Association for Project Management

Senior Managers' & Project Managers' Guide to Critical Chain

Making the case for adopting critical chain project scheduling and execution management

THEORY OF CONSTRAINTS TOCICO INTERNATIONAL CERTIFICATION ORGANIZATION

Because when projects succeed, society benefits

Senior Managers' and Project Managers' Guide to Critical Chain

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Theory of Constraints International Certification Organization (TOCICO)

The Theory of Constraints International Certification Organization (TOCICO) is pleased to endorse the *APM Senior Managers' and Project Managers' Guide to Critical Chain*. This comprehensive guide provides valuable insights and practical strategies for implementing critical chain project management, a methodology that aligns with theory of constraints (TOC) principles.

As an organisation committed to advancing the application of TOC principles worldwide, TOCICO recognises the significance of this guide in helping project managers and senior managers improve project performance, enhance resource utilisation, and achieve project objectives more effectively. We commend the authors for their dedication to promoting excellence in project management and their efforts to share valuable knowledge with the project management community.

TOCICO is confident that this guide will be a valuable resource for professionals seeking to enhance their project management practices.

TOCICO Board of Directors

Contents

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Preface

My late father, Dr Eliyahu Goldratt, authored *Critical Chain* (1997) following the successful application of his theory of constraints principles to a series of projects at Statoil in Norway, at their request.

Critical Chain challenges entrenched beliefs and practices, such as 'The earlier you start, the earlier you finish', and the notion that 'Ensuring each task's timely completion guarantees the project's on-time delivery'. As the years unfolded, the methodology evolved, incorporating comprehensive solutions which address common obstacles to flow during both the planning and execution stages.

In the twilight of his life, my father was resolutely dedicated to elevating his legacy work to mainstream prominence. As part of his devotion to making critical chain mainstream, my father ardently advocated for critical chain to be included in credible industry training and for it to be recognised in established bodies of knowledge. The incorporation of critical chain into the *Body of Knowledge* of the Association for Project Management (APM) marked a significant milestone, endorsing its legitimacy. In unison with APM, we acknowledge critical chain as a natural and credible evolution of critical path, especially in projects where resource contention and uncertainty are the predominant obstacles to timely delivery.

We commend APM and the esteemed authors of this guide for their advocacy of diverse methodologies. More than two decades after the publication of *Critical Chain*, empirical evidence unequivocally attests to its efficacy. However, its transition to mainstream acceptance is contingent upon an increasing number of managers daring to transcend the status quo and instigating transformative changes in project management paradigms.

We wholeheartedly endorse this enlightening *Senior Managers' and Project Managers' Guide to Critical Chain*. It serves not just as a source of valuable insights but a clear call to action.

Rami Goldratt
CEO
Goldratt Group

Executive summary

There is empirical evidence that extraordinary results can be achieved with critical chain. The approach has delivered significant improvements in performance in complex design and development, manufacturing and maintenance projects across various industries. This guide provides a compelling case for adopting critical chain using a phased business change approach and simple principles (rules of flow) to address uncertainty, resource contention and other root causes of poor project delivery.

Critical chain is an evolution of critical path to better manage the execution of projects. The benefits (such as improved delivery throughput, shorter project durations and reduced stress) become quickly evident when the behaviours are aligned to the coherent set of critical chain principles. Some are 'back to basics' project management principles, some are borrowed from lean, and some are new concepts developed by Dr Eliyahu Goldratt.

The guidance provides 10 simple rules of flow, as well as advice on how to manage the implementation of a new way of working in an existing project team or organisation. The key ingredients of successful deployment and sustainment are to ensure that the roles and responsibilities are clear, that people receive the right training, and that tools and metrics are changed to enable the new ways of working.

A number of valuable resources and the steps to get started are also recommended.

Introduction

Various studies have described significant challenges to project delivery performance, quoting high failure rates (e.g. Flyvbjerg, 2011; Flyvbjerg and Gardner, 2023). There are many root causes and ways to address them. A recurring theme is that complex projects, programmes or portfolios, by their very nature, must cope with a high level of uncertainty, variability and change. Dealing with uncertainty and the resulting resource contention are the predominant obstacles to on-time delivery. Critical chain is an approach with a track record of successfully dealing with these issues.

The purpose of this guide is to make a compelling case for using critical chain, as an evolution of critical path, to manage the execution of projects. It will describe its benefits and provide explanations to use with stakeholders.

Critical chain project management has delivered significant improvements to performance in complex design and development, manufacturing and maintenance projects across various industries (e.g. aerospace, defence, pharmaceutical, construction, automotive, communications, consumer goods and energy). It has been used at all scales of project, from small projects to complex multi-year megaprojects. The approach can be used to manage individual small-to-medium-sized projects, but it is particularly beneficial for larger, complex programmes and portfolios.

> … there is empirical evidence that extraordinary results can be achieved with critical chain.
>
> *APM Body of Knowledge 7th edition* (Association for Project Management, 2019, p.176)

Critical chain embeds many of the 'back to basics' principles known to experienced project managers. However, it deals differently with durations, schedule contingency and resource contentions during planning. In execution, it facilitates the timely and supportive leadership behaviours required for the early identification of, and rapid recovery from, issues to mitigate schedule risk.

The guide is intended for senior managers and project managers who are looking for a new way to increase the likelihood of project success.

This guide is not a comprehensive 'how to' manual, but will direct you to excellent, relevant resources.

Case studies – Results achieved with critical chain

Image © Charin de Silva/Embraer

Embraer – E2 aircraft – Design and development

Case for change: To seize a significant opportunity in the single-aisle market, it was critical to design and deliver the new aircraft faster than ever before and on time.

What was achieved: The first new aircraft was delivered ahead of schedule, with no compromises in product quality. The first-ever maximum speed, maximum altitude and full-flight envelope testing was achieved on its first flight. It received the first-ever triple certification by US, European and Brazilian aviation authorities on the same day. The product was certified as meeting or exceeding product requirements. It represented the best-ever entry into service in terms of maturity and reliability. As a result, Embraer was able to grow to a leadership position in its market segment.

How it is sustained: Critical chain is embedded into the planning and operational toolset, engineering training, and leadership support and routines. It is also fully embedded into an overall company-wide lean philosophy. The portfolio of engineering modifications is still sustained at 95%+ on-time delivery through critical chain. Embraer's eight maintenance, repair and overhaul operations in the US are also adopting critical chain.

Project Management Institute Project of the Year Award 2019

TOCICO Process of Ongoing Improvement Award 2019

Aviation Week Laureate and Grand Laureate Awards 2019

For a video on this case study, go to: tocico.org/criticalchain

Hawk in front of hangar © BAE Systems Plc

BAE Systems – Hawk training jet – Maintenance, repair and overhaul

Case for change: To de-risk competitor threat ahead of re-contracting by improving performance and customer satisfaction.

What was achieved: Moving from 40% to 100% on-time delivery. Improving the ability to absorb further work (via the wing modification programme) with minimal additional resource. This increased customer satisfaction and the contract with the Royal Australian Air Force was renewed.

How it is sustained: BAE Systems embedded the way of working into its Exepron software tool, which is used by the shop-floor employees and senior management. Recurring training is provided to the entire operation every two years. By sharing critical chain best practice, the Hawk operation in the UK has since adopted critical chain and achieved similar benefits (reduced overtime, schedule improvements, and the ability to take on additional work with the same resources).

Project Control Expo – Project of the Year – Australia Award 2018 (BAE Systems Australia)

TOCICO Outstanding TOC Implementation Award 2024 (BAE Systems UK)

Finalist APM Programme of the Year Award 2024 (BAE Systems UK)

Finalist APM Innovation in Project Management Award 2024 (BAE Systems UK)

Finalist Project Control Expo Innovation of the Year Award 2024 (BAE Systems UK)

For a video on this case study, go to: tocico.org/criticalchain

Image © RBSL

Rheinmetall BAE Systems Land (RBSL) – Challenger 3 tank – Design and development

Case for change: Customer request to accelerate the programme due to changes in the geopolitical environment.

What was achieved: On-time delivery of a complex design and development phase with a new joint venture, post-Covid-19 disruption, and a decade since the company did a similar programme.

How it is sustained: Training and communication was given to all functions to confirm the 10 simple rules of flow, to achieve buy-in to the principles beyond the planning/project management community. Daily 15-minute full-project schedule reviews and weekly leadership escalation sessions drove timely schedule recovery.

Project Control Expo UK – Innovation Award 2023

Finalist APM – Programme of the Year Award 2023

TOCICO Outstanding TOC Implementation Award 2023

For a video on this case study, go to: tocico.org/criticalchain

1 Part 1: For the senior manager and project manager

What is critical chain?

Critical chain project management is a method of planning and executing projects which addresses resource conflicts to protect the schedule against uncertainty. Today's highly complex projects have to deal with a great amount of volatility, uncertainty, complexity and ambiguity (often described as VUCA). Critical chain builds on critical path and sound logical task networks (also known as 'precedence networks') to provide focus. It makes innovative use of a schedule buffer to drive the right behaviours to achieve on-time project delivery.

Critical chain uses optimistic task durations when scheduling the project, with the addition of a sizeable time buffer to protect the project's due date (the promise to the internal or external customer). The buffer is a shared project resource. An important consequence of this approach is that task estimates are not commitments made by the task manager but are simply a part of the method for calculating the estimated project duration and buffer size.

During execution, tasks that are underway and are forecast to take longer than their optimistic duration will consume some of the buffer. Those few tasks that are completed in less time than the optimistic estimate will add time back into the buffer. The rate of buffer consumption (relative to project progress) serves as a visible progress and performance indicator, and becomes an early-warning system.

A few key activities and behaviours are required to protect the schedule, for example:

- de-conflicting any major resource contention to avoid two tasks using key resources occurring at the same time, which would slow down execution
- relentlessly focusing on recovery actions to reduce or reverse excessive consumption of the buffer
- focusing on task preparation to ensure that people have everything required to finish the task, without having to stop to wait for inputs, materials or information

The story of critical chain's genesis

Following the success of his bestselling book *The Goal* (1984), Dr Eliyahu Goldratt was asked by Statoil in Norway to apply his theory of constraints concepts to project management.

Not being a project manager, he was introduced to the concept of critical path, a series of dependent tasks which determines the overall project duration. He observed that critical path tasks often formed only a small proportion (less than 1% at Statoil) of the volume of project tasks.

As an outsider, he made a number of other insightful observations:

- If critical path tasks take longer than planned, the project as a whole takes longer.
- If critical path tasks take less time than planned, surprisingly these gains do not often result in the project finishing early.
- Task duration estimates can include significant 'safety time' (i.e. additional time to cope with uncertainty and the working environment when juggling multiple demands), as people are measured against them and penalised for not meeting them.
- However, the additional time is wasted due to a human tendency to start tasks late (student syndrome), tasks expanding to fill the allotted time (Parkinson's law), and additional non-essential work being carried out (gold plating).
- Early finishes are not passed on or even reported, as it will change expectations for future estimates.

He concluded:

We need to remove the 'safety time' (the additional time allowance in estimates) from individual tasks and aggregate the safety time into a project buffer at the end of the critical path to protect the whole project.

Source: abbreviated from *The Critical Chain Implementation Handbook* (Updegrove, 2014, pp.3–5)

Why should senior managers and project managers embrace critical chain?

Time is the only resource you cannot buy more of. It is the role of the senior manager and project manager to select the right methodology to deliver projects successfully.

Kendall and Austin (2012) analysed over 60 organisations publicly reporting improvements as a result of implementing the critical chain methodology described in this guide, as illustrated below.

Table 1: Improvements achieved by using critical chain

Metric	Average	Worst case	Best case
Project duration	–39%	–13%	–78%
Schedule adherence	+70%	+15%	+222%
Throughput	+53%	+14%	+150%

Source: Kendall and Austin, 2012

Senior managers should embrace critical chain to replicate these results by clearly prioritising tasks to protect the duration of the longest chain of dependent tasks in a project.

As a senior manager, it is all too easy to be dragged into constant firefighting and repeated planning. However, it is the senior manager's role to support the design and implementation of a system of work which provides early-warning indicators. This system should be able to accommodate, to some degree, the inevitable delays and issues that will affect on-time delivery.

The role of the project manager is to apply the right approach according to the nature of the project and to systemically address resource contention and uncertainty.

What benefits does critical chain deliver?

The following are the main benefits experienced by project teams implementing critical chain (Leach, 2014);

1. improved project success in terms of delivering the full scope, on or ahead of time and on or under budget
2. reduced project duration
3. increased project team satisfaction and reduced stress
4. simplified project management in terms of level of scheduling, less rescheduling, simpler reporting, and simpler priorities for decision-making
5. increased throughput with the same resources, due to reduced resource demand conflicts and less demand to hire new critical resources or agree overtime
6. increased confidence among stakeholders (including internal and external customers)

Many video case studies describe these benefits, for example on TOCICO's website (tocico.org/criticalchain), and on YouTube and LinkedIn (search for 'critical chain project management').

What is the role as a senior manager to deliver the benefits?

It is vital for senior managers to provide visible leadership when introducing critical chain. Their role requires:

1. making the case for change as change leaders (see part 2) and winning hearts and minds
2. setting up the environment needed for people to operate with a new set of rules, rewarding adherence to the new ways of working
3. allowing critical chain pilot projects to tailor their approach to meet the intent of existing policies and practices used for project management, reporting and governance
4. communicating early successes
5. demonstrating servant leadership by supporting the project team in 'recovery action' escalation when critical path or critical chain tasks are consuming buffer

The project manager who is implementing critical chain needs to discuss expectations with the senior manager for being a proactive sponsor of implementing critical chain.

What are the critical chain principles and rules?

Critical chain consists of a coherent set of principles. Some are 'back to basics' project management principles, some are borrowed from lean approaches, and some are new concepts developed by Dr Eliyahu Goldratt.

The 10 rules of flow aim to describe, in practical terms, the process and managerial prerequisites to being able to work in 'the critical chain way'. The 'Rules of Flow' title was inspired by the novel *Goldratt's Rules of Flow* by Efrat Goldratt-Ashlag (2022). The rules clearly demonstrate that it is not just about scheduling with a significant time buffer (Rule 7) or staggering the work so as not to overwhelm a critical constraint resource (Rule 8). For critical chain to accelerate the flow of work and achieve the other benefits, all 10 rules need to be implemented.

Table 2: The 10 rules of flow

1. **Reduce the work in progress**	Reduce the number of live projects and tasks that are allowed to be worked on at any one time.
2. **Complete full kits**	Only release tasks to resources when they have everything they require to complete the task. Focus on enabling full kit well ahead of time.
3. **Release to capacity**	Release tasks in the correct sequence and priority to maintain the optimal level of work in progress.
4. **Reduce multitasking**	Minimise interruptions to allow people to focus on and finish each task as quickly as possible.
5. **Show servant leadership**	Ensure management and expert resources are visible and available, and are actively supporting daily recovery actions.
6. **Ensure clear definitions of 'done'**	Ensure the project scope is clearly documented and communicated, and all tasks have clearly defined criteria for handover and completion ('done').
7. **Plan for uncertainty**	The rolling wave plan has logically linked tasks of the right size. Position visible buffers to protect the plan from the uncertainty and changes to it in execution.
8. **Focus on the constraint/integration point**	Stagger the projects in the portfolio to synchronise resources and ensure they are not overloaded.
9. **Focus on remaining duration (the past is the past)**	Report the remaining duration of all (open) project tasks every day. Identify where and when to actively manage with fast recovery actions.
10. **Measure to drive the right behaviours**	Replace local efficiency measures that do not support flow with different measures aligned to deliver the project on time. E.g. introduce a Rule 1 – work in progress measure, a Rule 2 – percentage full kit-enabled work measure, a Rule 9 – buffer consumption rate measure.

Source: 'Rules of flow for projects, programmes and portfolios' by BAE Systems Plc, explaining critical chain principles. Reproduced with permission.

Where can I find further guidance?

Many valuable resources are available to inform your understanding of critical chain.

- *Critical Chain* is a novel by Dr Eliyahu Goldratt (1997) in which the main character, a lecturer at an MBA programme, teaches project management and explores with his students the systemic issues that cause project delay and (critical chain) techniques to address them.
- *The Critical Chain Implementation Handbook*, by David Updegrove (2014), is a comprehensive step-by-step 'how to' guide which also clearly explains the 'why'.
- *Advanced Multi-Project Management: Achieving outstanding speed and results with predictability*, by Gerald Kendall and Kathleen Austin (2012). A well-argued manifesto for critical chain in multi-project environments, providing practical guidance on implementation (including software requirements), case studies, and a clear description of agile vs critical chain (in Appendix D).
- *Theory of Constraints Handbook*, edited by James Cox and John Schleier (2010), includes five chapters on critical chain. It is recommended to start with chapter 3: Critical chain project management primer, and chapter 4: A field report, which provide a useful introduction with practical examples and lessons learned.
- TOCICO is the professional body which governs the body of knowledge of the theory of constraints, including the project management variant called critical chain. The TOCICO website (tocico.org) provides non-members with free access to some of the resources, and members can access a larger back catalogue of video case studies and training material. A dedicated critical chain page (tocico.org/criticalchain) contains free video case studies.
- *Goldratt's Rules of Flow* (2022) is a novel by Efrat Goldratt-Ashlag. The main character turns around a struggling family company using critical chain principles to increase the flow of work, address late projects and improve customer satisfaction.
- *Breakthrough project management* by Ian Heptinstall and Robert Bolton (2016) provides an introduction to critical chain and collaboration using project alliances on large capital expenditure projects such as construction.
- Search for 'critical chain project management' on YouTube and LinkedIn for a number of introductory training videos and case studies.

2 Part 2: For the critical chain business change implementation team

Project managers do not always have the ability and authority to change the scheduling and control methods from those they currently use to critical chain. Their wider organisation will have established norms and systems, and project managers are expected to comply with corporate policy and contractual requirements.

Critical chain also relies on the adoption of a different mindset to schedule risk, due dates, the release of work, different behaviours to the execution of work, and a different role for leaders.

For these reasons, introducing critical chain as a new way of working will need to be managed as a business change project.

Justifying the case for critical chain and sense of urgency

It is important to engage senior stakeholders and people at all levels to identify and socialise the case for change and sense of urgency.

The sense of urgency can stem from:

- a customer request to accelerate a project to meet operational demands (e.g. in defence during a period of conflict)
- the penalties for not meeting a regulatory deadline which a project aims to deliver (e.g. in financial services)
- the consequences of delaying the provision of the capability the project is providing (e.g. in health care)

A business change project team needs to develop and communicate a clear vision, drive momentum and remove obstacles. This is best done through an inclusive approach with workshops, training and two-way engagement sessions.

Creating a guiding coalition

Critical chain implementations which are purely focused on the schedulers/planners are bound to fail. The critical chain principles depend on different roles in a project organisation adhering to a new set of behaviours; for example, a procurement manager prioritising full kit materials for a critical chain task over other tasks, or an engineer understanding the clear handover requirements from one critical chain task to the next.

That is why it is important to cast a wide net when implementing critical chain. It is not just about scheduling and buffers; it is about improving teamwork in the cross-functional project team. Unless a systemic approach is taken to all the enablers for tasks on the critical chain, the buffer will be used too quickly and the project will still be late.

In addition to project managers, the stakeholders to involve are in functions such as:

- procurement
- engineering
- manufacturing
- logistics
- finance

An effective way to win 'hearts and minds' is to combine a training session on the principles of critical chain with a workshop to reveal the current challenges experienced by the project team. This provides an opportunity to map current pain points with the solutions that critical chain offers. In some cases, key basic project management foundations required for any project, as well as critical chain, are not in place. For example, there may be no sound logical network to identify the critical path/critical chain, or the work breakdown structure may be incomplete. These issues can be addressed as part of the critical chain implementation.

Planning the business change project

Implementing change is best done in small steps. This will reduce implementation risk, allow for learning and deliver quick wins. This, in turn, whets the appetite for more.

A deliberate pilot approach on a crucial part of the project organisation (rather than an insignificant area nobody is interested in) can be an effective phased implementation. However, it should be executed as a serious first phase of a further roll-out. Any indication that it is not a well-supported endeavour is guaranteed to lead to failure.

An example of a phase approach is the model below.

Critical chain project management deployment strategy

Case for change and vision	• Develop the case for change and diagnostic • Source training and expertise (partner with experts) • Identify pilot area and scope work content • Agree IT strategy	**Outcome** • Size of the prize • Justification for investment • High-level plan
Training & Pilot planning	• Awareness training • Advanced training • Leadership training • Learning from experience (e.g. from other Critical chain practitioners) • Pilot planning	**Outcome** • Capable teams • Knowledgeable leadership • Plan for pilot
Pilot deployment & Pilot review	• Pilot mobilisation • Pilot delivery • Pilot results review • Pilot lessons learned • Communication to stakeholders • Build internal capability • Plan further deployment	**Outcome** • Initial benefits, performance improvements • Lessons learned • Experience and confidence • Plan for deployment • Root cause/buffer analysis results
Deploy and Review	• Mobilisation • Delivery and ongoing improvement • Results review • Lessons learned review	**Outcome** • Performance improvements • Plan for sustainment
Sustain and Review (retrain every two years)	• Delivery • Results review • Lessons learned review • Expand internal capability to reach full autonomy	**Outcome** • Sustained improved performance • Annual review and corrective action plan

Source: 'Critical chain project management deployment strategy', BAE Systems Plc (reproduced with permission)

Sharing the vision and collaborating with all elements of the organisation

It is important to create and share a clear vision of how to accelerate project delivery or improve the reliability of on-time delivery, and agree it with all affected stakeholders. The first time someone is asked to stop working on other tasks to help recover a critical chain task, they, and other stakeholders, need to understand that this priority is set by the new critical chain approach and is more important than other local priorities. In addition, people should understand that they should avoid starting work on tasks which do not have full kit, where possible. The focus on full kit needs to be communicated to various elements of the organisation (e.g. engineering for drawings, procurement for parts, and management for certain approvals).

Common obstacles to implementation

There are several common obstacles to critical chain implementation or, in fact, when introducing any business change. By following the six steps below, these obstacles can be overcome, and this will increase the likelihood of success.

1. **Agree on the problem**

   It is important to explicitly capture the undesirable effects observed (e.g. lack of prioritisation, overloaded resources, delay) with the current way of working, for example in a workshop with key stakeholders.

2. **Agree on the direction of the solution**

   The direction of the solution (e.g. ensuring good project management foundations are in place and implementing the principles described in this guide) should be explained in terms that give confidence that they logically address the undesirable effects or problems that are currently observed.

3. **Agree that the proposed solution resolves the problem (even if not fully)**

   Stakeholders may require further detail about the proposed solution or more education. A disagreement over whether the solution will fully address the project's problems may stem from an unrealistic expectation. If 100% of the problem is not fully solved, but the performance is predicted to be twice as good as a result of the new approach (e.g. it will rise from 40% to 80%), it will still be worth implementing the solution. People need to accept that doubling performance is a laudable aim, even if it does not achieve 100%. Further improvements can be targeted after doubling performance.

4. **Address concerns that the proposed solution may create other problems**

   Such reservations need to be treated seriously, but do not in themselves invalidate the solution. A good example is that it may create a problem when reporting earned value management (EVM) or other project metrics. This reservation can be overcome by providing different views of the schedule (buffered and unbuffered) to satisfy the needs of different stakeholders.

5. **Identify and address obstacles to implementing the proposed solution**

   The implementation builds on good project management practices, and as such is not a fundamental change. However, some time needs to be set aside to ensure the foundations are in place (for example, going back to basics if necessary) and to introduce the new principles and ways of working. In busy projects that are already at risk of delays, asking for time and resource to implement critical chain can be an obstacle. The case needs to be made that the time needed for training, coaching, and applying critical chain principles to the plan is not significant and will be offset by much faster delivery. Other obstacles may be related to policies or customers. It should be stressed that such obstacles in themselves do not invalidate the solution, but need to be tackled to ensure successful implementation.

6. **Address unverbalised fear**

   Any residual fear and unease needs to be overcome by supportive leadership, encouraging curiosity and providing psychological safety.

Measuring and celebrating success

New behaviours are embedded best by rewarding desired behaviours. This can be by simply providing positive feedback to the individual or their manager. Other reward mechanisms can be used to signal exemplar behaviour to the individual, the team and the wider organisation, for example when they have recovered a forecast buffer consumption or significantly improved full kitting tasks before release.

Implementing the 10 rules of flow

Rule of flow 1: Reduce the work in progress

Reduce the number of live projects and tasks that are allowed to be worked on at any one time.

The aim is to avoid multitasking by removing interruptions to tasks. Multitasking can be perceived as efficient, but in fact it is highly inefficient. Starting and stopping tasks means that activities take significantly longer than if they were completed without interruptions.

The impact of multitasking is illustrated in Figure 1.

- The top line shows each task being worked on sequentially.
- On the second line, each task is worked on for a short time before being interrupted as another task is progressed a little before switching again. Now all three tasks have a longer duration (from start to finish) and two of the three (A and B) are finished later than in the top line. This scenario assumes there is no loss of productivity in task switching, but this is rarely the case.
- The third line adds the impact of task-switching productivity losses. One study found that multitasking can reduce productivity by as much as 40% (Foerde et al., 2006). Not only have the durations of each task extended but they also use more resource time, which on many projects means increasing cost and impacting profit.

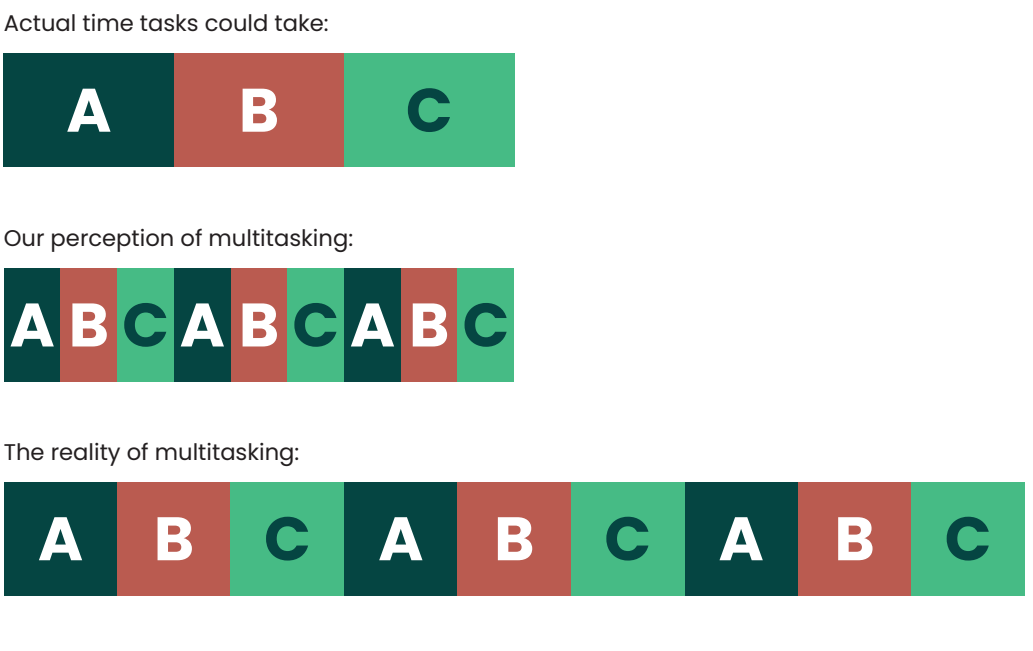


Figure 1: Impact of multitasking

Actions to take

- Prioritise the projects. Capture a full list of all projects and prioritise them using business criteria (e.g. return on investment).
- When first introducing critical chain, freeze enough of the lowest-priority projects (usually those responsible for at least 25% of the load).
- Ensure nobody works on frozen projects.
- Establish rules for the maximum number of open projects at any one time, and for when a new project can be started.
- Each person/resource should be clear which single project or task they should work on.
- As much as possible, ensure people spend 100% of their time on a single task at a time ('focus and finish' working).
- Other work is left unassigned until the first activity is completed.

Tip

Frozen tasks can be reviewed, prioritised and prepared to ensure they are completed rapidly once released, resulting in additional capacity and lead-time gains – as long as this preparatory work is not carried out by the critical resources who are executing the tasks (e.g. by other non-critical resource).

Rule of flow 2: Complete full kits

Only release tasks to resources when they have everything they require to complete the task. Focus on enabling full kit well ahead of time.

The difference between preparation activities and task execution activities is not always explicit or clear. When this is coupled with pressure to begin the next project or task as soon as possible, tasks are often started without the required preparation or materials being ready and available. Tasks may then be started but cannot be completed without interruption. Having everything in place that is needed before a task commences to enable successful delivery increases efficiency. Full kit items can include materials, equipment, information or approvals.

Actions to take

- Identify the key full kit points in the project schedule or task list and produce full kit checklists for each.
- Appoint full kit managers to coordinate, audit and control the completion of full kits.
- Ensure that team members are fulfilling any missing full kit items before the gate and/or key task is reached.
- Put on hold any task that is being worked on without full kit.
- Restrict work on any task without a completed full kit (unless it is authorised at senior level and the impact is understood).

Tip

A full kit manager needs to be appointed, but it is often a new responsibility for an existing team member. The full kit manager should be someone with sufficient authority to hold back tasks with incomplete kits. Underutilised resource should be directed to focus on full kit preparation, which will increase the number or percentage of tasks which are ready to be released.

Rule of flow 3: **Release to capacity**

Release tasks in the correct sequence and priority to maintain the optimal level of work in progress.

Having reduced the work in progress (Rule 1), a release mechanism is needed to control the amount of work in progress in order to maximise flow and avoid overloading resources. If tasks are released too early, the team will be flooded with too much work once again. If tasks are released too late, the team will find themselves starved of work and their output will reduce. This is especially important to consider as the capacity and flow will increase as the rules of flow are followed. The release gate manages releases of work to ensure that the load on resources is balanced for optimal loading and throughput.

Actions to take

- Put a mechanism (release gate) in place to schedule what work is released and when.
- Introduce a one-in one-out policy for releasing tasks to resources.
- Regularly review and maintain the priority and sequence of unreleased tasks, informed by the logic network in the schedule.
- Ensure activities are not started before they are required (or fully kitted).

Tips

- Take the opportunity to use a visible queue of prioritised and unreleased work to embed the 'focus and finish' mindset with resources.
- Encourage them to focus on one task and complete it as fast as possible.
- Demonstrate that everyone is adhering to the priority and staggering of different tasks and that the work will not be released too early. Coach team members to limit their own work in progress.

Rule of flow 4: Reduce multitasking

Minimise interruptions to allow people to focus on and finish each task as quickly as possible.

Multitasking can be driven by high levels of work in progress (see Rule 1) as people try to keep everything moving a little. However, other interruptions impact the flow of work. An interruption is anything that disrupts someone so that they cannot progress a primary activity or chain of work. Interruptions limit peak performance on an activity and, even if the person returns to the original piece of work after an interruption, the damage to flow is significant.

When attention is taken away to respond to different issues, general administration activities or other business priorities, capacity is wasted due to the ramp-up and ramp-down needed for stopping and starting work and context switching. In addition to capacity, there are also human factors and safety implications around regular interruptions and distractions.

Actions to take

- Reserve 'protected working time' in diaries to ensure that both project workers and non-project workers know when interruptions are to be avoided.
- Reserve your own 'interruptible time' and let colleagues know when you will be available to field queries and so on.
- Present visible physical and digital 'do not disturb' indicators to colleagues.
- Prepare full kits ahead of each protected working time window to ensure work can be completed.
- Escalate instances of interruptions to managers so that they can be addressed and reduced.

Tips

- When setting up 'protected working time' windows, make sure that team members are informed and can see the 'do not disturb' indicators, such as a label in an instant messaging tool or a physical symbol on someone's desk or door.
- Synchronise protected time windows for team members who often work together. This not only reduces the likelihood that they will interrupt each other but also aligns the times they are available for each other (and can interrupt each other).
- Keep a log of the instances of, and reasons for, interruptions. This will help to identify and address the causes.

Rule of flow 5: Show servant leadership

Ensure management and expert resources are visible and available, and are actively supporting daily recovery actions.

A servant leader puts the needs of employees first and helps people to develop and perform as highly as possible. A servant leader (an expert or manager) needs to free up capacity each day to remove blockages to flow and recover excessive buffer consumption.

Expert resources need to have the capacity to solve difficult technical issues or authorise technical approvals. Managers need to have the capacity to make decisions and assign recovery actions when there are delays.

Actions to take

For expert resources:

- Identify the expert resources who are frequently needed to address escalations.
- Reassign to other team members all tasks that can be offloaded from these expert resources.
- Free up enough protected capacity and make daily slots available for the expert resources to address project issues.
- When project planning, actively assign the lowest possible (suitably qualified and experienced) skill set to tasks, not the highest.

For management:

- Receive regular updates to stay informed about project health.
- Prioritise and protect enough daily capacity to be available for escalations which cannot be addressed by the project team.
- Free up some time each day to deal with blockages to flow and to support project recovery actions.

Tips

- No longer assigning the 'best' available resource to a task will be a difficult mindset for some project teams and expert resources alike. Spend enough time to ensure that the team understand why this is an important step (i.e. to free up the experts) and the global benefits it will bring.
- Having management available every day is key. The focus must be on supporting and taking recovery actions. Avoid spending time on actions which do not promote flow.

Rule of flow 6: **Ensure clear definitions of 'done'**

Ensure the project scope is clearly documented and communicated, and all tasks have clearly defined criteria for handover and completion ('done').

It is important to begin with the end in mind. When there is no agreement over what 'good' looks like, the handover requirements cannot be clarified. This leads to mistakes, rework, misaligned priorities and missing kit items, which can cause delays and disruptions to flow. It also leads to resources not handing on 'completed' work to the next stage of the project as soon as possible – further increasing the effect of Parkinson's law. Establishing the definition of 'done' helps to ensure that activities are aligned, outputs meet expectations, and follow-on tasks start efficiently.

The 'definition of done' is used as a quality check for the team. Some aspects of the scope will be developed as the project progresses (e.g. rolling wave planning). However, before work on the next wave, tranche or phase is planned and executed, the scope and 'definition of done' need to be agreed and documented.

Actions to take

- Create 'definition of done' statements for tasks and use them to make project plans more robust and realistic.
- Write task descriptions and task activities as outcomes or 'done statements'.
- Produce clear lists of what outputs are required for a task (to be marked as 'done') and make them part of the full kit for handover to the next task.
- Assign clear owners for the work, for both completing and receiving it.
- Schedule and prepare task handovers. Ensure that each handover communicates accurate and reliable task-relevant information to the team or resource receiving it.

Tips

- It takes practice to switch mindsets from 'What actions do I think we need to take to complete the work?' to 'What does it look like when it is done?' Create a safe space for team members to describe the requirement and then reword it into 'done' statements. The extra time invested in achieving better alignment in planning is tiny compared with the benefit: the increased speed and improved quality gained in execution.
- It is important to validate both sides of 'done'. Make sure that both the receiver and the giver are aligned with what 'done' looks like. A handover has not been completed until both parties agree it is 'done'.

Rule of flow 7: **Plan for uncertainty**

The rolling wave plan has logically linked tasks of the right size. Position visible buffers to protect the plan from uncertainty and changes to it in execution.

Projects and programmes can be very long, and trying to predict far into the future is difficult. When project plans are too long and too detailed, uncertainty grows and the plans become unusable and unmanageable, and repeatedly need replanning. This does not support good execution.

Critical chain uses the established practice of rolling wave plans but adds buffers to manage the uncertainty and focus on execution and not on (re)planning. Rolling wave plans are particularly important on truly one-off projects where a project template is not available. In recurring projects, a template approach can negate the requirement for rolling wave plans.

When projects and tasks last too long, two behaviours in execution must be avoided: Parkinson's law (when tasks fill the available time without a focus on completing and handing over the task as soon as possible) and student syndrome (when time is wasted due to starting late, in the belief that there is plenty of time to complete the task). These behaviours arise when a project's safety time (the additional time assigned to protect the task's due date) is held at the task level and contained within the task's estimated duration, as is normal on non-critical-chain projects. These behaviours result in the safety time being wasted, jeopardising the project's on-time completion.

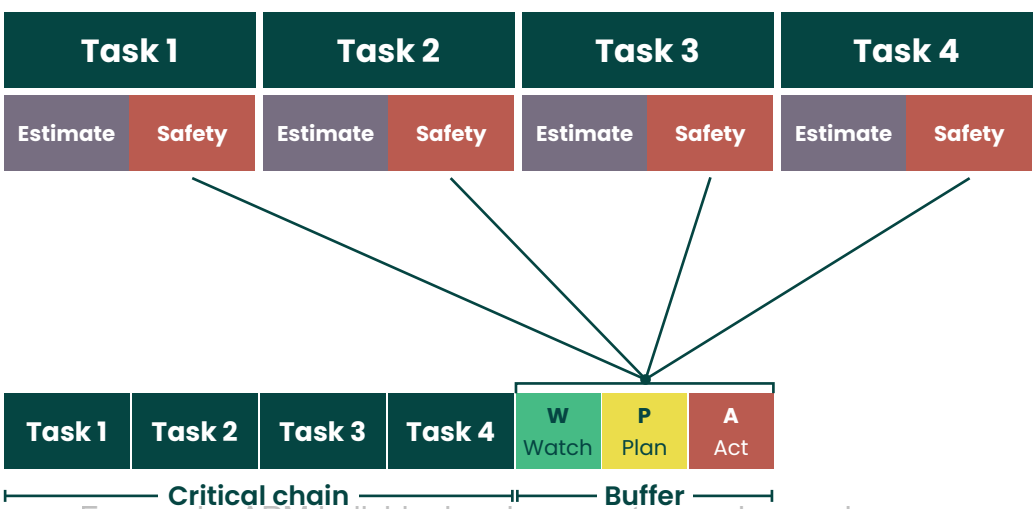
Buffers need to be positioned to protect the overall project and its due date – not individual tasks. Long projects and programmes need to be broken into separate, executable phases of between three and six months.

Actions to take

- Size projects in distinct phases of three to six months.
- Keep the separate phases synchronised at a higher level of planning. Compile high-density plans in the short term and low-density plans in the long term.
- Schedule subsequent phases in advance, before the current phase ends.
- Create a simple, robust schedule for each phase.
- Build the project plans with the wider project team.
- Assign the optimal level of resources to each task.
- Keep tasks at a good level of granularity – in the range of 5 to 20 days in terms of elapsed duration.
- Insert a project buffer at the end of the critical chain to protect the project from uncertainty, and insert feeding buffers ahead of key integration points.

Estimation can be done using various techniques (some very statistical and mathematical). Three practical approaches are recommended:

1. Best case in a three-point estimate (see *APM Body of Knowledge 7th edition* (Association for Project Management, 2019, section 4.2.6)).
2. Historical reference critical path technique:
   a. Halve the original task duration estimate based on historical reference data or current critical path practice.
   b. Add a quarter of the original task duration (half of what has been taken out of the task duration) as a buffer at the end of the critical path/chain. Due to the concept of risk aggregation, not every task will need the full protection. (This uses the same principle as home or car insurance premiums, which are less than the cost of rebuilding a house after a fire or replacing a written-off car, because most insurance holders will not make a claim.)
3. Optimal conditions estimating technique, informed by experience:
   a. Ask the people who are best placed to estimate task duration how quickly a task can be done under the following conditions: safely, to the right quality standard under optimal conditions, with no interruptions, with full kit provided, with clear definition of 'done', and with experts and managers available to resolve issues. It also needs to be clear that people will not be penalised if the task is not completed within this duration (there is a buffer which can be used if required). A punitive culture around late task delivery results in people understandably adding their own safety buffer within their task duration estimate. In critical chain, task due dates are not commitments. However, project due dates are hard commitments to internal or external customers. These commitments are protected by the buffer in the schedule in cases when task durations don't achieve their 'optimistic duration estimate'.
   b. Add half of this optimistic but achievable task duration as a buffer at the end of the critical path/chain to protect the project.



Tips

- Internal or external stakeholders may find the buffer too large (a third of the project duration as illustrated in the critical chain buffered schedule at the bottom). The diagram can be used to explain how the buffer was extracted from safety time for each task and only half the amount of safety time extracted from the original schedule is now required to protect the critical path/chain (i.e. the size of the buffer at the bottom schedule is only half the duration of all the safety blocks added up in the top schedule).
- No single person has or can have the necessary knowledge to properly build a robust project schedule on their own. In addition, there will be the need, in execution, to try to recover some time when delays are experienced, buffer is consumed, and recovery actions need to be taken. This is very difficult when project team members have no buy-in to the schedule and its original durations, dependencies and assumptions. Representatives from all areas of the business who will be affected by the project should be part of a cross-functional planning team.
- The purpose of a good plan is to accelerate execution. The aim is to have a schedule which adequately reflects reality but is not too detailed to make understanding and maintaining it difficult. It needs to be 'good enough'.
- There will be a significant temptation to pull forward similar work from future phases to try to gain efficiencies by batching it together. Work may also be pulled forward to drive earned value management metrics on hours worked or to achieve milestone payments sooner. Resist doing this without carefully considering the impact! Pulling work forward increases WIP and multitasking, diverts attention and capacity away from completing the current phase, and significantly disrupts the flow. Focus on the flow and the critical chain of each phase for best results while considering the project's goal.

Rule of flow 8: **Focus on the constraint/ integration point**

Stagger the projects in the portfolio to synchronise resources and ensure they are not overloaded.

In multi-project environments (or multiple workstreams in a project), the pace of completion is not determined by resources and their capacity. The pace is determined by the legs of the project faultlessly coming together at integration points (e.g. final assembly, testing, a key process on high-value equipment of which there is only one). If one or more issues are found during this integration, not only can the project suffer significant delays, but very often the resources needed to rectify the problem may be unavailable as they are assigned onto other projects.

Critical chain appreciates the significance of the integration point as a constraint that determines the flow of work to project completion. That is why the work needs to be released in a staggered manner to optimise the flow of work reaching the integration point (i.e. the constraint). For example, the aircraft fleet plan is optimised to prevent several aircraft coming in for maintenance in a sequence that overloads key resources (e.g. if avionics test equipment or specialist avionics resource is limited).

Actions to take

- Identify the key integration point (or a part of the integration phase) to smooth the loading.
- Agree a WIP limit for integration. Where the WIP limits are violated, stagger and smooth the projects out to the future until there is no WIP violation.
- For all projects, review the integration tasks and place these, in project priority order, on a timeline.
- Give these projects new, staggered due dates based on the integration smoothing and the planned timelines.
- Only release projects according to the new staggered plan.

Tip

Check that the actions to stagger work across integration points are achieving the desired effect. The aim is for a 'roughly right' indicator. Temporary levels of high load for resources can be absorbed by the project buffers. A continuous level of high load indicates that additional smoothing is required at integration.

Rule of flow 9: Focus on remaining duration (the past is the past)

Report the remaining duration of all (open) project tasks every day. Identify where and when to actively manage with fast recovery actions.

In execution, to answer the question 'When will the task/project finish?', a forward-looking assessment is needed. The remaining time needed to complete the task/project is the key measure here. Non-critical-chain reporting methods capture the amount of work completed, but not necessarily the remaining duration scheduled to complete the work.

Too often, the progress on a task is not linear; the last 10% of a task or project can take as much time as the preceding 90%.

To have a true understanding of the health of a project, the estimated time required to complete the remaining work (relative to the project deadline and the remaining buffer protecting it) is the only information that matters.

Actions to take

- Capture the remaining duration of time required for all open critical chain/path tasks on each project each day to determine how much of the project buffer has been consumed to date.
- Calculate how much of the critical chain has been completed.
- Compare the critical chain completed against the buffer consumed to date. The target is that the percentage of buffer consumed should be less than or equal to the percentage of the critical chain that is complete. If at project completion all the buffer is consumed, the project has still been delivered on time.
- Excessive buffer consumption (when the percentage of buffer consumed is more than the percentage of the critical chain that is complete) provides an early (red) warning that urgent recovery action is needed to:
  - remove the cause of the need to consume buffer
  - accelerate the open tasks to recover the buffer.

Fever chart

The fever chart maps at regular intervals the buffer consumed (days of buffer consumed as a percentage of the total buffer time in days) and the position along the critical chain (days of critical chain completed as a percentage of the total critical chain duration in days). This chart is normalised and will look the same for every size of project, providing a familiar and consistent view of progress and schedule risk to senior managers, project managers and the project team.

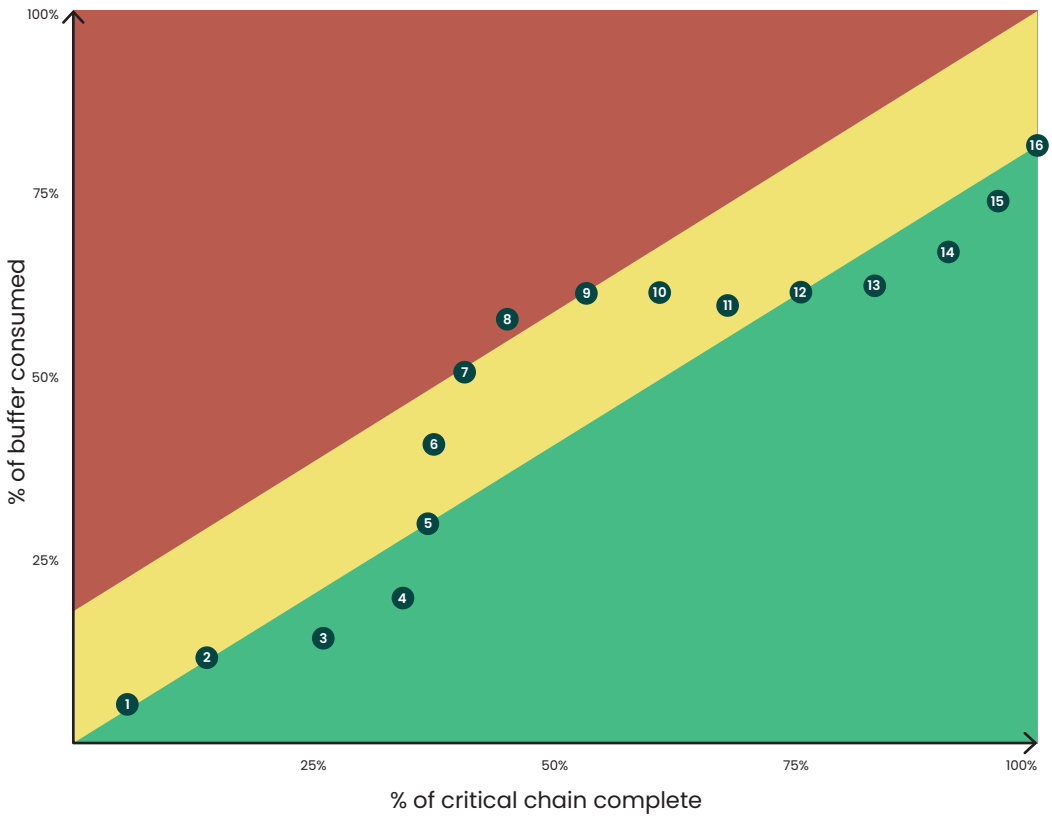


Figure 2 Fever chart

Tips

- Making the buffer status of all projects visible, live and commonly understood is key to to driving good behaviours, facilitation of teamwork, and proactive problem solving.
- Once the red/yellow/green status is available for projects and their tasks, project teams and management can plan their support and interventions:
  - Green: Good probability of completing on time or early. No action required. There may be an opportunity to complete early or to slow the project down to assist a red project.
  - Yellow: At risk of not completing on time. Proactively prepare for recovery, should this trend persist.
  - Red: At great risk of not completing on time. Take recovery actions immediately.
- When a project does trend into the red, do not spend time on who is to blame nor on any post-mortems during execution. Focus instead on the recovery actions. Post-mortems and lessons learned can be completed later, once the project is back on track or, better yet, when it has been completed on time. It is, however, important to capture the reason for buffer penetration for later analysis of common trends.

Rule of flow 10: Measure to drive the right behaviours

Replace local efficiency measures that do not support flow with different measures aligned to deliver the project on time.

It is well documented that measures drive people's behaviours. When there are too many or contradictory measures, project team members' behaviours may be contrary to those desired. By setting measures that support the delivery of the critical chain, project delivery can be improved.

The success of projects and project improvement is linked to people's behaviour just as much as it is to the tools and methods deployed. Many undesirable behaviours stem from a (very desirable) intent to control or reduce costs. When projects and tasks are delivered fast and delivered on time, costs are controlled and reduced. Improving flow and increasing system output are key to driving down costs.

Ensure the measures are consistent with the desired adherence to the rules of flow and critical chain principles. For example:

- Rule 1: a 'WIP' measure.
- Rule 2: a percentage 'full kit-enabled work' measure.
- Rule 9: a 'buffer consumption relative to critical chain completion' measure (fever chart).

Actions to take

- Identify measures to stop recording because they are damaging flow, work in progress and the on-time completion of projects. These are usually:
  - resource activity measures: activity does not equal progress
  - project date priorities: soonest does not always equal most urgent
  - task date priorities: these drive student syndrome and Parkinson's law
  - local cycle time: improving local performance does not always improve global performance
  - cost measures: the aim is to increase output, not just to reduce costs. In some cases targeted additional spending may even be justified on critical path/chain key resources (e.g. overtime) to avoid costly delays

- Introduce measures that promote flow and on-time completion of projects, for example:
  - work in progress levels: how much work is currently being progressed
  - remaining durations: estimate of time it will take to complete the work
  - buffer status: how much of the buffer has been consumed in relation to the amount of the critical chain of work being completed
  - status of recovery actions: speed of completing recovery actions
  - full kit compliance: percentage of work which is released with full kit as a percentage of all the work released
  - throughput: output of completed work over a given period
  - integration/constraint performance: degree to which the integration point/constraint is overloaded or underutilised
  - delivery date performance: percentage of milestones completed on time

Tips

- Positive reinforcement is far more effective than negative reinforcement:
  - Seek to find examples of the desired behaviour and openly praise (micro-reward) people as soon as the desired behaviour is observed.
  - People like to be told they are doing a good job and will modify their behaviour to seek praise if they know that praise is available.

3 Part 3: For the project team

For the project team, it is important to follow a structured process when introducing critical chain, such as the five-step deployment strategy in Part 2 on page 16. The key ingredients of successful deployment and sustainment are to ensure the roles and responsibilities are clear, that people receive the right training, and that tools and measures are changed to enable the new ways of working.

Roles and responsibilities

A number of roles focusing on key critical chain activities need to be owned by specific people on the project. These do not necessarily need to be additional resources and often align with existing roles.

Table 3 Roles and responsibilities

Role	Responsibilities
Senior manager as the business change project sponsor	To advocate for new ways of working with stakeholders (both internal and external to the project). Point of escalation for recovery actions.
Project manager	To be the key advocate for implementing critical chain in the way the project is run and to live by the critical chain principles.
Business change implementation manager	To plan and manage the implementation of critical chain on the project. The key role is to deliver successful adoption of critical chain.
Full kit and release manager	To ensure the highest possible degree of full kit before work is released. To release work based on priorities set by the critical chain principles to optimise utilisation of resources and release non-full-kit work by exception only.
Trainer and coach	To provide the organisation with the internal capability to implement critical chain on a given project and future projects. To build internal capability to sustain the new way of working in the long term.
Critical chain implementation steering board	Cross-functional group of senior stakeholders who meet regularly (e.g. fortnightly or monthly) to discuss progress against a critical chain business case and implementation plan, resolve obstacles to implementation, and support the sponsor and implementation manager in achieving the benefits.

Training and coaching

Training and coaching are often required to ensure that the organisation is equipped to deliver projects using critical chain.

Training: The key to effectively upskilling an organisation is to ensure that external trainers 'train the trainers'. Internal trainers should subsequently deliver the training internally. This also helps to sustain it in the long term. It is highly recommended that organisations initiate a retraining programme every two years to ensure behaviours are sustained and changes in leadership and team members do not dilute the approach.

Coaching: Especially during the pilot phase of implementation, coaching is critical to ensure that the right behaviours are embedded. This is valuable for project managers, especially coaching on how to conduct short and effective daily project update meetings. Coaching is also key for senior managers to ensure a relentless focus on recovery actions when the buffer starts to be consumed at a high rate. For long-term sustainment, an enduring coaching capability needs to be maintained by identifying and upskilling critical chain experts and providing them with coaching skills.

Technology and tools

The planning aspects, especially the visualisation of the buffer and buffer consumption, can benefit from technology and specialist tools. These also help to embed the solution and reinforce behaviours. However, it is important that a critical chain introduction does not become technology led. Proving the techniques without technology (even by just using a whiteboard, for example) can help to reinforce that critical chain is about behaviours in execution, and is not just a different way of planning. Some critical chain rules of flow can be implemented using existing technology (e.g. reporting on the percentage of tasks with full kit).

Key requirements for tools to support critical chain in planning and execution are as follows:

- ease of high-level network planning (right-to-left, sometimes referred to as 'pull planning'), and converting this into a schedule
- ability:
  - to add a schedule buffer at the end of the critical path/chain
  - to add feeding buffers at non-critical-chain integration points in the schedule
  - for tasks to consume buffer if the forecast duration exceeds the planned duration
- ease of creating a visualisation of the buffer and buffer consumption (fever charts)
- ease of updating the remaining duration and automatically updating the fever charts

Kendall and Austin (2012) devote two chapters to software requirements for critical chain: requirements for planning (buffers, global resources and alignment) and execution (buffer and role-based views).

Ease of use is a primary requirement to support adoption, especially during execution.

A simple spreadsheet (e.g. in Microsoft Excel) can visualise a fever chart of buffer consumption with four pieces of source data:

- percentage buffer consumption (days of buffer consumed divided by days in total buffer)
- percentage critical chain completed (days of critical chain completed divided by total number of days in the planned critical chain)

Where MS Project is used, a plug-in called Fusion Desktop, by ProChain, can show traditional and more optimistic buffered views of the same schedule (see prochain.com).

It may also be possible to adapt current planning tools to visualise the buffer and buffer consumption, for example by extracting data and using a preferred visualisation tool, such as Microsoft's Power BI (microsoft.com/en-gb/power-platform/products/power-bi) or Tableau (tableau.com).

For a comprehensive implementation of critical chain across a multi-project, multi-user, collaborative team, a dedicated server-based tool is more appropriate. Enterprise tools include Exepron (exepron.com), Fusion Online by ProChain (prochain.com) and Aurora by Stottler Henke (stottlerhenke.com). Several other options are available.

Measures, behaviours and practices

Certain measures may result in motivating inappropriate or conflicting behaviours. For example, earned value management measures do not distinguish between 10 hours of progress on a critical chain task and 10 hours on a non-critical task. Nor does EVM encourage 100% completion to ensure the next task in the chain can progress. Starting a new task, rather than 'focus and finish' a critical chain task, gives the same measure in terms of earned value.

A more aggressive plan, with a protective buffer at the end of the project, will work only if people are not penalised for not meeting the estimated task durations. A more supportive servant leadership approach is required:

- to ask about root causes of predicted delays and to offer assistance to address the root causes
- to reduce the drivers which result in multitasking and get back to a 'focus and finish' approach
- to provide support and remove obstacles (in terms of approvals, materials or information provision)

If these do not recover the forecast buffer consumption, it is best to accept that some of the buffer will be consumed without judgement … that is what the buffer is for!

In addition to task progress metrics, there are other measures which drive the right behaviours, such as the percentage of released tasks that have the full kit to complete the task without interruption.

Reviewing flow-based measures during daily stand-up meetings (DSUMs) helps to drive the right behaviours. DSUMs should be kept short (15 minutes as a guideline) by using 'managing by exception' principles and focusing only on live critical chain tasks.

Scaling up and influencing the project context

Although a pilot approach is recommended for introducing critical chain, it works best if critical chain is scaled up and applied across all projects in the organisation. This helps with resource management, as it is difficult to de-conflict key resources when resources are assigned to both critical chain and non-critical-chain projects or operations. It is also important that priorities set by critical chain for materials and supporting functions are not competing with other prioritisation rules on non-critical-chain projects.

It is important for organisations to change their policies, procedures, and sometimes contracts, to embed the critical chain way of working. It may be necessary to adjust measures and incentives which drive people to go against the critical chain principles.

When starting a pilot project, it is recommended to brief the wider group of senior managers early in the process and to share early results to foster buy-in. A proactive communication campaign to identify opportunities and share lessons learned can help to drive organic adoption. Top-down leadership from the project management function can make sure that the enablers for success and wider adoption are in place, such as updates to functional guidance, training and toolsets.

So what next? A call to action

1. Be curious and explore the available resources.
2. Talk to people who have implemented critical chain. APM (apm.org.uk) and TOCICO (tocico.org) can introduce you to experienced practitioners.
3. Seek external training and coaching for your first implementation.
4. Identify an area to pilot the approach.
5. Get started! Apply the 10 rules of flow and learn by doing. The positive results will show very quickly if the rules are applied well.

Appendix: Mapping critical chain to key elements of the *APM Body of Knowledge*

The *APM Body of Knowledge 7th edition* (Association for Project Management, 2019) *(APM BoK 7)* contains content on both critical chain and critical path planning and scheduling (sections 4.2.5 and 4.2.6). Table 4 describes some key critical chain points worth highlighting in the wider context of Chapter 4 ('Planning and managing deployment').

Table 4: Key critical chain points

APM BoK 7	Key considerations when implementing critical chain
4.1 Defining outputs • Success and benefits • Objectives and requirements • Options and solutions • **Scope** • **Quality planning**	**Scope and quality planning** The focus on accelerating the flow of work highlights the importance of scope and quality, which go hand in hand. To ensure that the work flows through the delivery organisation, with multiple handoffs along the critical path/chain, the 'definition of done' at task or work-package level needs to be clearly understood. This is true for the people doing the work as well as for the people receiving the output to use in the next part of the workflow. Having good-quality inputs (full kit) before releasing or starting work enables the task to be completed faster without interruptions. That is why quality control on full kit and 'definition of done' is crucial to achieving a smooth flow of work.

4.2 Integrated planning • Contract award • Risk identification • Risk analysis • **Estimation** • **Scheduling – critical path / critical chain** • Resource optimisation • Cost planning • **Contingency planning** • Deployment baseline	**Estimation and contingency planning** Estimating durations: Using three-point estimates in planning is excellent for building confidence and for surfacing assumptions and uncertainty. In critical chain, the optimistic estimated values (best case) are used first and then contingency is inserted as a buffer (see pp.172, 174 and 176 of *APM Body of Knowledge, 7th edition* and p.148 of APM's *Planning, Scheduling, Monitoring and Control*). This is not for ease of planning but is rather a crucial tactic for when the project is deployed and is in execution. Removing the contingency from the task level and aggregating it into buffers reduces the effect of student syndrome and Parkinson's law on project resources and provides superior safety to the project timeline and due dates, ensuring faster execution. In cost-estimating a critical chain project, an additional contingency account might be needed to cover the time buffer when project resources are costed to a project's budget. This is because, as the buffer is used, a task may use more resource and so increase cost. It is very unlikely that all project resources will have the same time-cost value, and so the contingency needs to cover both the use of buffer time and the differences in rates. **Scheduling – critical chain** In *APM BoK 7*, a short description of critical chain focuses mainly on its scheduling aspects. This guide expands on other aspects beyond scheduling, to ensure that critical chain implementations succeed.
4.3 Controlling deployment • **Progress monitoring and reporting** • Contract management • Risk management • **Contingency management** • Issue management • Change control • Configuration management • Quality control	**Progress monitoring and reporting – remaining duration** The key elements required for any performance measurement are 'baseline, performance data, assessment and implications' (see p.190 of *APM BoK 7,* and p.223 of *Planning, Scheduling, Monitoring and Control*). In critical chain, especially when it is crucial to meet the project due dates, this is done by reporting a daily assessment of the time left on each of the open tasks (i.e. the remaining duration of each activity at 'time now'; see p.314 of *Planning, Scheduling, Monitoring and Control*). This information allows for the best understanding of the implications on the health of the project tasks, project chains, the project buffer and, ultimately, the completion date. **Contingency management (schedule)** Visual buffer management (see pp.172, 174 and 176 of *APM BoK 7*): in critical chain project management, prior to drawing on management reserves (protection for the unknown unknowns), the project contingency (protection for the known unknowns) is separated and measured visibly by identifying how much buffers (see p.164 of *Planning, Scheduling, Monitoring and Control*) are consumed relative to the progress of the project. This serves as a first line of defence, aligning focus and priorities in execution to ensure project progress is in line with contingency consumption. When risk or delays occur, the buffer is depleted. This depletion provides an excellent focus and quantification for how much recovery is needed to bring the project back on track. If buffer recovery actions are taken sufficiently early during execution, projects rarely need replanning or redating.

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