VECTOR Consulting Group | Leveraging the Potential

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Accelerated construction projects using the Theory of Constraints

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Caught in the time Warp!

Large construction and erection projects seem to have a dubious record - most of them are delayed with significant cost overruns. The problem of delayed projects is well documented in statistics released by various government agencies, not only in India but also in countries like US and Japan. While statistics in public domain are mostly that of work executed by government agencies but the story in private sector is equally bad. Not much statistics is available in public domain. We at Vector Consulting Group have come across many organizations which have a perfect record – never in the history have they ever delivered a large capital project on initially committed due date with full scope, while being within budget. The ones which claim to be on-time is mostly on revised due dates. It is not that all projects are delayed. However a highly successful project, delivered ahead of time while being within budget is such a rare event that it usually ends up as a newspaper item.

"We-should-have-planned-better" Syndrome

Most of the analysis of delayed projects point to numerous uncertainties which seem to be out of locus of control of management. Most project managers will point to issues like

- Delays in decisions/approvals
- Scope changes /Rework
- Delays in appointment of contractors/vendors
- Bad weather
- Inadequate resources or incompetent contractors
- And…

The list can go on and on. Can we improve the situation? For answers, let us look at the existing body of knowledge of project management. It talks about implementing numerous tools, templates and processes in areas of integration management, scope management, time, cost, quality, human resource, risk, communication and procurement management to solve the problem. Interesting enough most of the processes are in the domain of planning.

So if we plan better, we can deliver better. Or in other words, the better we are in envisaging the future and plan for it, the better will be the reality. But reality is so cruel – however good plan we make, uncertainties spoil the show in no time. It is no wonder that despite the widely held belief (great planning leads to great delivery), in many environments the plans are not even made or made just to show it to outside agencies.

The initial plans, made with enthusiasm of starting the project go haywire within no time and rest of the project is managed based on perception of urgency of the day in the mind of the project manager. Let us try and analyse further. The fact is most projects are delayed. Another fact is, in many projects, planning is neglected. But how do we know that the cause "improper planning" leads to the effect of "delayed projects"? If improper planning was the reason for delayed projects, then why do managers not plan better using all the established processes and tools of planning and solve the problem? I would assume that after one failed project, managers would follow all the established guidelines and planning processes and we should have much better record of project performance. But still after many years of development of project management body of knowledge, a project delivered ahead of time and within budget and full scope is rare.

Every project starts with a plan which goes haywire when uncertainty hits the project. We all turn wise with hindsight. But then we cannot go back in time and change reality. How sad! It looks so hopeless. Is their a better, simpler and a practical way to solve the seemingly complex problem? Is their an inherent simplicity hidden in the complexity of managing a large erection project involving many stake holders?

The opportunity in projects – Controllable Wastages

The lead time of projects can be classified into 1) value added touch time on the longest path, 2) interruptions (or waiting time) and 3) rework. Even though most managers point to "out of locus of control" reasons for project failure but an analysis of time at end of a project will point out that the touch time is only 20 to 30% of the lead time. (Excerpt from Lean thinking by James P Womack and Daniel T Jones, "Five-sixth of a typical construction schedule for a custom-built house is occupied with two activities: waiting for next set of specialists (architects, drafters, plumbers, electricians, roofers etc) to work a particular job into their complex schedule and rework to rip out and correct the work just done").

About 70% of the lead time is either wastages which can be controlled or due to uncontrollable uncertainties. Significant part of time in a project is controllable wastages which can be eliminated to create buffers for absorbing the uncontrollable uncertainties. How is that in most projects, we end up wastages. Is it something to do with the way we manage the projects?

Turning task estimates to commitments – is it a good practise?

Most project managers would talk about problem of estimates being inaccurate. But the problem is not so much in estimates but the way estimates are used. When estimates are converted to commitments in an uncertain environment, we get buffered estimates in return. The "realistic estimates" always have buffers embedded in it when they are used as commitments for an uncertain environment. This is natural as people would definitely try and protect themselves. Despite the protection, when uncertainty strikes, the buffers are usually not enough to absorb the delays. If we look at execution, the most of tasks finish on defined milestone date or delayed when hit by uncertain event. Despite protection planned around the milestones, the buffers are wasted in execution primarily due to following behavioural issues.

Parkinson's Effect

Parkinson's effect is defined as work expanding to fill up the allotted time. Parkinson's effect is widely seen in the pre-erection phase of the project, when the project is being executed mostly in an office.

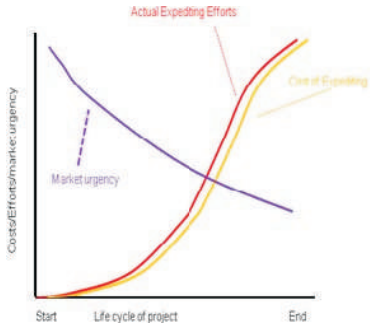
Work expanding to fill up the time allotted to it. You can give a task any time; it will take up the allotted time. If you do not give it any time, it may not end at all.

The monitoring of time in this phase of the project is usually almost absent, primarily because not much funds is committed at this stage. One can see time passing away in contractor finalization, drawings approvals, etc. In many situations commercial decisions are only taken by committee of managers who meet infrequently. This leads to batching of all important decisions while the project almost stands still between two committee meetings. Without any urgency of time, civil drawings get into multiple iterations with every drawing inviting a new idea from a different stakeholder.

If one evaluates the net touch time incurred on the project in the pre-erection phase, it will be less than 10% of the lead time till start of erection. Ironically the cost of expediting at this phase of project is much less than in the later part of the project where expediting costs are very high.

Parkinson's also creeps in during erection phase in slow mobilization of resources by contractor. The various norms used for defining contracts become self fulfilling prophecies, where contractors work only as per defined norms even when work can move at a faster pace. As due dates are agreed upon, most resources get into "leave it to us - we will manage it" syndrome, when questioned on the wastages. In projects, the task durations are also like self fulfilling prophecies.

The paradox: speeding up when costs are high



The student's syndrome

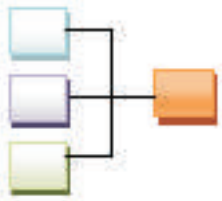
A deadline provides information on how much one can afford to delay the start of the job.

Student's syndrome is a date driven behaviour, where managers postpone start of the work close to the milestone. As a result the buffer is wasted even before the start of the work. For example, the follow up for vendor supply starts more vigorously, close to the delivery dates, as a result when uncertainties are discovered nothing much can be done. The milestones of various office work like technical evaluation of vendor quotations, finalization of drawing etc are done close to milestones leading to wastages of buffers and leaving nothing to manage the uncertainties.

De-synchronization

Both Students Syndrome and Parkinson's Effect ensure tasks are at the best either completed on milestones or delayed when uncertainty hits. So we do not see gains making up delays in a series of dependent tasks of a path. Worse, at every integration point, only the worse delays of the multiple converging paths are passed on leading to pile up of accumulated delays. It is no wonder that departments working at the end of the project phase are usually under high pressure to recover the accumulated delays. In some projects, managers try and slow down work on feeding chains to match up delays in longest path leading to cascading effect of delays across many converging paths.

At the integration points the worse of delays propagate. Gains are never passed on.



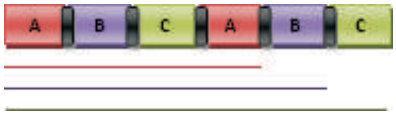
Rework and Interruptions at site
Due to delays in pre-erection work, projects are usually delayed at the start of the erection work. In such situations, managers resort to fast tracking (starting site work even before finalization of drawings specs and decisions) to gain on time. This usually leads to interruptions at site or worse rework when drawings are changed.

Bad Multitasking: the most devastating form of wastage.

Case: *Three work fronts to be executed by same resource*

Scenario 1: Without multi-tasking

Scenario 2: With multi-tasking



With multitasking, the elapsed time of every work front increases while causing wastage of resource capacity due to additional setups and skew of work front completion

When too many work fronts are started simultaneously with limited resources – bad multitasking creeps in. Bad multitasking significantly prolongs projects' lead time while causing wastage of resource capacity (due to additional setups) and rework due to frequent switching. Bad-multitasking is predominant in the pre-construction phase of the project, where resources switch between other projects or between various modules on same project. Bad-multitasking is observed in the design or architect's office when too much work is started with too few resources.

In erection, bad-multitasking creeps in when multiple erection sites are opened at the same time. Frequent shifting of contractor labour across multiple sites significantly delays progress of many work fronts. Many erection work fronts also put pressure on limited band-width of management and as a result the issue resolution time goes up significantly.

Light at the end of the tunnel – Critical Chain Project Management

Critical Chain Project Management (CCPM), invented by Dr Eli Goldratt in the 90s offers a radical approach to planning and execution which helps prevent wastage of buffers and at same time leave sufficient to absorb the impact of genuine uncertainties. Implementing CCPM is about implementing following 4 steps.

Step 1: Eliminating the Bad Multi-tasking
We learnt that the reason for bad-multi-tasking is too many work fronts/projects opened in parallel with too few resources. This way of working, strains management band-width, delays the issue resolution time, creates priority conflicts, and leads to vicious loops of resources waiting for one another and resultant expansion in project lead time. Bad multi-tasking can be eliminated by deliberately controlling the number of open work fronts. The work-fronts are released for execution in a staggered manner to maintain a constant WIP of work-fronts in progress. If it is a multi-project environment, the starts of the project are deliberately staggered based on the limiting factor of the organization.

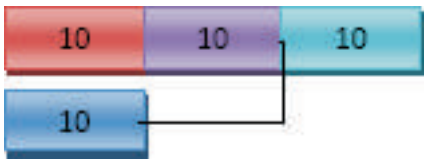
This step is counter-intuitive to commonly held belief that early start leads to early finish. In an environment of limited resources, early start does not lead to early finish, it just leads to increased queues in front of the scarce resources and almost all projects are delayed.

Many construction projects are delayed due to this erroneous management paradigm of starting many project ASAP, ignoring the limited management bandwidth and other scarce resources (which includes cash at times). While most construction organizations would see this approach of staggered start as being a growth limiting strategy but actually it is contrary. It is almost impossible for an organization to scale up an entire project support organization including the top management to accommodate the rising load. It is almost impossible and even unnecessary to scale up for the increased load. As a first step, it is important to exploit the scarce resources and get more projects out from the same capacity and then invest in new capacity. Current environment of bad-multitasking (experienced as frequent priority shifts and many interruptions due to delayed decisions) indicate to significant wastage of resource capacity. Staggered starts ensures, less projects in progress at any point of time, and full resourcing of those few projects. The rate of output of projects goes up, lead times go down while all projects finish earlier than otherwise.

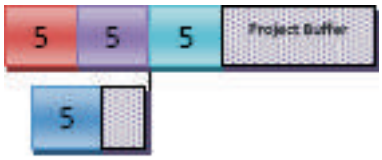
Step 2: Good enough planning

Creation of an environment of no bad multitasking is essential to put any meaningful planning processes in place. An environment where priorities change frequently, the precise task scheduled deterministic plans become haywire within no-time. However If we have implemented step1, the environment would be more stable and we can then take advantage of good planning processes. We need not over do this step with too much task detailing. There is a price we pay for no plan (creates confusion of handovers between resource groups) and also for too detailed plan (leads to fragmented accountability and more buffers at task level). What is required is a project plan which is good enough for execution. Any plan which does not help execution is not a good enough plan. In conventional project management we make a project plan with precise task schedules always with the assumption, that the only way to finish a project on time is to finish each task on time. This way of planning is close to being an ostrich, hiding away from the fact that in an environment of uncertainties, it is almost impossible to predict when a specific task will start and end, much before the start of the project. We learnt this way of planning leads to hidden buffers in every task and subsequent wastages in form of student's syndrome (delaying start of the task to close to the milestone) and parkinson's effect (work expanding to fill up the allotted time).

Traditional Plan



Critical Chain Plan with Buffers



CCPM approach accepts the fact that precise task scheduling at the beginning of a project is futile as uncertainties are not known upfront. At same time the paradigm of task level buffers leads to wastages. CCPM way of planning involves, shifting the buffers out from the tasks to the end of the respective path to protect the overall path. The task durations are made seemingly "unrealistic" and the aggressive estimates are not made into commitments. The realistic task durations are cut by half during the planning and it is openly accepted that many tasks will fail on those timelines. The other half duration removed from every task along a chain of tasks is aggregated at the end of the chain to provide protection to the chain as a whole. The buffer at the end of the longest chain/path is called the project buffer while the buffer at end of feeding chains is called the feeding buffers (inserted at point where feeding chains integrate with the longest chain of tasks). The aggregation of buffers from tasks of a chain offers the opportunity to reduce the overall buffers while maintaining the same level of protection. Typically buffer sizes are 1/3rd of the total lead time. The buffers are meant to be consumed as task durations are aggressive.

This is very different from typical approach where management gives a different date to execution team, one tighter than given to the customer and puts pressure on execution team to meet the "internal due date". The buffers in CCPM are explicit and meant to be consumed in execution.

The actual task scheduling, the start and end time of the tasks, are not set in the planning. The task scheduling in CCPM methodology is left to execution, after starting the tasks, when people have the best possible information about the tasks. Since task scheduling is left to execution, the focus of CCPM is good enough planning (instead of detailed planning) and very good execution.

Step 3: Proactive Execution

The task durations of a CCPM plan cannot be used as commitments. It cannot be used to evaluate task failures; else we can go back to the damaging "task protection" behaviour. The new paradigm of execution is; the task level failure does not matter. The task durations are aggressive and everyone knows that there are significant chances of failure on those task times. But without these local deadlines, management seemingly looses supervisory control. We all know of status of tasks which do not have a target end date – they never get completed. At same time we learnt that task deadlines leads to an abdication culture where issues are detected late only close to milestones. We are caught in a conflict and people have learnt to live with damages of a task deadline rather than greater damage of not having it at all.

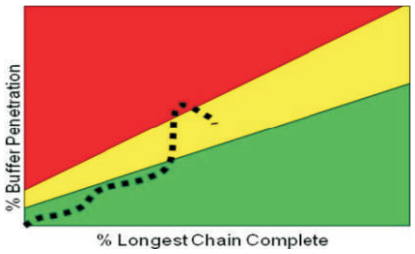
CCPM offers a way out of the conflict. Supervision philosophy in CCPM environment is daily flow tracking. With no task level deadlines to fall back on, focus shifts on the much needed daily management of work and preparatory of upcoming jobs. Daily, for all open tasks, remaining duration estimates (not commitments) are assessed to identify and eliminate wastages and at same time provide signals to succeeding resources on likely start date. Pre-planning is done based on expected start date as provided by the estimates of the predecessor task manager. The remaining duration also helps check the overall penetration into the buffer. The buffer consumption signals are also used to determine the priorities of tasks which in turn help align resources to the right areas. The priorities are set based on relative consumption of project and feeding buffers, so that resources and limited management bandwidth stay focussed on the current longest chain of the project. The entire organization focuses on ensuring flow of projects rather than managing to milestone. In a conventional management, as long as tasks meet milestones, it is considered a healthy sign. In CCPM environment, the wastages in from of interruption or work expansion is immediately identified and dealt with as there is no comfort of a milestone to evaluate the health. Yes, CCPM does call for more supervisory efforts and by limiting the number of projects or work-fronts in execution (step 1) we create the capacity for increased supervisory efforts.

Step 4: The real project control

Day to day flow management is good for task managers. We still need an overall control tool for management intervention. Top management does need a signal of when to intervene and when not to intervene.

Most management would like to believe that they are in control of their projects. But one can only claim control, when information of deviations is given in time, good enough to make up for the deviations. In most project environments, the fact that the project is delayed beyond repair is known to management only when it is too late to recover. Projects which seem to be on-time are suddenly delayed close to the end. This effect of "90% completion in 1 year and remaining 10% in another year" is primarily due to the way projects are measured. Most construction projects are monitored using volume based measures of work completion across all paths, regardless of criticality of work fronts. Measures like length (meters/day), area (sq mtrs per day) or weight (tonnage per day) of work completed or even the more sophisticated actual expenditure booking compared with planned expenditure, at times leads to priorities away from the longest path.

Project Control Chart



It can induce managers to start work on non-critical areas to makes up for the loss of progress on the current longest path. Mathematically, it makes up in the volume measure but for the project, no work on longest path, means no progress on the project as a whole. CCPM focuses on buffer consumption and work completion along the longest path. Simple colour signals of red (when rate of work completion is much lower than buffer consumption), yellow (when both rates are close to each other) and green (when rate of work completion is much faster than buffer consumed) provide an indication of the status of the project.

Red projects are further analysed to plan buffer recovery to get it back to the green status. The buffer charts provide the much required "real control" as management gets early warning signals. The project review meeting changes from rear view mirror driving (focus on elapsed milestone adherence and fault finding) to front view mirror driving (focus on recovering buffers, only when project is in red).

The Indian Experience

CCPM as a project management methodology is gaining popularity worldwide, particularly in defence and construction industry. In India, Vector Consulting Group has pioneered the implementation in various environments like new plant erection, plant expansion, new product development, and engineering to order environments.

The result in most environments was not only on-time delivery as per original plan but also significant lead time reduction (25% to 40%). Vector has been involved in projects where CCPM has helped finish projects in record time.

A large spinning plant green field project was put up in a record 9 months (while it typically takes about 12 to 14 months to put up a new plant of similar size). Similarly a blast furnace shutdown was completed in record 22 days as compared to typical 40 to 50 days. In most cases, there is no overrun of original budgets and scope is delivered in full.

The wastages of time and capacity in large construction project are very high, to the tune of 40 to 50% of the lead time. A good implementation of CCPM planning and execution process can easily reduce lead times by at least 25%. Since the processes are very counter-intuitive, implementing and institutionalizing the CCPM processes and culture in an organization is challenging. But then do we have an alternative?

The Author is a founding Director of Vector Consulting Group – India's largest and premier Theory of constraints based consulting company that engages with leading corporate to deliver bottom line results and takes its fee from the increase of profit thus delivered.