Practical Approach

towards Project Control Systems Using EVM & CCPM Integration

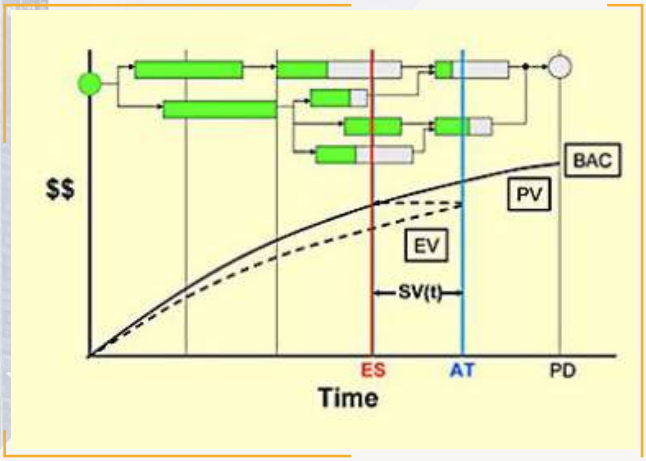
Essam Mohamed Lotfy, PMP, CCP

ELV – Projects Manager, NAFFCO, Abu Dhabi, UAE

Introduction

Despite widely-accepted project control systems utilities & ways of doing things are being used to watch (for changes, unusual things, etc.) the project performance it was seen/obvious that there is a large number of projects do not complete on time & within budget (For every 1$ billion invested in the United States, 122$ million was wasted due to missing project performance. (Source: Pulse of Profession Report 2016 PMI.org) However, Earned Value Management (EVM) ways of doing things are used to watch (for changes, unusual things, etc.) project performance the chances to have performance shortages still exist. Since most Project Managers focus only on gain & loss since EVM is cost-oriented this way most of Project managers might select wrong priorities and ignore the resource constraints and Actual site conditions.

It›s very important to successfully identify the good Projects control systems & progress review ways of doing things that promise that something will definitely happen or that something will definitely work as described the project completion on time, within budget. In order to tell apart the needed/ demanded good project management solid basic structure on which bigger things can be built and sustained project controls system it is preferred to move beyond traditional scheduling processes. Usually, most of projects have no ideal conditions for the activities of many possible/likely such as but not limited to, Project complex difficulty level, useful thing/valuable supply types and site location. The main concern of using traditional scheduling process is that most of the planners and/or schedulers ignore or do not think about/ believe uncertainties. However; PERT (The Program Evaluation and Review Technique) model is being used to calculate construction activity duration as an average of Optimistic, Pessimistic and Most likely duration of the activity. This model is being calculated to give a weighted average of activity duration it is a classic model that usually gives optimistic results. Another classic model is being used is CPM (Critical Path Method) which still ignores the the previously-mentioned uncertainties. The need for change from traditional scheduling process to a modern and practical model is to think about the uncertainties that may affect the project activities estimated duration and cost also, , and Project Managers with their teams have to have an



agreed-upon process that allows all of the project risk areas to be uncovered, tested/evaluated and dismissed or mitigated (Pre-Mortem managerial strategy – Source Wikipedia). The approach to this idea depends on TOC (Theory of Constraints or Explanation of why something works or happens the way it does of Restrictions) to put into use CCPM (Critical Chain Project Management) which were developed by Goldratt. This practical scheduling process applies the resource constraints on the project Critical Path to finally develop a Critical Chain.

The goal of this technical paper is to:

- Make the case for using a scheduling technique that considers uncertainties and natural variability that may impact the project activities especially in the construction field.
- Highlight hidden risks of using earned value management only.
- Make the case for implementing an integrated model of earned value management with critical chain project management that gives better early warnings to project management teams about any possible impact on the project completion date and budget.

"Apply Critical Chain Project Management and Utilize Collaboration between Project Stakeholders to get your Projects completed with less time and money"

Traditional Scheduling Process

Most planners or Schedulers don't like projects' team statement that "An activity might take from 10 to 21 days to be completed» Usually they argue against these ranged estimates and they tend to think about these activity durations will be thought about believe 21 days in which it means that an extreme safety buffers or contingency (Related to one thing depending on another thing might or might not happen) had been considered to cover any potential uncertainty «work expands so as to fill the time available for its completion» Parkinson's Law.

In GCC countries a very common statement is being used during construction project Kick-off meetings " This is a critical project and it is fast track project", this statement is used in a wrong or bad way by all project stakeholders and makes a lot of pressure over planners, project team, management and even the owner, because it puts all these stakeholders especially planners and/or schedulers in the mode that all activities should be crashed within limited time duration and limited resources as well ignoring the hidden uncertainties that may hit or affect the project activities duration and sequence.

Another point rises or comes up during project execution phase in any progress meeting that is being asked every time

"what is the progress status of the longest path activities or in other words what is the status of critical path activities".

Here the value of using earned value management rises and come up as this technique is a simplified indicator of project performance through CPI (Cost Performance Index) and SPI (Schedule Performance Index) that illustrate whether the project is under or out of control.

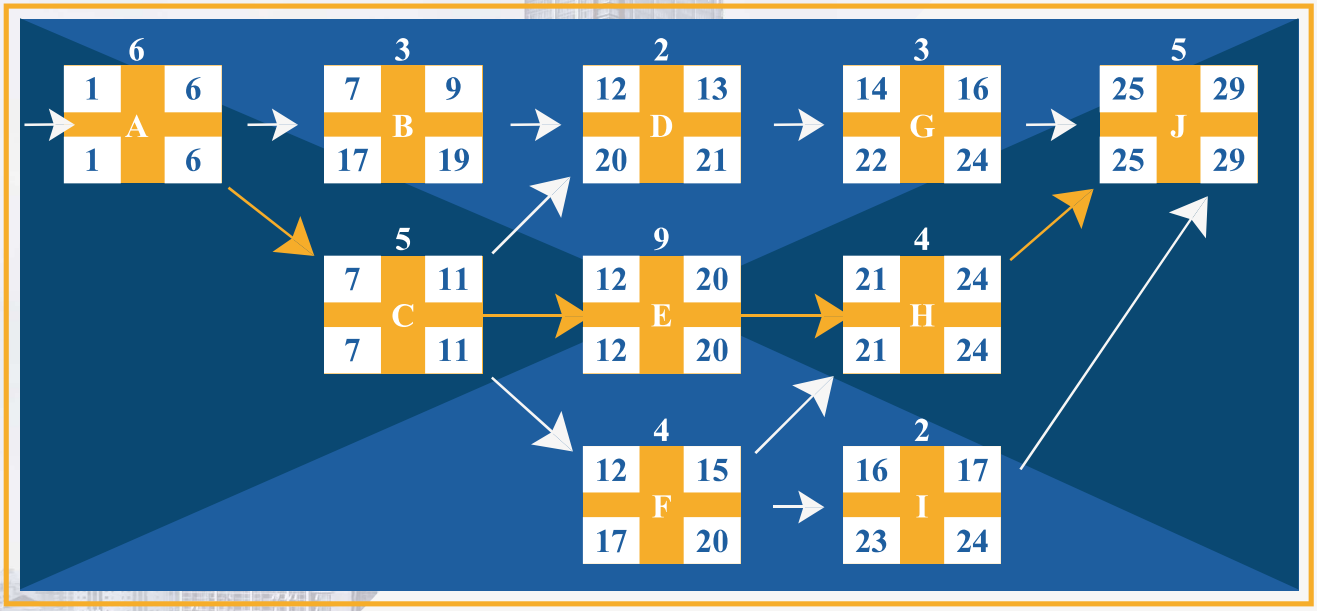
From the construction point of view most of the contractors depend on "How much they should have to be paid or how much they should gain monthly?" and how much work should be accomplished to be more paid, regardless the type or priorities of the activities to be executed if it is critical or non-critical activities. To do that the contractors always prioritize the expensive work packages to get more money or in other words, they execute the project based on their own cash flow priorities.

This severe misconception is that earned value reports will always show that CPI and SPI indexes are greater than one which means the project is ahead of schedule and under budget earned value management calculations focuses on Cost (Budgeted Cost Work Schedule and Budgeted Cost Work Performed).

Once CPI and SPI give a good indicator base on what has been paid the earned value report will not be able to give an early warning or red alarm if any of critical activities had been delayed or behind schedule.

Why this happens, because the project has been planned with traditional scheduling model ignoring the actual conditions and/or status of resources and their availability or related constraints. In other words, the activities dependencies are being captured without resource dependencies.

The following diagram1 shows a simple Precedence diagraming Network that illustrates the logical relations between a set of activities to develop the project schedule and identify the critical path.



A deep looking to this PDN will lead us to recall Murphy›s Law «If anything that can go wrong, it will go wrong" in other words "If everything seems to be going well, you have obviously overlooked something.

- It seems that Activity «J» duration might be varied and it›s not confident that it will be completed in 5 days since there is convergence as it›s being driven by activities «G», «H» & «I» and applying simple Monte Carlo analysis will show that the activity duration variability exists in «Murphy›s Law» and the duration might be more than 5 days. This simple example shows the weak point in either PERT or CPM method where it ignores the activity or task duration variability.

- In addition, there is always common management practice the delay the expenditure by delaying the Non-Critical activities within their allowable slack, Hence total slack on Non-Critical Paths "B-D-G" & "F-I" will be consumed and there will not be any buffer to protect the Critical Path "A-C-E-H-J".

- Another aspect is that CPM considers the starting date and duration of the activity without considering the real actions of finishing the predecessor activity, recalling the previous PDN obviously shows that if activity "G" will finish early successor activity "J" will start on date 25. On the other hand if activity "G" finish late or delayed with allowable slack, then activity "J'' will start od date 25 also, which means a delay or late completion of a predecessor activity could be propagated to the successor activities on its path. That means CPM method is not equipped to consider the real action of finishing predecessor activities.

Another concern related to CPM that it ignores simultaneous demand for the same resources within different activities; Since CPM doesn't consider the resource leveling or generally resources optimization and considers infinite resources. Looking to the PDN, Activities A-C-E-H-J is on the critical path and the diagram assumes that all activities logical dependencies have been captured.

The available resources are shown in the following table;

ACTIVITY	RESOURCE TYPE
A, C, F	$R_{(a)}$
B, E, I	$R_{(b)}$
G, H	$R_{(c)}$
J	$R_{(d)}$
I, D	$R_{(e)}$

And it is apparent from the resources table that there are lots of constraints regarding available resources which have not been captured while developing the PDN from logical dependencies perspectives, hence any lack of progress or delay it will obviously impact the critical path activities and delays the project completion date accordingly.

In Addition, this traditional scheduling technique considers the worst case of any activity duration with a single proposed duration estimates. However; PERT model may be used to average the activity duration.

As mentioned earlier ignoring resource dependencies will lead to neglecting the impacts of non-availability of resources assigned for both critical and non-critical activities, here the value of Critical Chain arises and the need of dynamic scheduling techniques as per ground conditions will take place. Furthermore; this traditional technique will lead to bottlenecks and resources conflict and priorities conflict as well or in other words Resource Contention (Source Paul H Pittman)

What Else Rather than Negligence of Resource Dependencies:

Using CPM will lead to two significant phenomena that might impact the project completion date:

- Student Syndrome: Student behaviors to extend the time to the exam and after successful postponing the exam, they will procrastinate the studying starting date. In other words, most of the project activities will not start unless a certain amount of the activities duration passed, which mean activities could be completed with less time duration.

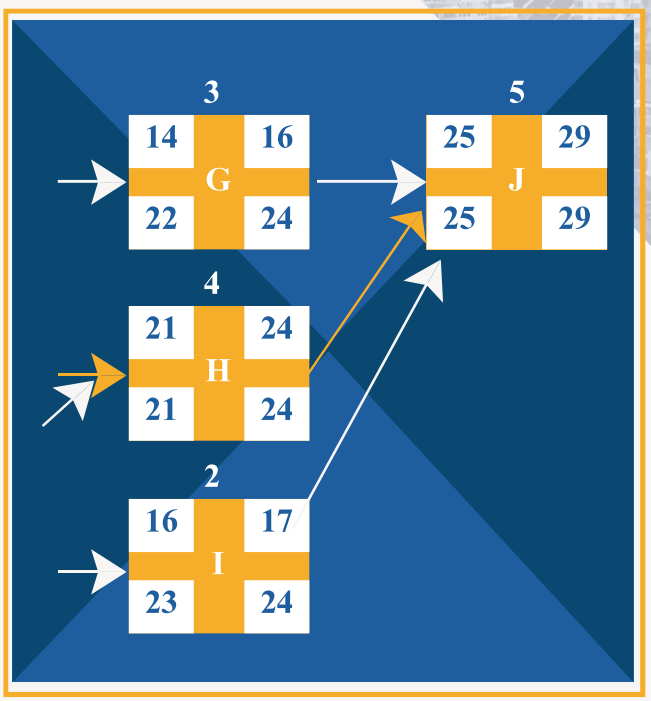
Using CPM will lead to utilize this syndrome to save enough buffers to protect the activity completion date and negligence of early completion.

- Sandbagging : Being conservative against completed activities by holding the completed activities until a convenient date for the project team. This will lead to exaggerating the activity duration estimates.

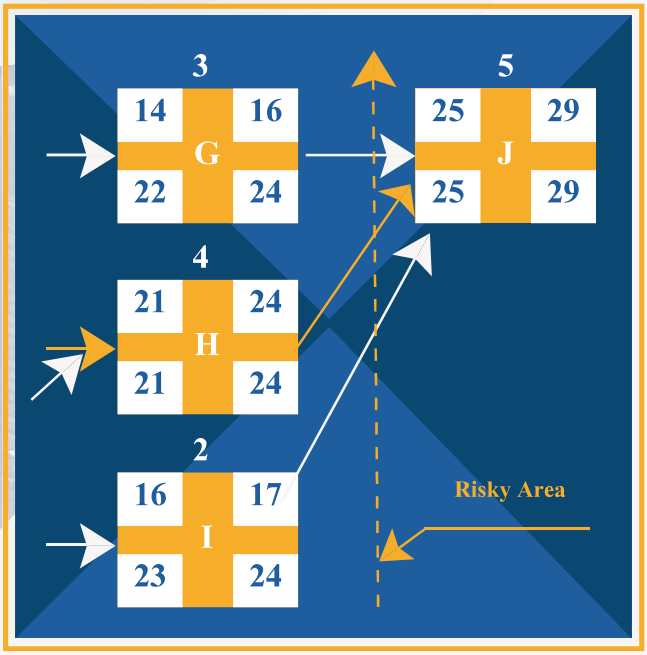
Critical Chain Scheduling Process:

Despite CPM is widely and common scheduling technique still there is still a huge need to implement resource management and consider resource constraints and dependencies while scheduling project activities. The main propose for any project manager is to minimize activities duration under resource constraints that affecting the project activities. The objectives of the technical paper are to segregate the activities buffers and redistribute or insert these buffers into strategic points to protect the critical activities and project completion date as well.

It was elaborated in the previous section the effect of convergence points that may lead to delayed starting dates of the activity



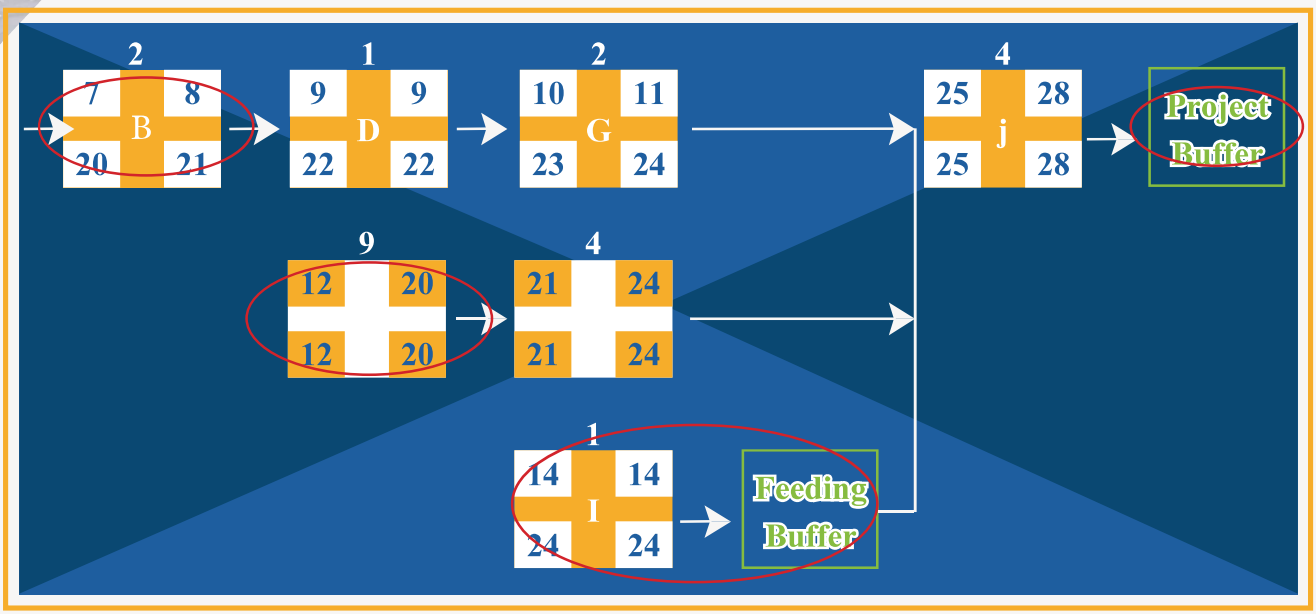
In simple words, the objective is to insert the buffers where risk exists and the riskiest points will be the convergence paths.

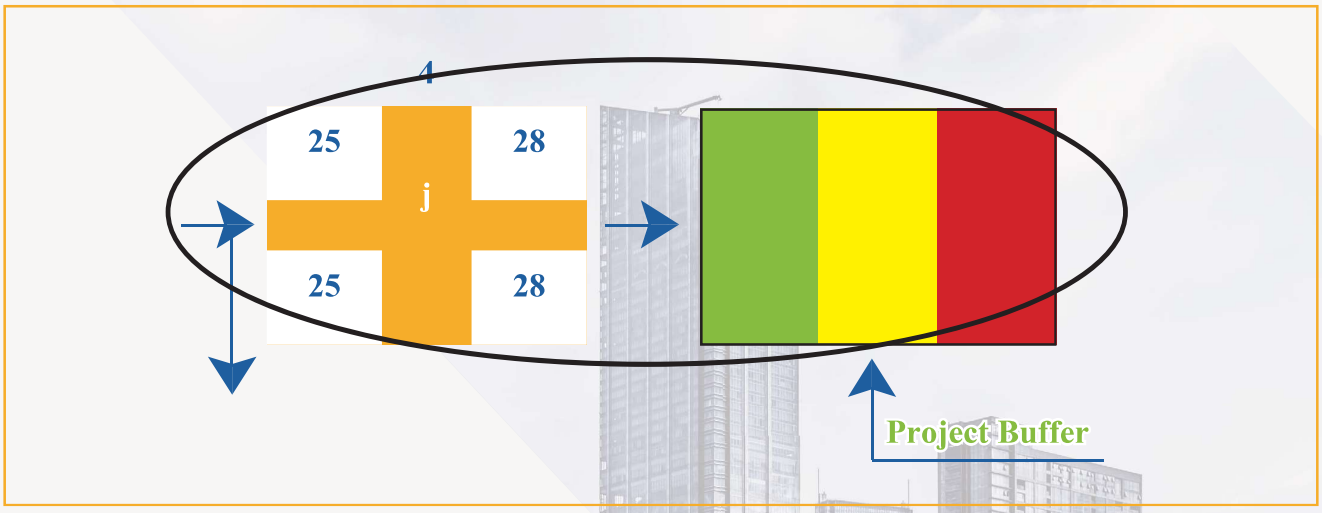


Implementing critical chain technique on Previous PDN

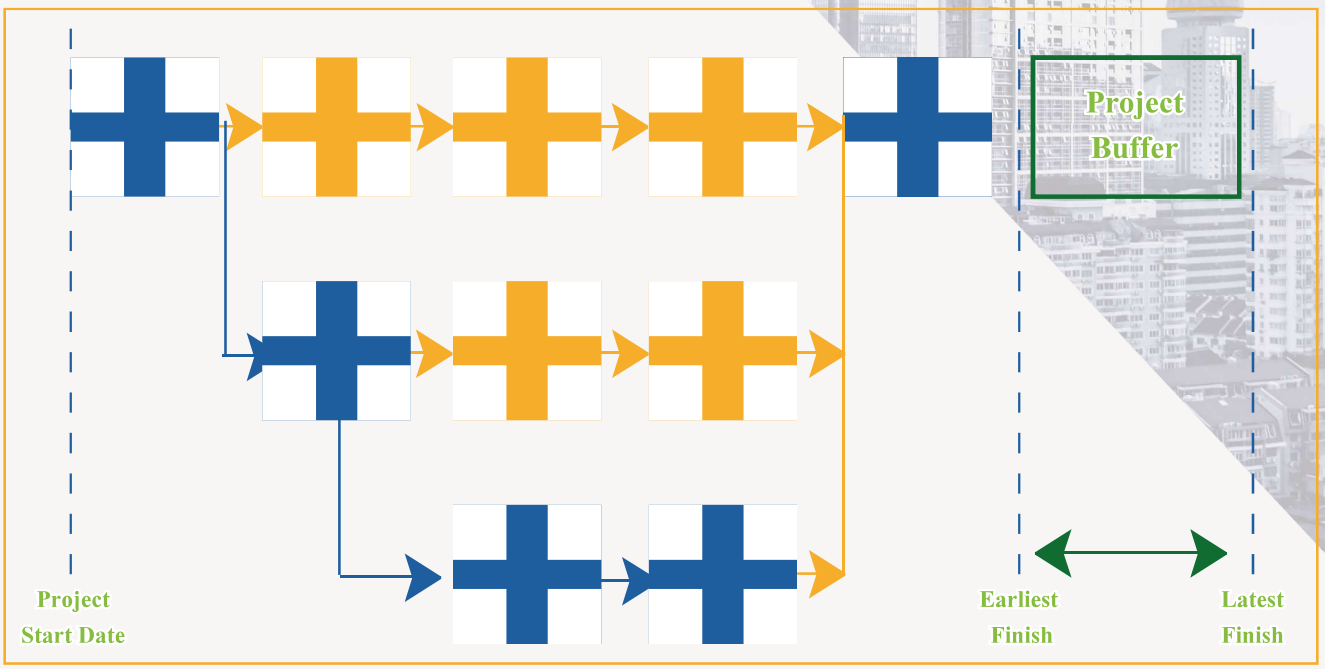
During Estimate activity duration process, Project Manager and his team should realize the fact that student syndrome and sandbagging should be avoided and the extra buffer that is being added by the team members should be avoided or shouldn›t be aggregated and redistributed according to the criticality of the activities and the real project conditions on the ground, hence the activity realistic durations will be decreased. Considering that the Critical Chain will rely on real-time synchronization of project activities based on resource dependencies and convergence paths by recognizing flexible task scheduling and explicit buffers in other words priorities of each activity will be determined instead of following the fixed schedule.

Revisiting previous PDN and considering the resources contention, it will be apparent that activities B, E, I utilizing the same resources which mean it will constitute a constrained path with resource dependencies and will be considered as a critical chain. That means activities B, I & J require redistribution considering the available resources.

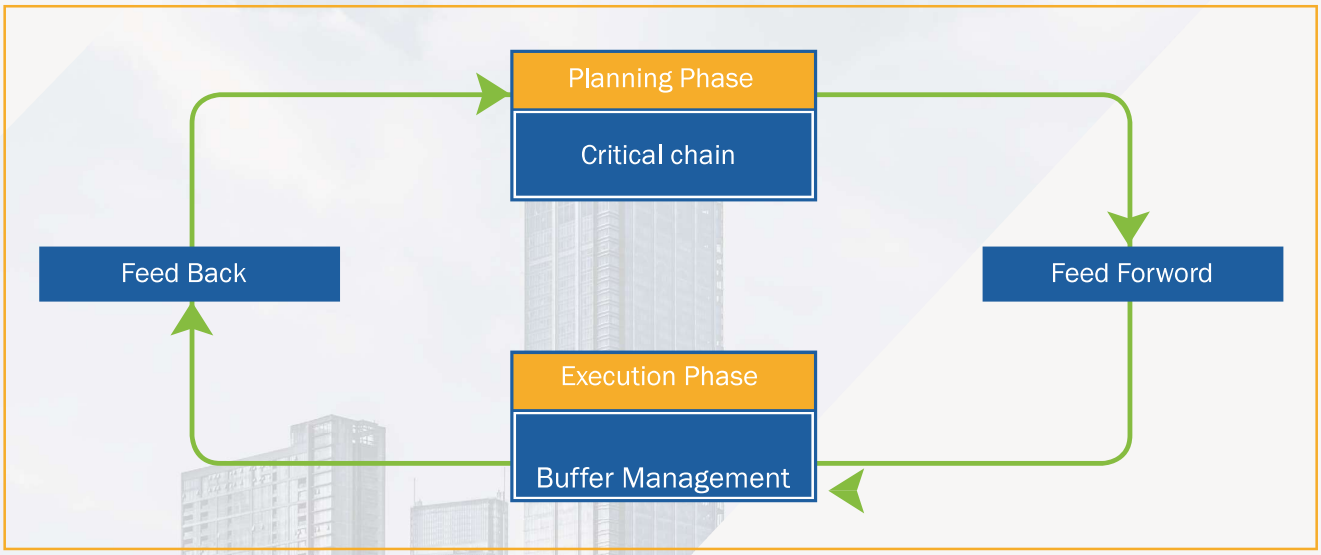




Applying CC concept will lead to aggressive duration and buffers will be added as it is clear that faster completion of activities and project accordingly costs less, but this requires proper control of cost and scope as well. Those buffers will be used if SPI shows bad performance. The next step is to identify the activities that will distinguish the earliest feasible completion date which will be considered as Critical Chain.



The range from earliest finish to latest finish will be considered as the project buffer, both project buffer and feeding buffers will be added again to crashed activities and the activities duration will be expanded with the buffers and those buffers to be hidden (explicit), then the new critical chain of activities duration will be estimated to create the baseline to prepare the Earned Value Management plan. This will lead to assure that any change in the Critical chain should be consistency be reflected in EVM baseline. To conclude the benefits of using critical chain scheduling technique and as illustrated through the figure, it can be stated that the critical chain is a performance engine of the project and buffer management is the guide that illustrates the suitable and convenient way to fine-tune the performance improvement. Critical chain is deployed during planning phase, while buffer management will be used as performance monitoring tool during execution phase that feeds back the critical chain to enable synchronization actions required to reprioritizing the project tasks and activities as per resource dependencies and any identified uncertainties, the following figure shows the life cycle of critical chain planning and buffer management;

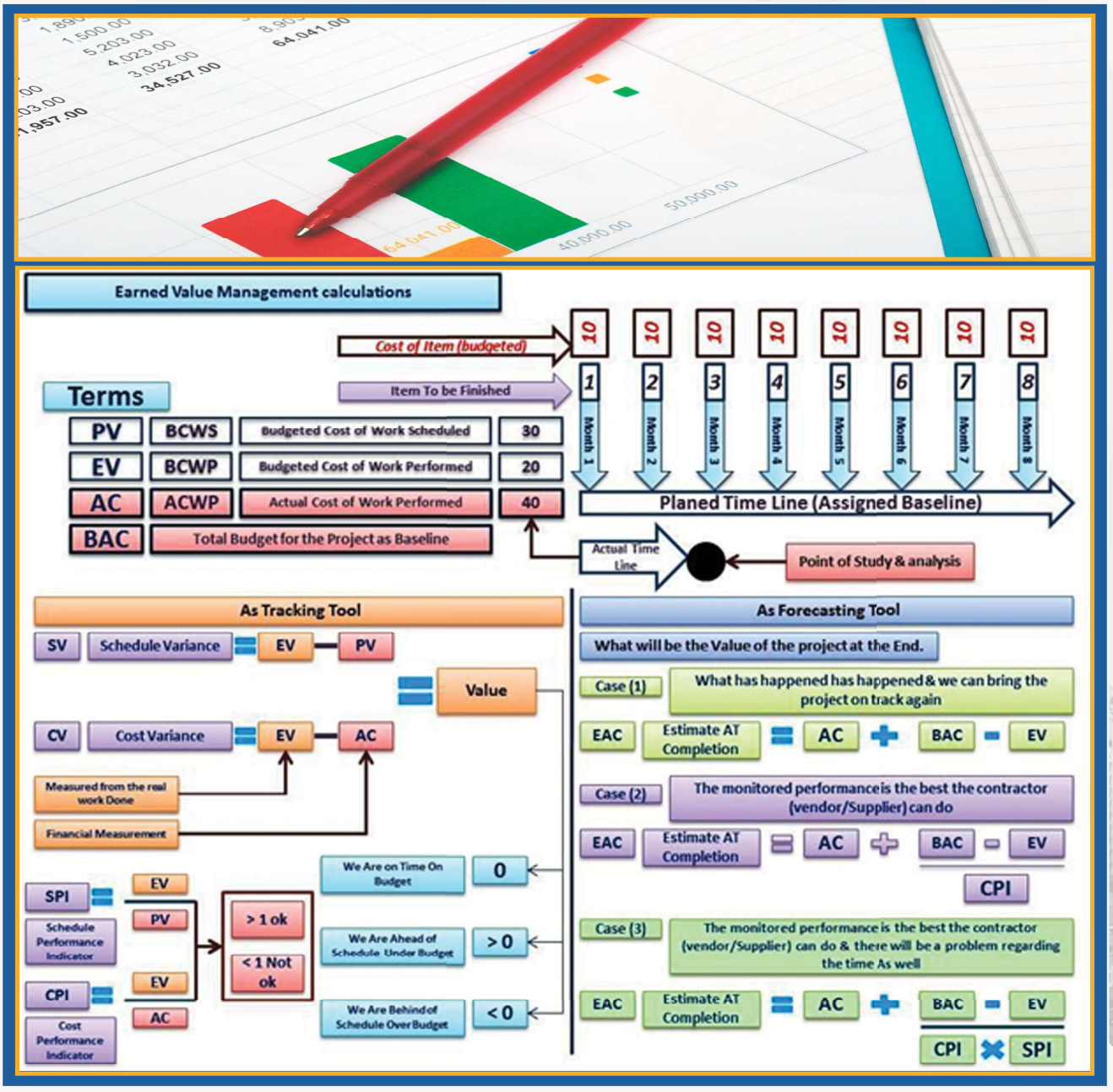


Finally, it is now clear that modern scheduling technique or critical chain scheduling technique addresses the theory of constraints by calculating the longest chain of dependencies (from resource dependencies point of view) and the activities chain to be reprioritized according to any identified uncertainties.

Using EVM in CC

Since EVM is the common utility to control the project schedule & Cost and in some Governmental and semi-governmental contracts it could be mandatory, the intention of this technical paper is to integrate the EVM with CC since utilizing EVM might give false or inaccurate indicators of project performance. It was apparent that CC buffer chart metrics with EVM traditional techniques will give proper indications of project performance. Moreover; it will give early warnings of potential problems to enable the Project manager and project team to act accordingly.

Hereinafter the basic concept of EVM where project manager and project team at any moment of the project could perform progress review by comparing how much spent against how much was planned using Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI) and Cost Performance Index (CPI). The following diagram illustrates the basic EVM flowchart:



The concept here is that Project schedule using CC will be planned to be completed sooner since feeding & Project buffer is being used. Hence the EV curve will show that the project completion dates the sooner than normal PV using traditional scheduling technique.

To overcome that situation a CCPM schedule should be developed and be sharing the project buffers across the tasks to reconstruct a traditional (non-buffered) schedule. Using a Gantt chart to reconstruct the schedule and calculate the PV.

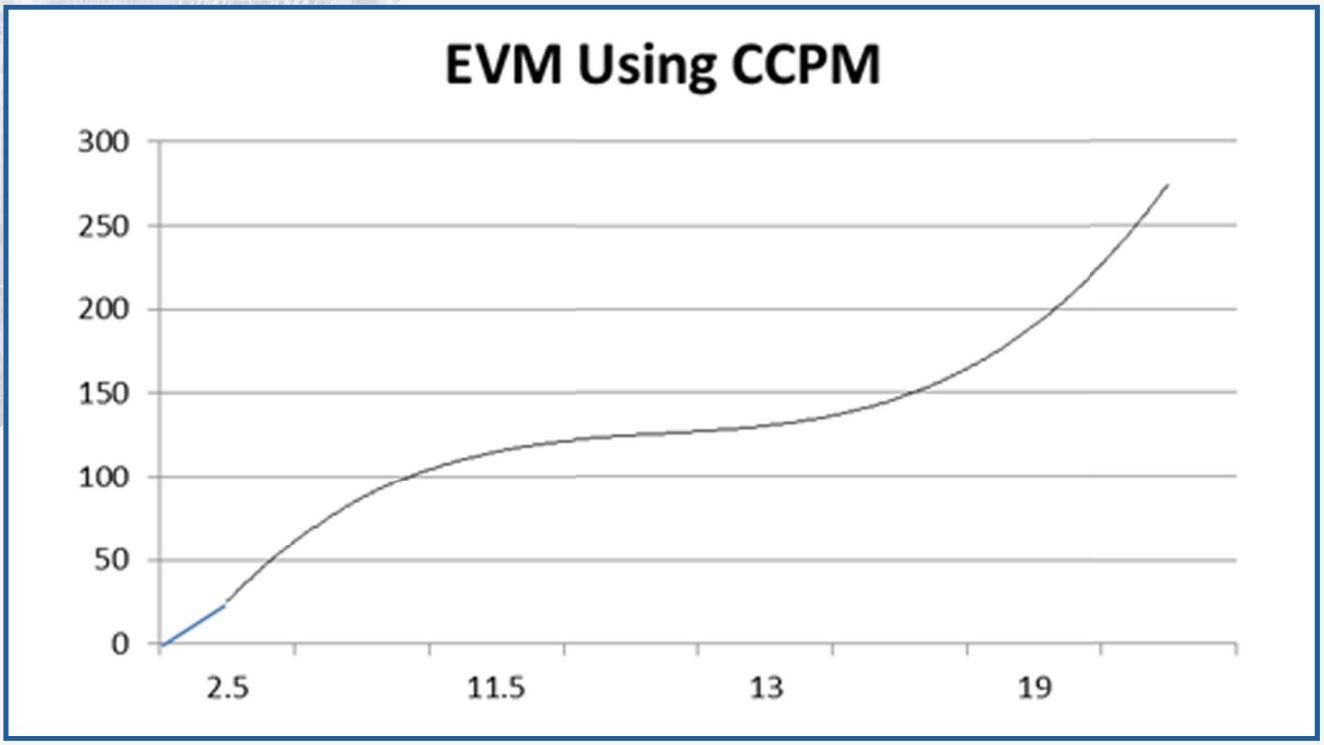
Applying the same concept to the previous example considering the resource unit cost is 10 USD per duration unit:

Traditional Schedule	B,(3)	E,(9)	I,(2)	J,(5)
CCPM Schuedule	B,(2)	E,(9)	I,(1)	J,(4)	PB,(3)

	B	E	I	J	Total
Traditional Schedule	3	9	2	5	19
Original Cost	30	90	20	50	190
Aggressive Duration	2	9	1	4	16
Buffer Duration					
Distributed Buffer	0.5	0	0.5	2	3
Re-Constructed Duration	2.5	9	1.5	6	19
Original Cost	25	90	15	60	190

Applying EVM Planned Value performance baseline using illustrated figures will enable the project manager and project team to have early warnings if any potential problem might occur?

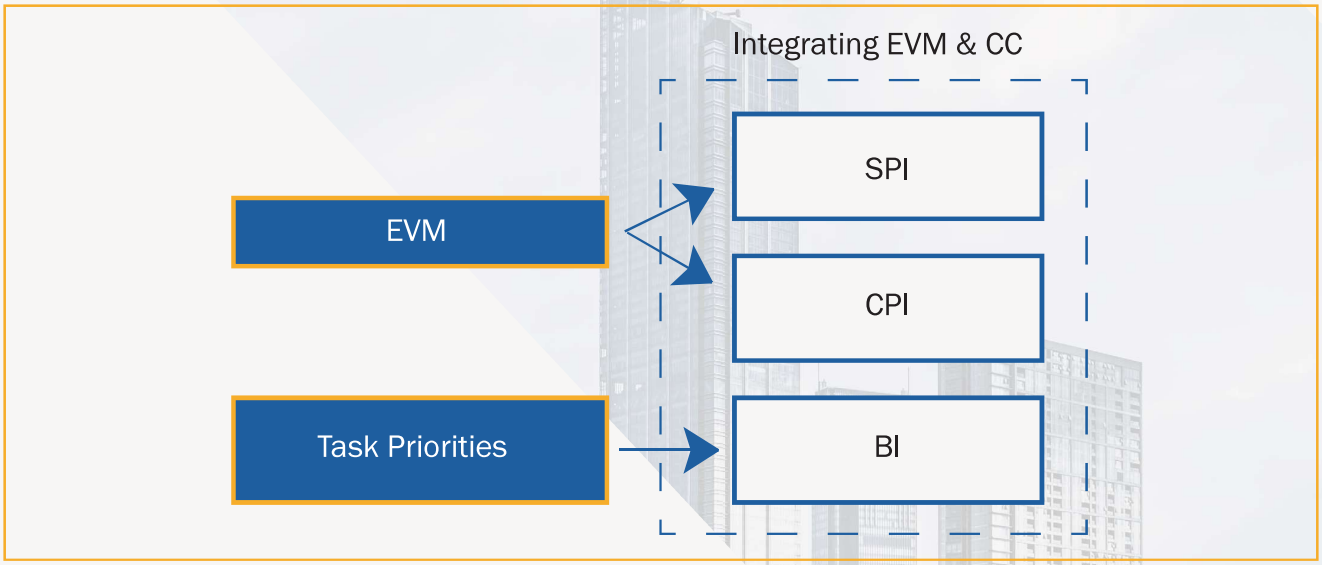
	B	E	I	J	
Re-Constructed Duration	2.5	9	1.5	6	
Cumulative Distributed	2.5	11.5	13	19	
Original Cost	25	90	15	60	
Cumulative Cost	25	115	130	190	



What Does It Mean?

Implementation of Re Constructed schedule will lead to review the project performance based on the remaining duration of each task on the critical chain and available resources or efforts hence the EVM presentation will not rely on SPI & CPI only but rather includes the BI (Buffer Index) which means if any task or activity is not completed or went wrong then the BI will raise the RED flag that there is a problem and predicts the potential problems that may lead to project completion delays.

Hence there will be a simple modification to EVM chart by involving the BI as follow:



Tacking the Project Performance

Applying the Integration model of EVM with CC will lead to proper resource and performance tracking using the BI chart Metrics as follow:

BUFFER CHART METRIC

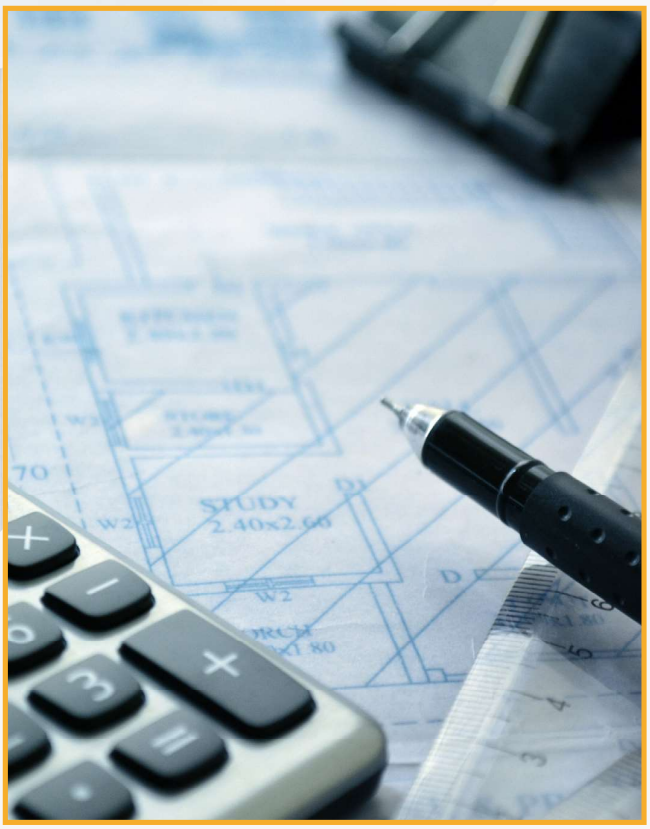
	GOOD BI	CP>1	SPI>1
POOR BI		Need More Resources, Hence Check the Priorities	Critical Path is besind schedule while feeding chain is performanceing well.so far this requeries buffer recovery by adding more resources.
CP<1	resources are not Productive and required more Supervision. Moreover,Task duration needs to be more aggressive (cutting time duaration)		resources are Productive and required more Supervision.Moreover,Task duration needs to be more aggressive (cutting time duaration)
SPI<1	Critical chain should revised to assure the missing dependencies,(cc repair)	Since CPI is good while project is behind schedule there might be a need of adding more resources for buffer recovery.	

Conclusion

It was apparent through the technical paper that critical chain technique could be considered as a modern management technique that exposed the agility concept that reduces the risk of project failure and resources contention as well. The concept that moving from the area that considers the resources contentions and conflicts as a fact of life to the area that project manager and project team treats the project tasks as per their priorities. Furthermore; the project manager moves from the concept of considering the activities start and finish dates as per schedule to deal]l with activities start dates as soon as their predecessor activities completed, in other words, to finish the activities as soon as possible (Avoiding student syndrome & sandbagging).

Redistributing the plenty of safety margins of all project activities that have resource constraints will enable the project manager and project team to develop realistic feeding buffers and project buffers as well. These buffers will be utilized only when is needed due to resource constraints and activities priorities.

Implementing EVM on traditional schedule baseline is mandatory from contracts administration point of view especially in governmental and semi-governmental contracts, however; this will lead



to inaccurate project performance reviews since it will report the performance of tasks separately. Here the value of integrating EVM with CCPM and utilizing BI (Buffer Index) arises. Where the project manager and the project team will be aware of early signed of project performance by knowing the early or proactive corrective actions that should be taken to getting back the project on track.

Hence Project manager and project team should deal with project activities while implementing critical chain through:

1 - Recognize the resource dependencies and constraints while estimating activity duration.

2 - Treat duration estimates as a forecast process rather than committed duration according to the real constraints on the ground.

3 - Minimize the chances of multitasking.

4 - Perform integrated Risk management by utilizing the buffers where risky paths exist especially convergence.

5 - Combine the EVM key performance indexes CPI & SOI with BI (Buffer index) to have early warning signs.

6 - Treat the early signs positively by taking proactive corrective actions to get the project back on track.

References

1 - Pulse of Profession Report 2016 PMI.org

2 - Application of CCPM (Critical Chain Project Management) to generate gains for industrial customers, Shirish M. Kulkarni, Jayanti Das, and Ajay Deshpande, (Presented at Project Management Leadership Conference, QAI - 2009), Version1.1, July 2009

3 - Scheduling for Success with Critical Chain, by Rob Newbold, September 2010

4 - An overview of Critical Chain applied to Project Management, FRANCISCO CORREIA, ANTÓNIO ABREU, ISEL, Polytechnic Institute of Lisbon, Lisbon, PORTUGAL

5 - Critical Chain Project Management (CCPM) at Bosch Security Systems (CCTV) Eindhoven A Survey to explore improvement opportunities in the scheduling and monitoring of, product development projects, University of Twente, School of Management and Governance

6 - Effective Procurement for Major Projects, Ian Hepinstall, European Public Sector Effectiveness Conference, 24th Oct 2013, Vilnius, Lithuania