

On Critical Chain Scheduling & Buffering: A Critique on the Theory of Constraints as Applied to Project Management ¹

Dr. Kenneth F. Smith, PMP

In a PMWJ article last year,² I addressed several major causes of project schedule slippages. Amongst them was **normative use of the PERT formula**³ -- a practice that both **Dr. Eliyahu Goldratt** of **Theory of Constraints (TOC)**⁴ fame and myself pinpointed as detrimental; *albeit from different perspectives*.

PERT's 'Earliest Expected Time' includes a safety factor for risk; but **Goldratt conjectured** all too often, **it proliferated procrastination**. While trade union shop stewards defended the need for safety norms, without a sense of urgency, workers wallowed in 'wait & hurry up,' and downstream managers similarly deferred preparing for succeeding activities. Consequently, instead of the prevailing practice, Goldratt advocated **tighter planning deadlines**. His recommended approach was to schedule activities with '**Most Likely**' -- or better -- time estimates; and **relegate the time component of All Critical Path-related activity risks** to a collective '**Project Buffer AFTER** the last project activity. [NOTE: This was a **TOC** technique – extant since 1990 – which Goldratt had utilized effectively to improve scheduling efficiency in production line flow-through, and logistical supply chain replenishment.]

I had also experienced that many estimators treated the '**Pessimistic Time**' estimate diffidently, citing 'Murphy,' 'unknown unknowns,' &/or jokingly proposing 'Infinity minus 1' for the value. So Goldratt's conjecture -- *that activity risks were overestimated* -- was not unreasonable. However, his assumption that it led to complacency and time wastage, as well as his approach for dealing with risk disquieted me as contraindicated, which precluded me from applying his 'collective risk buffering' technique *in toto*. Nevertheless, I saw some value in the systematic technique when I first encountered it in the late 1990's; **adapted** it for my planning consultancy work and training workshops as another '**best practice**;' and also included the variation amongst my aforementioned suggested

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² Smith, K. F. (2022). Schedule Slippages, Root Causes & Recommended Remedies, *PM World Journal*, Vol. XI, Issue V, May. <https://pmworldlibrary.net/wp-content/uploads/2022/05/pmworldjournal117-May2022-Smith-schedule-slippages-root-causes-remedies.pdf>

³ PERT Earliest Expected Time = [Optimistic Time + 4(Most Likely Time) + Pessimistic Time] / 6

⁴ Goldratt E. M. What is this thing called the theory of constraints? NY: The North River Press, 1990.

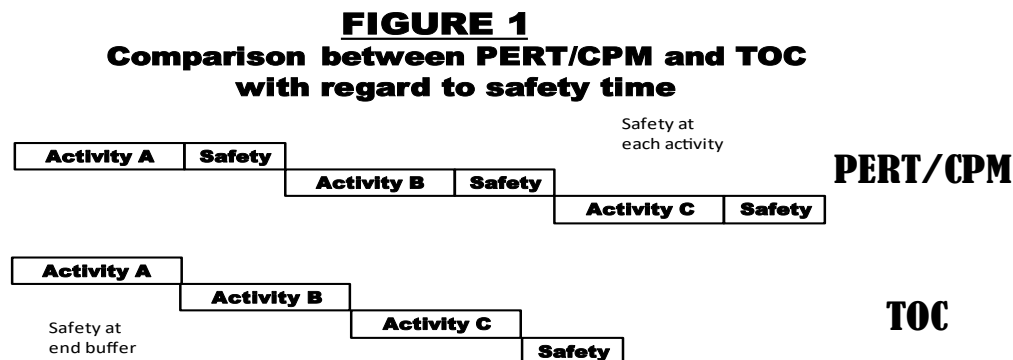
remedies to rectify the project schedule slippage situation. Subsequently, I developed a complementary ‘quick & easy’ **buffering template** for on-the-job application -- illustrated in that same article.

Recently however, a colleague referred me to an article by **Graham Rand**⁵ -- *contemporary to Goldratt’s exposition* -- in which the red flags that disconcerted me in 1997 were highlighted as **positive aspects!** Consequently, *even at this belated date*, it is imperative I summarize Goldratt’s rationale (as outlined in Rand’s article) to clarify why and how I modified the buffering approach.

To reiterate: while acknowledging the prevalence of risk in all situations, **Goldratt** conjectured ‘**Pessimistic Time**’ estimates inflated the ‘**safety time**’ embedded in the weighted means of ‘**Earliest Expected Times**’ “*beyond reasonable degrees of certainty.*” **To rectify this situation, Goldratt’s prescription was essentially threefold:**

1. **Use ‘Most Likely,’** or closer to ‘**Optimistic Time**’ estimates for scheduling, then
2. **Reschedule** all the individual activities in the project, and
3. **Relocate the time for the individual activity-weighted risks on the critical path** to a single **consolidated ‘safety buffer,’** after the last activity in the project.

These concepts were effectively summarized and illustrated in **Figure 1** from **Rand’s** article:



⁵ Rand, G. R. Critical chain: the theory of constraints applied to project management, Department of Management Science, The Management School, Lancaster University, Lancaster LA1 4YX, UK. [E-mail address: g.rand@lancaster.ac.uk (G.K. Rand)]. (Circa 2000)

While I accepted the concept of a consolidated end-of-project safety buffer of **some** amount -- as illustrated above -- there is sound rationale for buffers to be linked with – *rather than completely disassociated from* -- their activities. IMO, scheduling critical path activities and milestones while ignoring the intrinsic safety margins developed by the PERT formula is simply Pollyannaish!

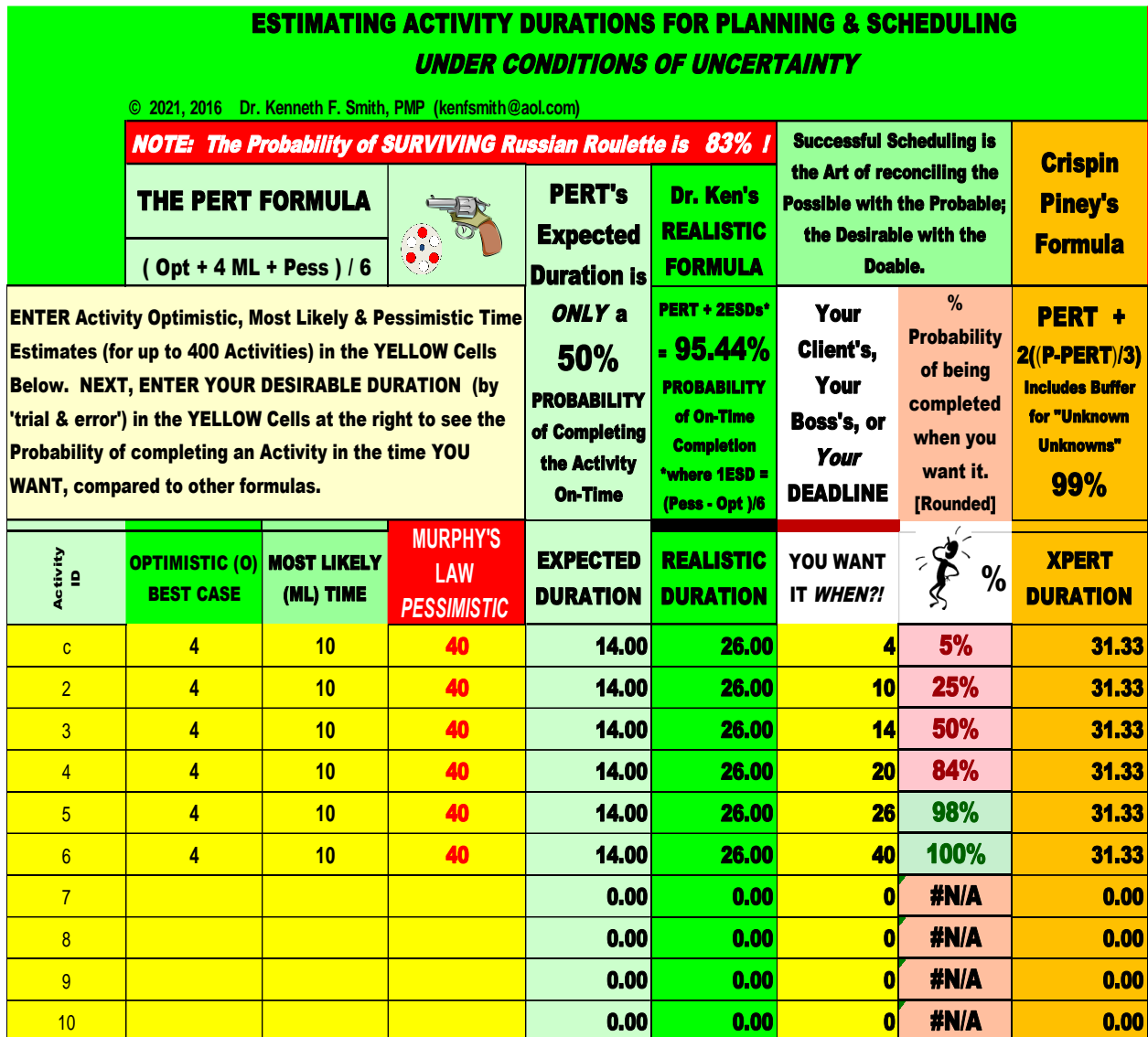
Moreover, while **Goldratt viewed the resultant risk** embedded in an '**Earliest Expected Time**' (EET) as inflationary, **I was opposed to utilizing it because** – *despite inclusion of the 'safety' factor -- it was insufficient*, because as a weighted mean, the activity EET still had **only a 50% probability of success!**

That is akin to playing Russian Roulette with three bullets! Thus, to me, **Goldratt's proposal** to utilize the '**Most Likely**' or even **tighter times** -- for scheduling – *i.e. without the safety* – **would only exacerbate the problem!**

Au contraire! Rather than available time being wasted, from my perspective projects were already too tightly scheduled. Thus, **the best way to reduce schedule slippages would be to increase the time scheduled** to perform the work, taking probability theory into account. This I did by modifying the PERT formula to derive a '**Realistic Time**'⁶ with a 95% probability for success. To further that end, I developed a template – *illustrated in Figure 2* – where managers and schedulers could see, and -- *by trial & error* -- select the most desirable options for each activity in their project to suit their unique situation.

⁶ Realistic Time = Earliest Expected Time + [(Pessimistic Time – Optimistic Time)/3]

FIGURE 2

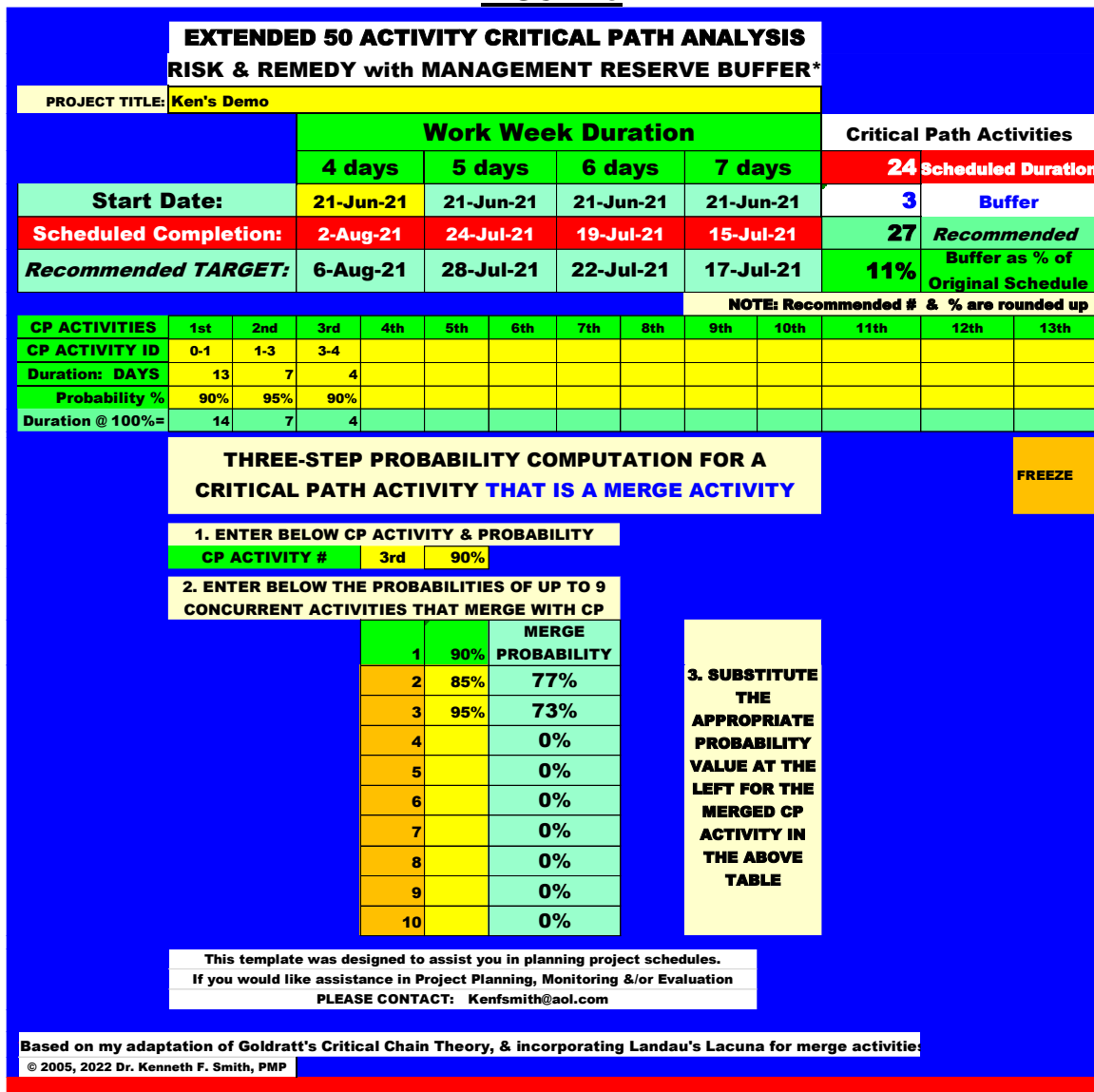


I then adopted Goldratt’s concept of a final safety buffer *for residual risks* from the critical path and related feeder activities, and utilized it for internal project management, as well as progress reporting against the contractual completion deadline.

I also modified the probabilities for **Critical Path Merge Activities** based on Landau’s **Lacuna**.⁷ To address that aspect, I developed another template for ‘quick & easy’ computational use, as illustrated in Figure 3.

⁷ “The *probability* of completing a critical path ‘merge’ milestone on time *is reduced* by the *combined probabilities* of its preceding concurrent activities” (assuming they are scheduled ‘just-in-time,’ even if not on the critical path). Martin (Marty) Landau [1921-2004] Professor of Political Science, UCLA.

FIGURE 3



[Incidentally – whether intentionally or inadvertently – Rand’s Figure 1 depicting only a single small ‘safety’ in the TOC case, as opposed to one approximating the three larger activity ‘safeties’ in the PERT/CPM example is very misleading; as it implies a much shorter overall schedule.]

Tightly scheduling activities without their safety buffers is both illusory and self-deceiving! Structural rigidity amplifies -- rather than dampens – vibrations. Similarly, in the event of adversity, tight scheduling will not shorten actual activity duration, but *is guaranteed to increase the stress levels of the project team and downstream stakeholders when it occurs.* Each and every time any project activity slips schedule,

it creates a ripple effect throughout all subsequent activities, and -- *without adequate buffers* -- discombobulates a tightly constructed critical path.

Although TOC may be great for refining and fine-tuning product production lines to peak efficiency, the only scenario where I can conceive TOC could be advantageous for managing projects is a **strictly linear situation where the objective is to complete the process as soon as possible; all downstream activities in the critical chain are the responsibility of -- and implemented by -- the same team members; and collateral merge activities are not constraining.** For example, a cross-country trek, an expedition to climb a mountain, or a limited military offensive. Then, as each activity is accomplished, the team is ready to move forward.

Monitoring the status of several on-going disparate activities in a project being implemented by other entities, as well as coordinating the startup of their imminent successors is difficult enough. **Having to reschedule every subsequent activity in the critical chain each time any activity slips schedule** would be a chaotic nightmare for everyone involved.

Far better in such circumstances to have a relatively stable schedule, with intermittent safety buffers to dampen the knock-on effect from predecessor activity slippages. After all, although project managers and their clients would like their projects to be completed sooner rather than later, the true objective should be **ASAP -- As Soon As Possible**, with emphasis on the **Possible**; rather than an overly optimistic delivery date that meets wishful expectations, but inevitably slips schedule. And the **best practice** for attaining that objective is succinctly expressed by the timeless Project Management adage:

PLAN YOUR WORK
[Realistically, I should add]
THEN WORK YOUR PLAN!

I trust in this brief discussion I have sufficiently clarified the reasons for my limited acceptance of Goldratt's rationale and rejection of his approach, but nevertheless **enthusiastically adapted his end-of-project buffering concept**; so, readers can judge, then adopt or adapt,⁸ as best they see fit.

Goldratt's scheduling strategy was based on his perception of workforce psychology as succinctly summarized by Graham Rand. Workforce mismanagement & employee interaction are indeed other topics worthy of consideration; and for insights on that I recommend reading Scott Adams – author and creator of the comic strip *Dilbert!*

⁸ As usual, the templates are free – together with over 100 others – on proof of purchase of my book Project Management PRAXIS, [available from Amazon here](https://www.amazon.com/dp/B08K9K9K9K).

About the Author



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Initially a US Civil Service Management Intern, then a management analyst & systems specialist with the US Defense Department, Ken subsequently had a career as a senior foreign service officer -- management & evaluation specialist, project manager, and in-house facilitator/trainer -- with the US Agency for International Development (USAID). Ken assisted host country governments in many countries to plan, monitor and evaluate projects in various technical sectors; working 'hands-on' with their officers as well as other USAID personnel, contractors and NGOs. Intermittently, he was also a team leader &/or team member to conduct project, program & and country-level portfolio analyses and evaluations.

Concurrently, Ken had an active dual career as Air Force ready-reservist in Asia (Japan, Korea, Vietnam, Thailand, Indonesia, Philippines) as well as the Washington D.C. area; was Chairman of a Congressional Services Academy Advisory Board (SAAB); and had additional duties as an Air Force Academy Liaison Officer. He retired as a 'bird' colonel.

After retirement from USAID, Ken was a project management consultant for ADB, the World Bank, UNDP and USAID.

He earned his DPA (Doctor of Public Administration) from the George Mason University (GMU) in Virginia, his MS from Massachusetts Institute of Technology (MIT Systems Analysis Fellow, Center for Advanced Engineering Study), and BA & MA degrees in Government & International Relations from the University of Connecticut (UCONN). A long-time member of the Project Management Institute (PMI) and IPMA-USA, Ken is a Certified Project Management Professional (PMP®) and a member of the PMI®-Honolulu and Philippines Chapters.

Ken's book -- **Project Management PRAXIS** ([available from Amazon](#)) -- includes many innovative project management tools & techniques; and describes a "Toolkit" of related templates available directly from him at kenfsmith@aol.com on proof of purchase of PRAXIS.