to?

## The way to stop the bad-multi-tasking is by staggering the projects

Questions to guide us in choosing the staggering point:

1. Where are the projects most likely to be stuck for the longest time?

2. Where are the projects most likely to cause bad multi-tasking?

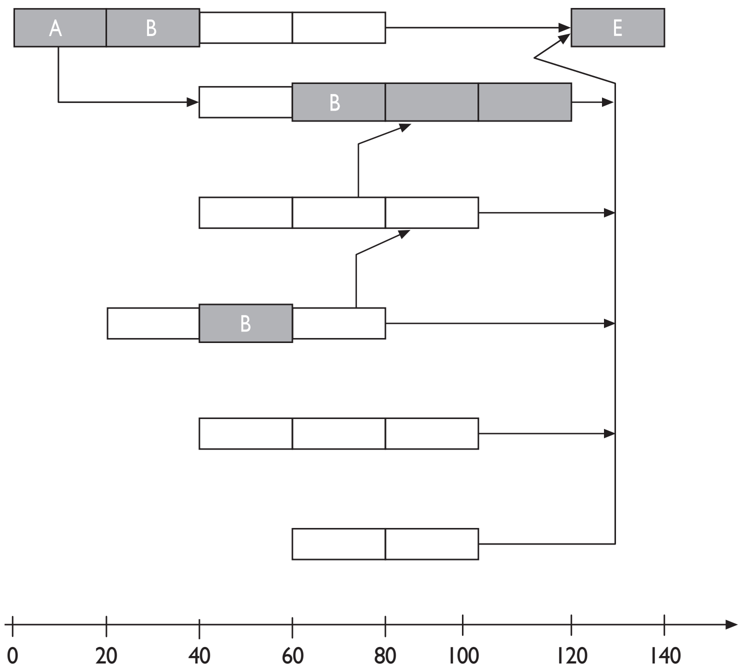
3. Where is it most important to exploit the resources?

## Simulated project results with the DRUM

| Days until project completion: | 10% chance to complete | 50% chance to complete | 90% chance to complete |
|---|---|---|---|
| Project 1 | 130 | 155 | 195 |
| Project 2 | 255 | 302 | 360 |
| Project 3 | 305 | 370 | 425 |

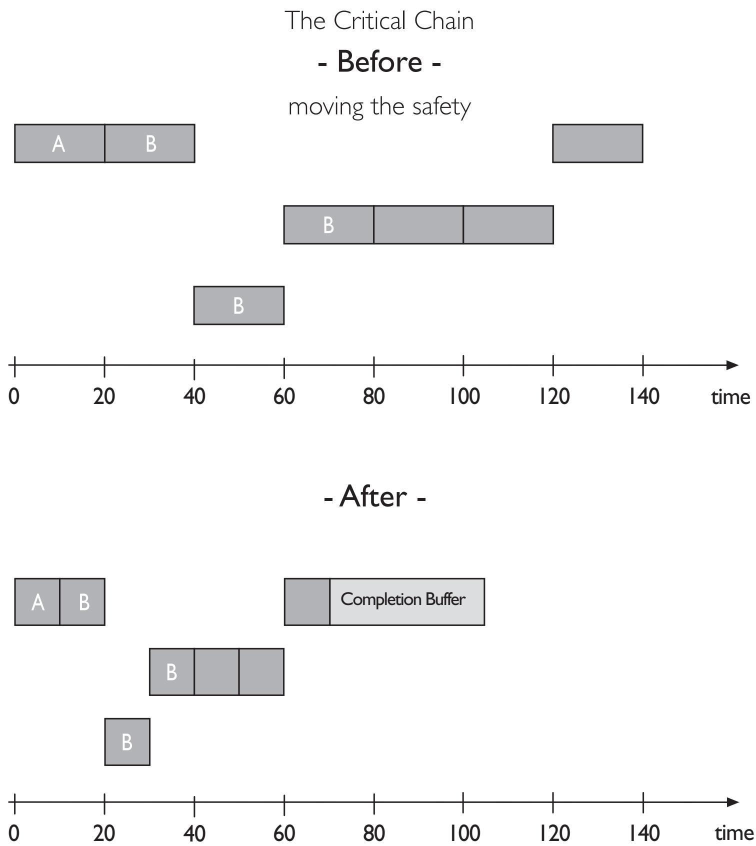
# Step 1: IDENTIFY the system's constraint

Critical Chain: the longest chain of dependent tasks.



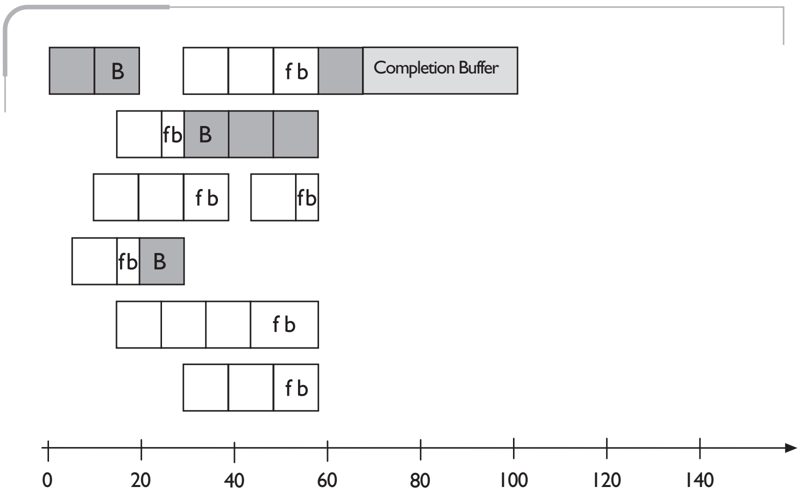
## Step 2: Decide how to EXPLOIT the system's constraint.

Move the safeties from the tasks to the place where they protect the completion time of the project.



## Step 3: SUBORDINATE everything else to the above decision.

Move safeties to protect the critical chain from disturbances occurring everywhere else.



## Simulated project results with the DRUM and BUFFER

| Days until project completion: | 10% chance to complete | 50% chance to complete | 90% chance to complete |
|---|---|---|---|
| Project 1 | 81 | 111 | 190 |
| Project 2 | 160 | 200 | 235 |
| Project 3 | 185 | 210 | 240 |

# How do we set priorities?

Buffer management!

## Simulated project results with the DRUM, BUFFERS and BUFFER MANAGEMENT

| Days until project completion: | 10% chance to complete | 50% chance to complete | 90% chanceto to complete |
|---|---|---|---|
| Project 1 | 80 | 95 | 115 |
| Project 2 | 140 | 160 | 180 |
| Project 3 | 170 | 190 | 210 |

## Judging the status of a project

Percent of critical chain completion.

Ratio between consumption of the completion buffer and critical chain already complete.

Rate of consumption of the completion buffer.

## Summary

It is not important to complete each task on time, it is essential to complete the project on time.

Get consensus to rebuild each project PERT according to protected critical chain.

Get consensus to stagger the projects according to a chosen DRUM.

Put the mechanism to enable smooth buffer management.

# TOC terms and definitions

The following terms and definitions were selected from the APICS Dictionary (James F. Cox III and John H. Blackstone Jr., Editors, 9$^{th}$ edition, Falls Church, VA, 1998). The terms are reprinted with permission by APICS, The Educational Society for Resource Management. Additional copying or distribution of the terms is unlawful.

To obtain the complete APICS dictionary, TOC publications, APICS Membership, or information on the Constraints Management Special Interest Group and other APICS activities, contact:

APICS, The Educational Society for Resource Management

1-800-444-2742
www.apics.org

**activation**
– In constraint management, the use of nonconstraint resources to make parts or products above the level needed to support the system constraint(s). The result is excessive work-in-process inventories or finished goods inventories, or both. In contrast, the term *utilization* is used to describe the situation in which nonconstraint resource(s) usage is synchronized to support the needs of the constraint. See: utilization.

**buffer**
– In the theory of constraints, buffers can be time or material and support throughput and/or due date performance. Buffers can be maintained at the constraint, convergent points (with a constraint part), divergent points, and shipping points.

**buffer management**
– In the theory of constraints, a process in which all expediting in a shop is driven by what is scheduled to be in the buffers (constraint, shipping, and assembly buffers). By expediting this material into the buffers, the system helps avoid idleness at the constraint and missed customer due

dates. In addition, the causes of items missing from the buffer are identified, and the frequency of occurrences is used to prioritize improvement activities.

**constraint**
– Any element or factor that prevents a system from achieving a higher level of performance with respect to its goal. Constraints can be physical, such as a machine center or lack of material, but they can also be managerial, such as a policy or procedure.

**control points**
– In the theory of constraints, strategic locations in the logical product structure for a product or family that simplify the planning, scheduling, and control functions. Control points include gating operations, convergent points, divergent points, constraints, and shipping points. Detailed scheduling instructions are planned, implemented, and monitored at these locations. Other work centers are instructed to "work if they have work; otherwise, be prepared for work." In this manner, materials flow rapidly through the facility without detailed work center scheduling and control.

**convergent point**
– In the theory of constraints, a control point in the logical product structure where nonconstraint parts are assembled with constraint parts. To maintain the flow of parts to products, the schedule of nonconstraint parts must be synchronized with that of constraint parts.

**critical chain**
– In the theory of constraints, the longest route through a project network considering both technological precedence and resource contention constraints in completing the project. Where no resource contention exists the critical chain would be the same as the critical path.

**critical chain method**
– In the theory of constraints, a network planning technique for the analysis of a project's completion time, used for planning and controlling project activities. The critical chain, which determines project duration, is based on technological and resource constraints. Strategic buffering of paths and resources is used to increase project completion success.

**current reality tree (CRT)**
– A logic-based tool for using cause-and-effect relationships to determine root problems that cause the observed undesirable effects of the system.

**divergent point**
– In the theory of constraints, a control point in the logical product structure where a common part or assembly can be directed to two or more different end items. To maintain the flow of parts to products, the schedule of common parts must be synchronized with the constraint schedule and shipping commitments.

**drum**
– In the theory of constraints, the constraint is viewed as a drum, and nonconstraints are like soldiers in an army who march in unison to the drumbeat; the resources in a plant should perform in unison with the drumbeat set by the constraint.

**drum-buffer-rope**
– In the theory of constraints, the generalized technique used to manage resources to maximize throughput. The drum is the rate or pace of production set by the system's constraint. The buffers establish the protection against uncertainty so that the system can maximize throughput. The rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint.

**drum schedule**
– In the theory of constraints, the detailed master production schedule for the plant that sets the pace for the entire system. The drum must reconcile the customer requirements with the system's constraints.

**evaporating cloud**
– In the theory of constraints, a logic-based tool for surfacing assumptions related to a conflict or problem. Once the assumptions are surfaced, actions to break an assumption and hence solve (evaporate) the problem can be determined.

**excess capacity**
– A situation where the output capabilities at a nonconstraint resource exceed the amount of productive and protective capacity required to achieve a given level of throughput at the constraint.

**excess inventory**
– Any inventory in the system that exceeds the minimum amount necessary to achieve the desired throughput rate at the constraint or that exceeds

the minimum amount necessary to achieve the desired due date performance. Total inventory = productive inventory + protective inventory + excess inventory.

**five focusing steps**

– In the theory of constraints, a process to continuously improve organizational profit by evaluating the production system and market mix to determine how to make the most profit using the system constraint. The steps consist of (1) identifying the constraint to the system, (2) deciding how to exploit the constraint to the system, (3) subordinating all nonconstraints to the constraint, (4) elevating the constraint to the system, (5) returning to step 1 if the constraint is broken in any previous step, while not allowing inertia to set in.

**future reality tree (FRT)**

– In the theory of constraints, a logic-based tool for constructing and testing potential solutions before implementation. The objectives are to (1) develop, expand, and complete the solution and (2) identify and solve or prevent new problems created by implementing the solution.

**idle capacity**

– The capacity generally not used in a system of linked resources. Idle capacity consists of protective capacity and excess capacity.

**idle inventory**

– The inventory generally not needed in a system of linked resources. Idle capacity generally consists of protective inventory and excess inventory. See: excess inventory, productive inventory, protective capacity.

**inventory**

– In the theory of constraints, inventory is defined as those items purchased for resale and includes finished goods, work in process, and raw materials. Inventory is always valued at purchase price and includes no value-added costs, as opposed to the traditional cost accounting practice of adding direct labor and allocating overhead as work in process progresses through the production process.

**operating expense**

– In the theory of constraints, the quantity of money spent by the firm to convert inventory into sales in a specific time period.

**policy constraint**

– In the theory of constraints, a constraint which is not physical in nature. This category includes the entire system of measures and methods and even the mindset that governs the strategic, tactical, and operations (day-to-day) decisions of the organization.

**prerequisite tree (PRT)**

– In the theory of constraints, a logic-based tool for determining the obstacles that block implementation of a problem, solution or idea. Once obstacles have been identified, objectives for overcoming obstacles can be determined.

**productive capacity**

– The maximum of the output capabilities of a resource (or series of resources) or the market demand for that output for a given time period.

**product structure**

– The sequence of operations that components follow during their manufacture into a product. A typical product structure would show raw material converted into fabricated components, components put together to make subassemblies, subassemblies going into assemblies, etc.

**protective capacity**

– A given amount of extra capacity at nonconstraints above the system constraint's capacity, used to protect against statistical fluctuation (breakdowns, late receipts of materials, quality problems, etc.). Protective capacity provides nonconstraints with the ability to catch up to "protect" throughput and due date performance.

**protective inventory**

– The amount of inventory required relative to the protective capacity in the system to achieve a specific throughput rate at the constraint.

**supply chain**

– 1) The processes from the initial raw materials to the ultimate consumption of the finished product linking across supplier-user companies.

– 2) The functions inside and outside a company that enable the value chain to make products and provide services to the customer.

**theory of constraints (TOC)**

– A management philosophy developed by Dr. Eliyahu M. Goldratt that can be viewed as three separate but interrelated areas-logistics, performance measurement, and logical thinking. Logistics include drum-buffer-rope scheduling, buffer management, and VAT analysis. Performance measurement includes throughput, inventory and operating expense, and the five focusing steps. Thinking process tools are important in identifying the root problem (current reality tree), identifying and expanding win-win solutions (evaporating cloud and future reality tree), and developing implementation plans (prerequisite tree and transition tree).

**theory of constraints accounting**
– A cost and managerial accounting system that accumulates costs and revenues into three areas–throughput, inventory, and operating expense. It does not create incentives (through allocation of overhead) to build up inventory. The system is considered to provide a truer reflection of actual revenues and costs than traditional cost accounting. It is closer to a cash flow concept of income than is traditional accounting. The theory of constraints (TOC) accounting provides a simplified and more accurate form of direct costing that subtracts true variable costs (those costs that vary with throughput quantity). Unlike traditional cost accounting systems in which the focus is generally placed on reducing costs in all the various accounts, the primary focus of TOC accounting is on aggressively exploiting the constraint(s) to make more money for the firm.

**throughput**
– In the theory of constraints, the rate at which the system (firm) generates money through sales. Throughput is a separate concept from output.

**TOC performance measures**
– In the theory of constraints, throughput, inventory and operating expense are considered performance measures that link operational decisions to organizational profit.

**transition tree (TRT)**
– In the theory of constraints, a logic-based tool for identifying and sequencing actions in accomplishing an objective. The transitions represent the states or stages in moving from the present situation to the desired objective.

**utilization**
– In the theory of constraints, utilization is the ratio of time the resource is needed to support the constraint to the time available for the resource, expressed as a percentage. See: activation.

**VAT analysis**

– In the theory of constraints, a procedure for determining the general flow of parts and products from raw materials to finished products (logical product structure). A *V logical structure* starts with one or a few raw materials, and the product expands into a number of different products as it flows through divergent points in its routings. The shape of an *A logical structure* is dominated by converging points. Many raw materials are fabricated and assembled into a few finished products. A *T logical structure* consists of numerous similar finished products assembled from common assemblies, sub-assemblies, and parts. Once the general parts flow is determined, the system control points (gating operations, convergent points, divergent points, constraints, and shipping points) can be identified and managed.