Critical Chain Project Management

Will you dare to finish all your projects on time?

- Training material -

Marris Consulting

Online, 10th - 12th of May 2022

Version 1.0

Extract

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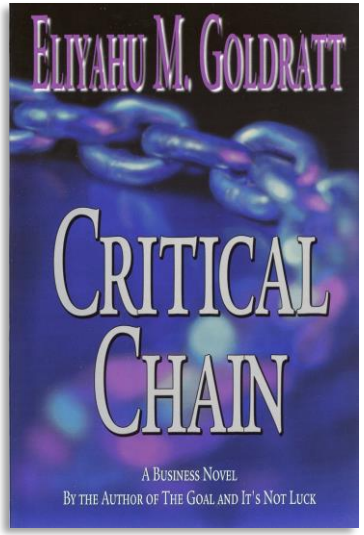

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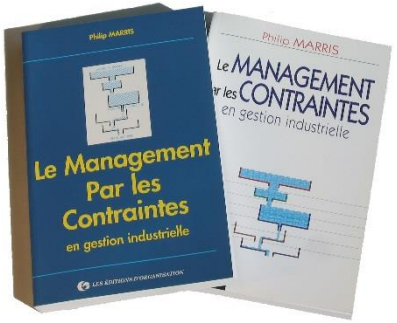
Training facilitator: Philip Marris, CEO of Marris Consulting, ToC & Lean expert, >35 years, >270 projects

- Consultant (warning!).
- Theory of Constraints specialist. 35 years of ToC experience. Started working with the founder Eliyahu Goldratt in 1986. >35 year-experience of Lean (Manuf. & Engineering)
- >35 years of experience helping over 270 companies in all industries.
- Over 50 assignments in project environments especially New Product Development & MRO (Maintenance Repair & Overhaul).
- Author of the very boring but bestselling French textbook about ToC in manufacturing *Le Management Par les Contraintes.*
- Author of numerous articles. Over 10 conferences a year worldwide.
- Administrator of several LinkedIn discussion groups. Creator of the French website chaine-critique.com and curator of several Critical Chain, ToC, "ToC + Lean + Six Sigma" news websites.
- Founder and CEO of Marris Consulting based in Paris, France. Founded in 2004. Motto: *Factories, People & Results*.



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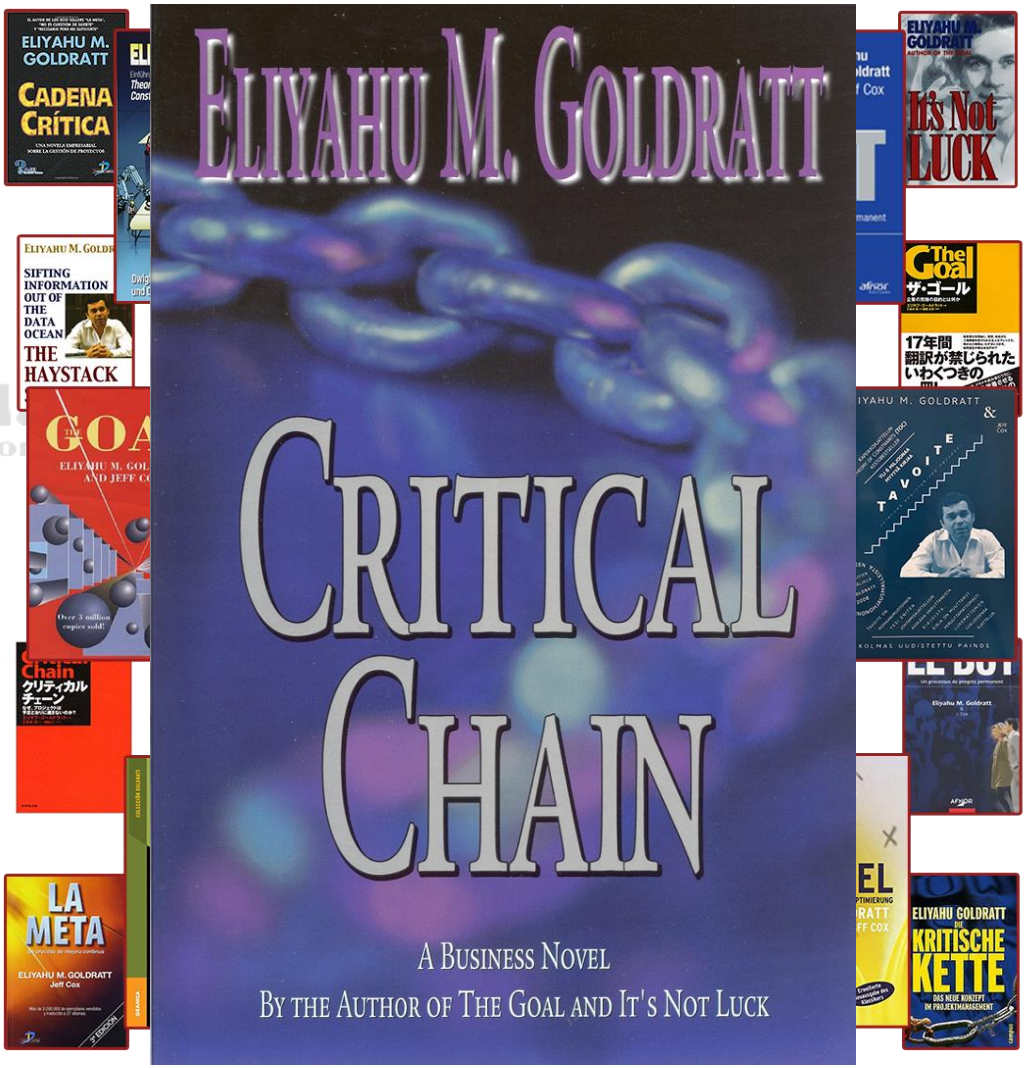
A first novel dedicated to production: *The Goal*… and later, a novel dedicated to project management: *Critical Chain*

The Goal:

- Over **7 millions** copies sold worldwide
- Translated in **32 languages**
- Chosen as one of the 25 most influential business books by **Time Magazine** in September 2011.

Critical Chain:

- How to apply the principles of the novel *The Goal* to the world of projects?



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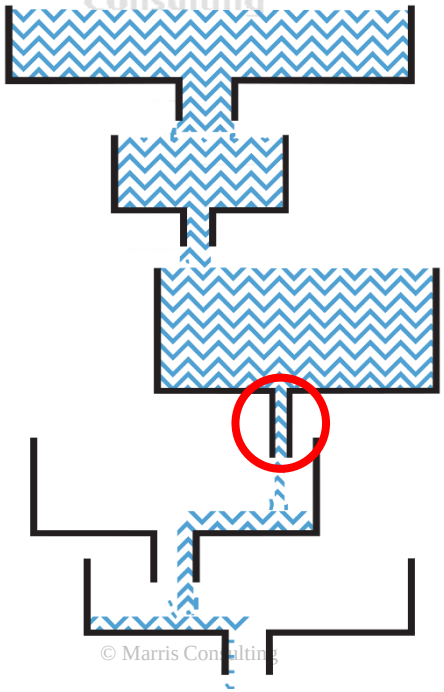
Focus on improving the system constraint that determines the overall performance

It is no longer possible to distribute work equitably: organizations are necessarily unbalanced

- Companies (factories, engineering departments …) and other organizations inevitably have unbalanced capacities.
- Annual budgets pretend to balance organizations but they don't succeed.
- There is always a constraint somewhere in the system.
- One hour lost on that constraint (the bottleneck)
  = one hour lost for the system = one hour of lost sales.
- One hour gained on a non-bottleneck is an illusion. A non-constraint must only work according to the constraint's requirements.
- A dual view is mandatory: different rules for constraints and non-constraints.



The sum of local optimums is not equal to the global optimum

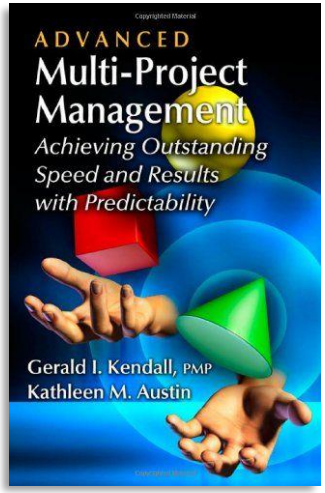
Over the past 15 years, Critical Chain has demonstrated its ability to greatly improve the performance of project planning and execution

- Critical Chain Project Management (CCPM) enables organizations to finish their projects on time, without budget overruns nor loss of initial specifications.
- Furthermore CCPM can, simultaneously, significantly reduce project durations and increase the efficiency (productivity) of the resources involved.

Results	Average	Worst case	Best case
Project duration	-39%	-13%	-78%
Number of projects completed in a given time	+70%	+15%	+222%
Throughput	+53%	+14%	+150%

Source: "Advanced Multi-Project Management Achieving Outstanding Speed and Results with Predictability" 2013 book by Gerald I. Kendall & Kathleen M. Austin, page 95. The analysis is based on public information available concerning 60 different organizations working in different industries that had applied CCPM.

See appendix for a list of cases. A more complete list is available at www.chaine-critique.com



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Traditional Project Management is widely used…and doesn't work well

- Project success, in terms of delay and cost, is strongly correlated to the company maturity in project management.
- A 2012 PMI (Project Management Institute) study estimates that at least 30% of projects are not achieved on time in companies with a high degree of Organizational Project Management maturity, and more than 60% of projects are late in companies with a low maturity in project management.

- Causes of delays are diverse:
  - Resources are not available on time
  - Specifications change during the project and generate additional work
  - Technology is not mastered
  - … etc.

Comparative study – Project Performance

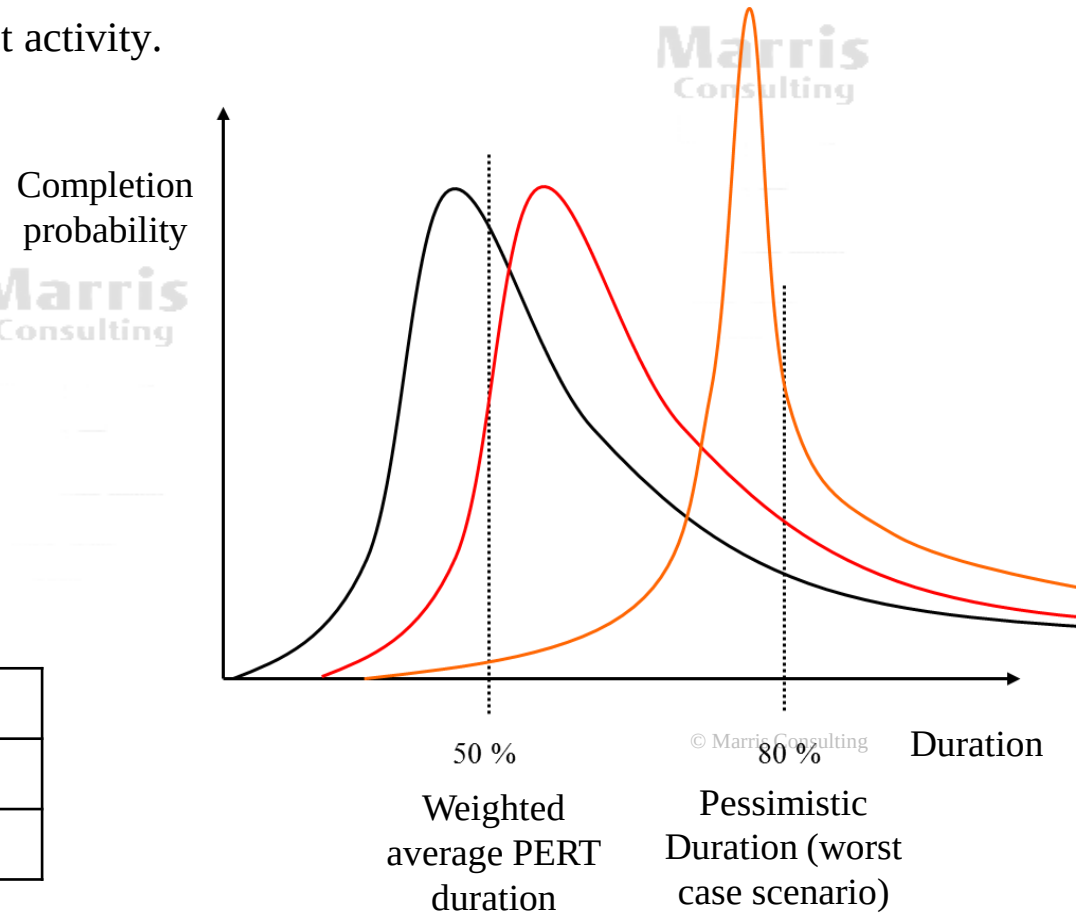
Source	%On-time	%On-scope	%On-budget
Wellington Study - The state of project management survey 2016	68 %	69 %	69 %
PMI - Pulse of the Professions 2016	49 %	62 %	53 %
P2 Consulting - Industry trends project management survey 2015	61 %	56 %	64 %
Average	**59 %**	**62 %**	**62 %**
Conclusion	About 40% of projects are late, or too expensive, or do not deliver the initial scope.		

Extract

Scheduling projects according to the worst case scenario leads to numerous disruptive behaviours

- The duration based on the worst case scenario or pessimistic durations, adopted by project managers, is often twice as long as the PERT duration.
- Thus there are huge margins built into each project activity.
- The existence of these margins results in particular behaviours:
  - Student syndrome: A difficult task or a lowly motivating task is often postponed to the very last moment, the same way a student waits until the last minute to start an assignment,
  - Parkinson's law: the work spreads out in order to occupy the whole available time.

▬	PERT Weighted average
▬	Student syndrome
▬	Parkinson's law



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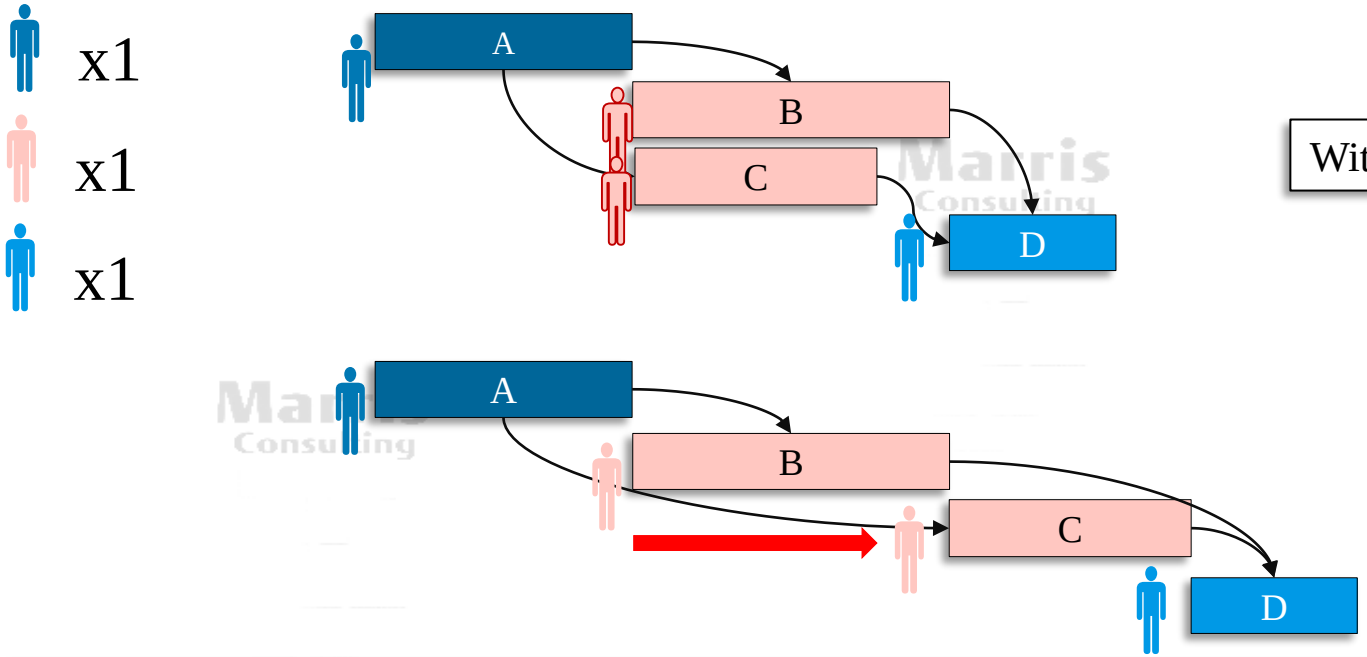
The capacity of the resources is rarely taken into account

- Levelling (*technique to adjust start and finish dates taking into account resource contentions in order to balance the demand for resources and their availability**) exists in almost every project management software.
- It is rarely used, because resources are not described in schedules, but also because levelling extends the project scheduled duration:



Levelling is yet the unique way to take into account the resource capacity

* Source: PMBOK Project Management Body Of Knowledge / Project Management Institute (PMI)

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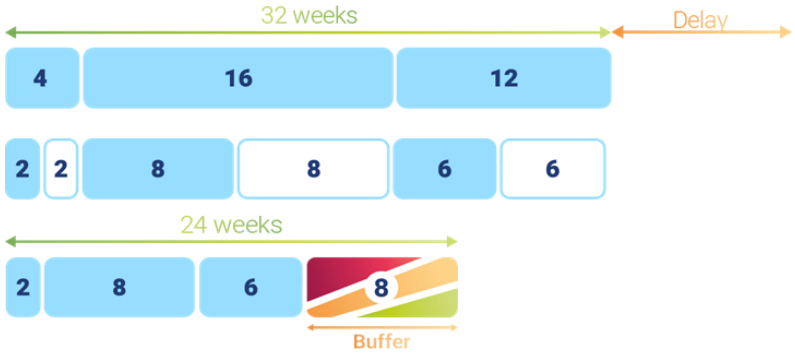

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Reminders of some good practices:

The standardization is a process of permanent capitalization of projects knowledge

- The project typology is a task networks categorization of different projects in an enterprise. The classification by typology allows you to create a standard schedule according to the project type.

- The benefits of using standard schedules are many, since they enable:
  - Not to start each new project from a blank sheet, and thus not to discover tasks during the execution of a project (all the more harmful when the project manager is a new recruit),
  - To capitalize on good practices and lessons learned from past projects (remarks, points of vigilance, etc.),
  - To improve the communication and understanding of everyone's role in a project,
  - To identify the profiles necessary for the constitution of the project team, give a realistic estimate of the deliverables delivery dates

An example of a product development portfolio (*Research, Development & Industrialization*) :

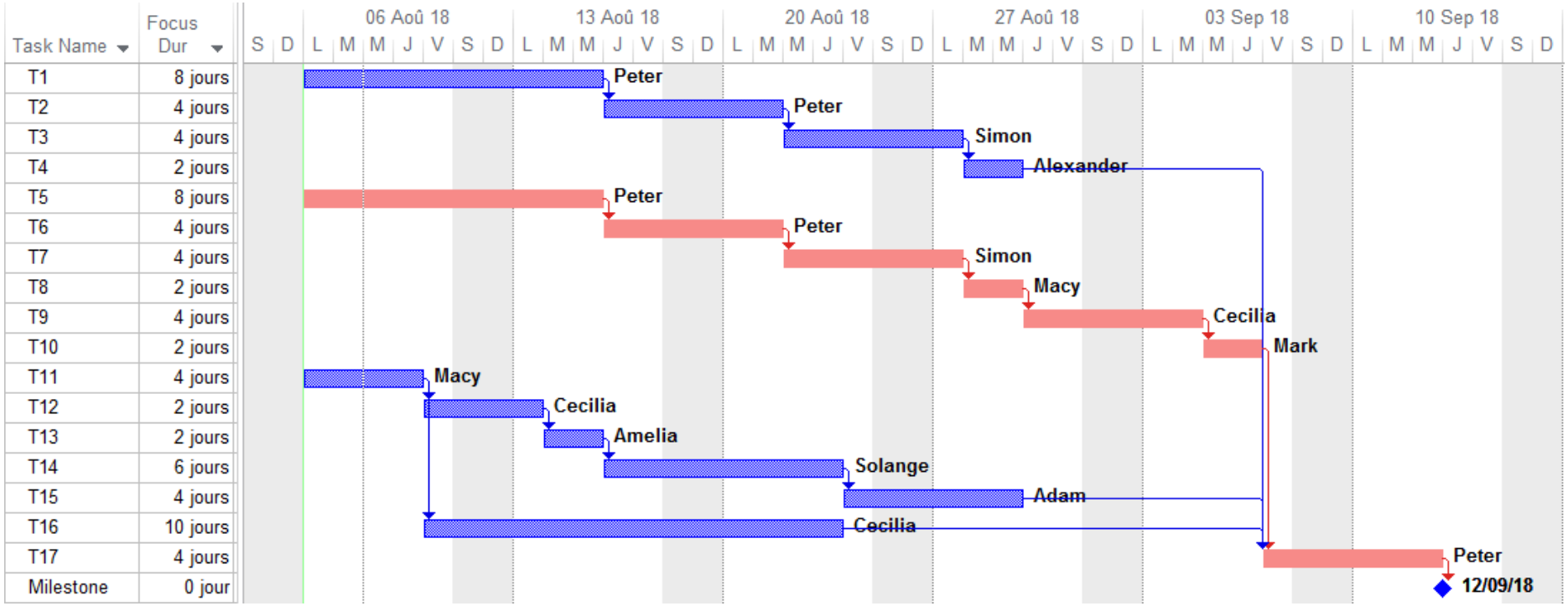
- Development of (real) new products,
- Development of a variant or improvement of an existing product
- Change of production process or material for an existing product
- Adaptation of a product to a new country
- Research / Technological watch
- Call for tenders

Having standard schedules is a more of a Lean Engineering idea than a CCPM invention

Extract

A dynamic schedule must include resources

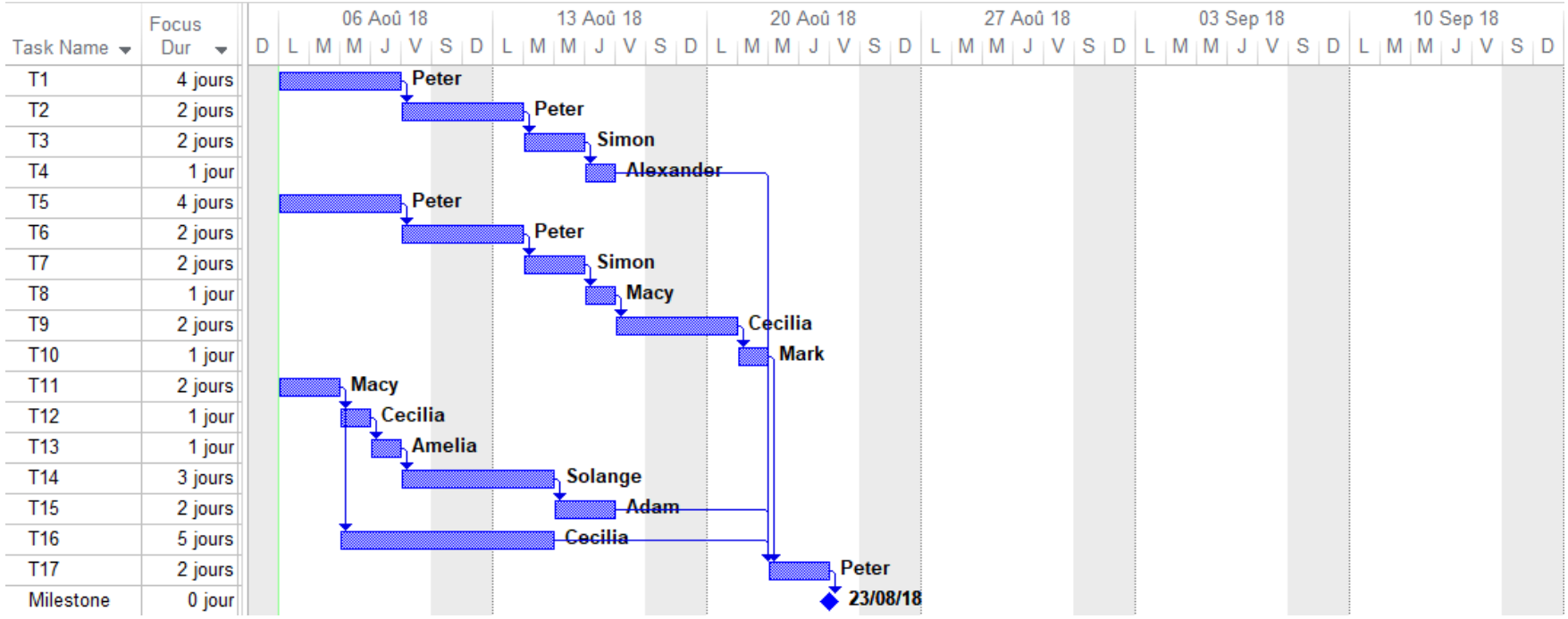
- Resources are seldom taken into account in schedules, consequently:
  - A resource can be assigned to several tasks at the same time (no levelling),
  - The critical path neglects resource constraints
- Non-critical tasks are planned to start as soon as possible.



Critical Chain Scheduling
Step 1: Delete individual margins

Extract

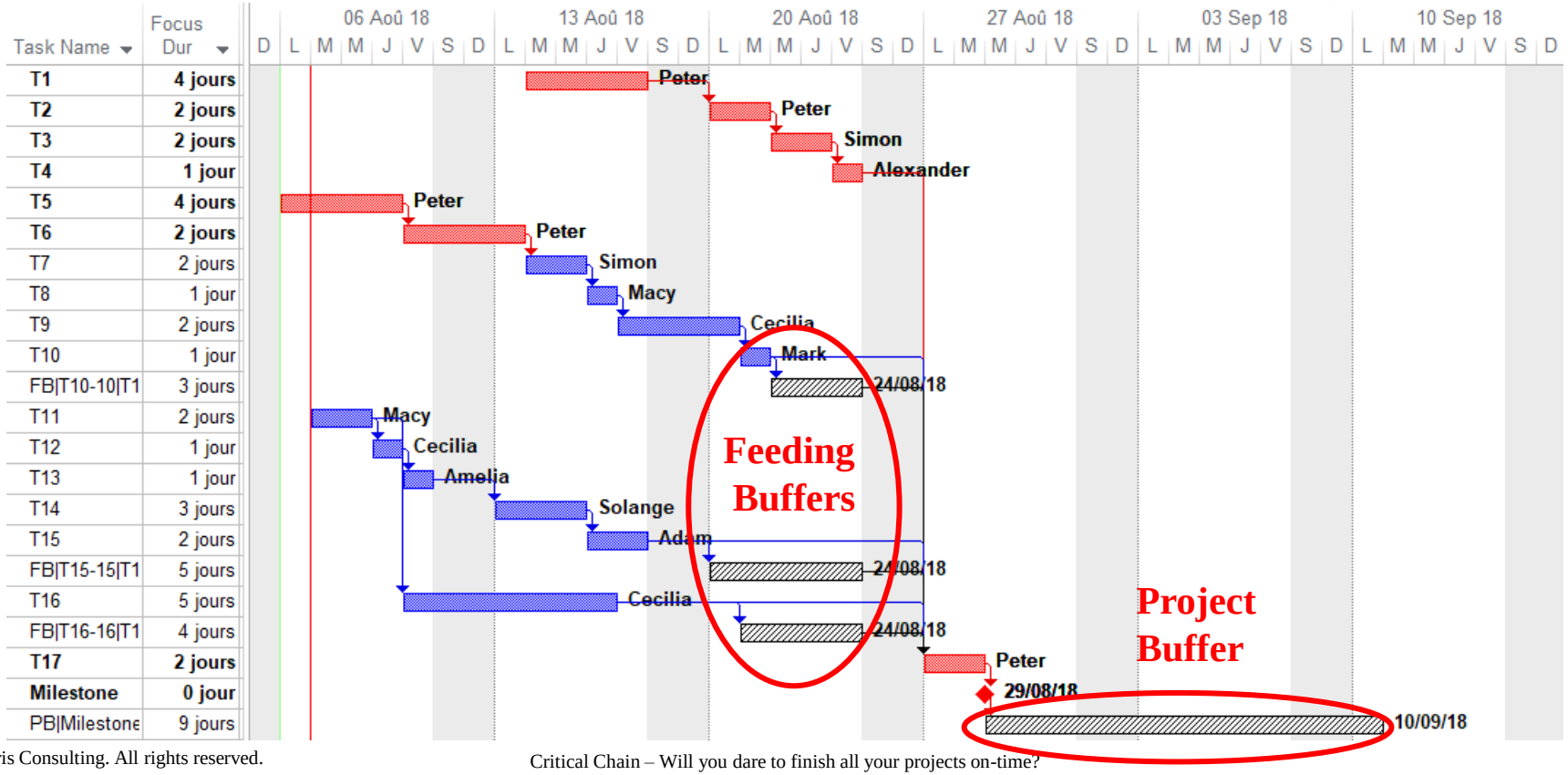
- With Critical Chain, the task durations in the schedules are so-called "focused" durations, corresponding to the working time necessary to complete the activity, without built-in safety margins.
- Traditionally, the durations used are generally equal to twice the focused durations, in theory all the durations are arbitrarily divided by 2.
- In this way, the wastage of local and individual safety margins is prevented.This way, we prevent the waste of local and individual margins.



Critical Chain scheduling
Step 5: Buffers calculation and integration

Extract

- The project buffer mutualizes safety margins of critical tasks. It represents about one third of the total project length.
- Feeding buffers protect the Critical Chain from non-critical chains/ tasks.
- Non-critical tasks are scheduled « Just-in-Time » thanks to the feeding buffers.



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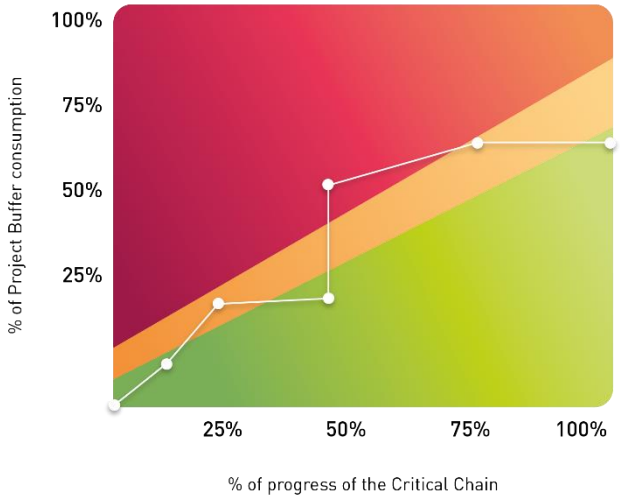

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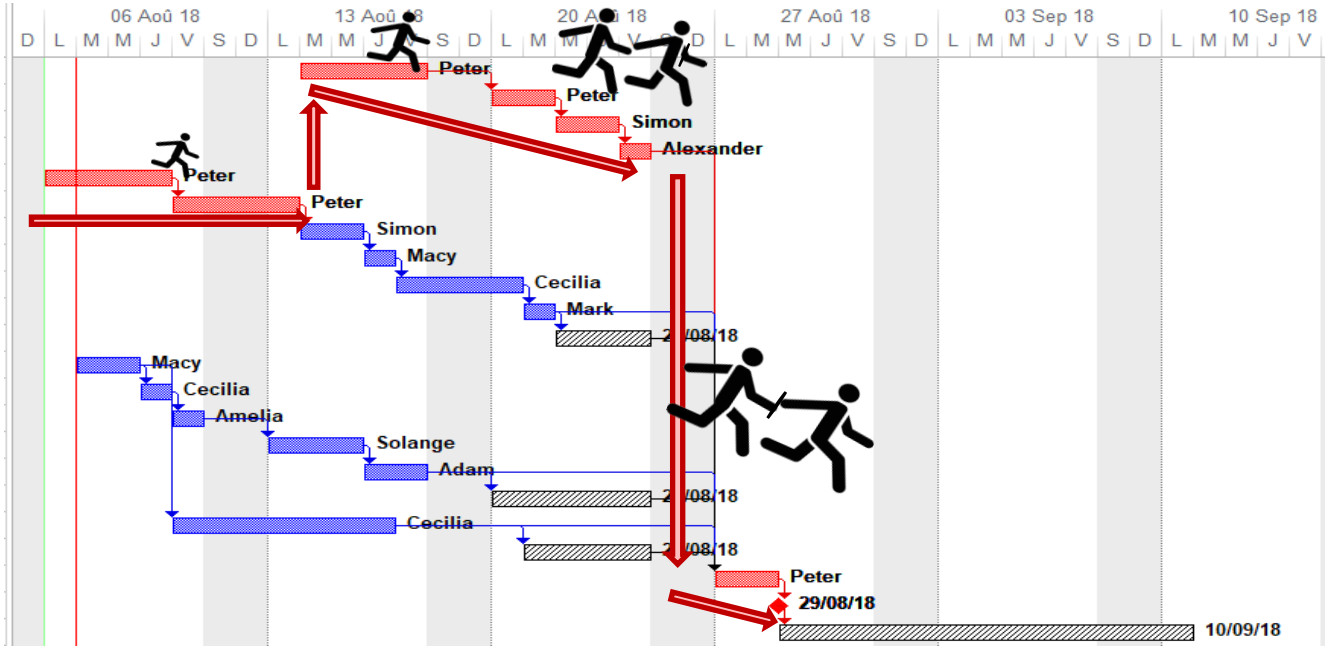
Then during the project execution, we focus on the smooth execution of tasks on the Critical Chain

- The project is carried out according to the principle of the relay race throughout the Critical Chain.
- Having a mascot (a noticeable object) enables one to follow physically the successive offices and workstations the Critical Chain passes through.



By asking less than 1% of the resources to run, it's in fact the whole company that goes faster

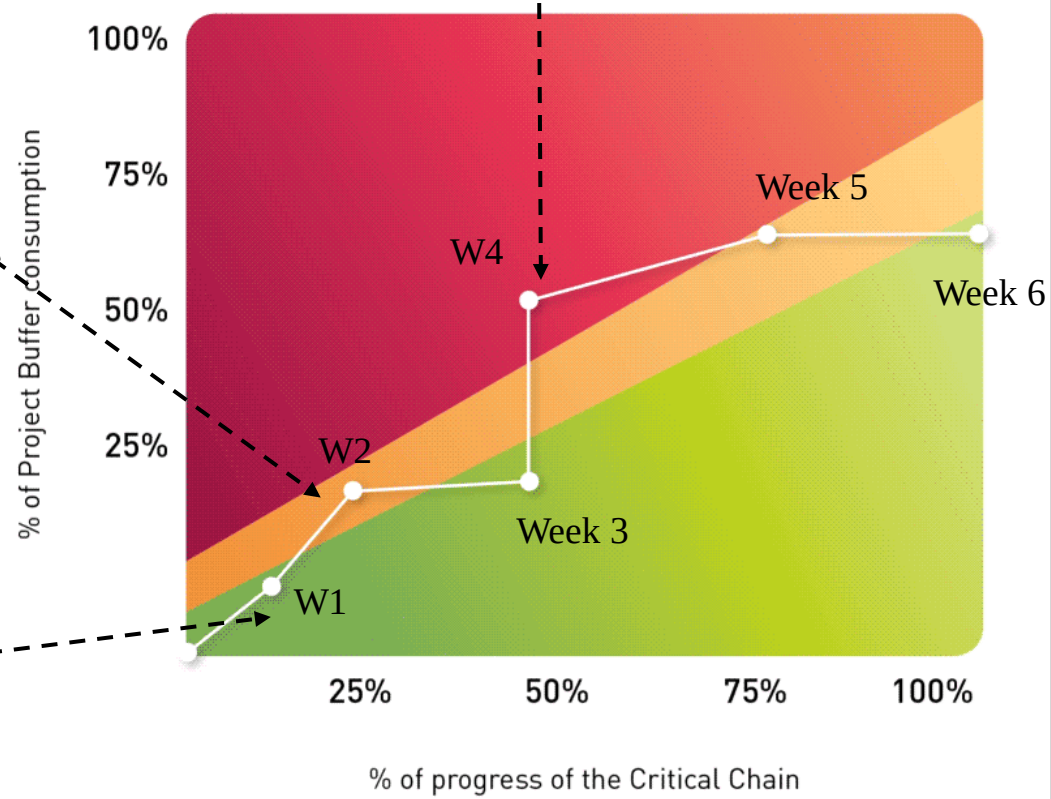
Extract

Project monitoring is much easier thanks to the **Project Fever Chart**

Red zone = risky zone
Start right now corrective actions

Yellow zone = warning zone
Identify main cause of delay and prepare action plan

Green zone = comfort zone
No action needed



Finished project with project buffer not fully consumed

This means that the project finished **before** the end date

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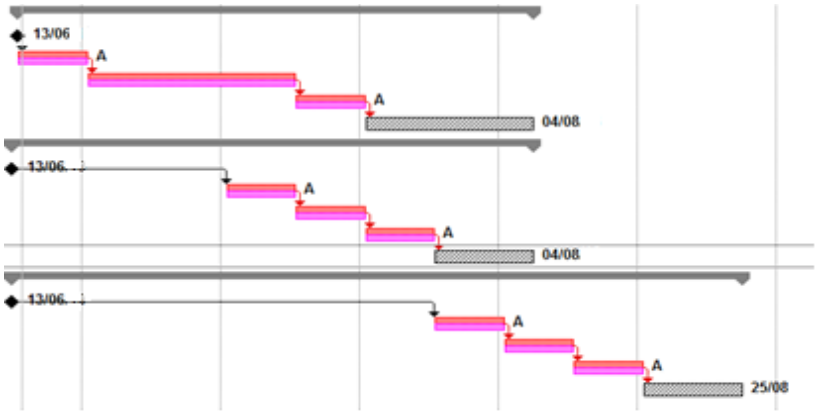

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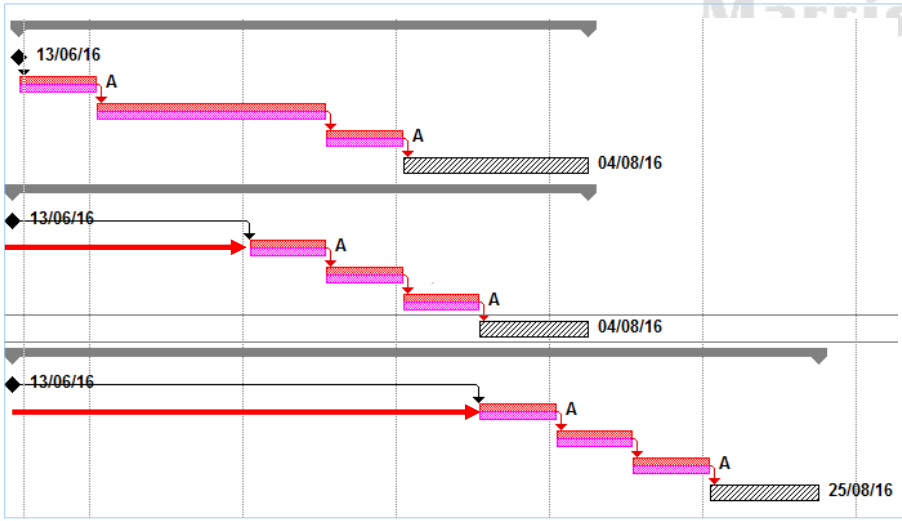
The identification of the portfolio constraint is the key to determining realistic project due dates

- A project portfolio is a set of projects for a given resource pool
  - There can't be any resource contention between 2 project portfolios

- The projects start dates within a Critical Chain projects portfolio depend on the availability of the capacity constraint of the portfolio
- Shifting the start dates of the projects according to the bottleneck is called « staggering »



The start date of the second and third projects were shifted according to the availability of the resource A which is the capacity constraint of the portfolio.

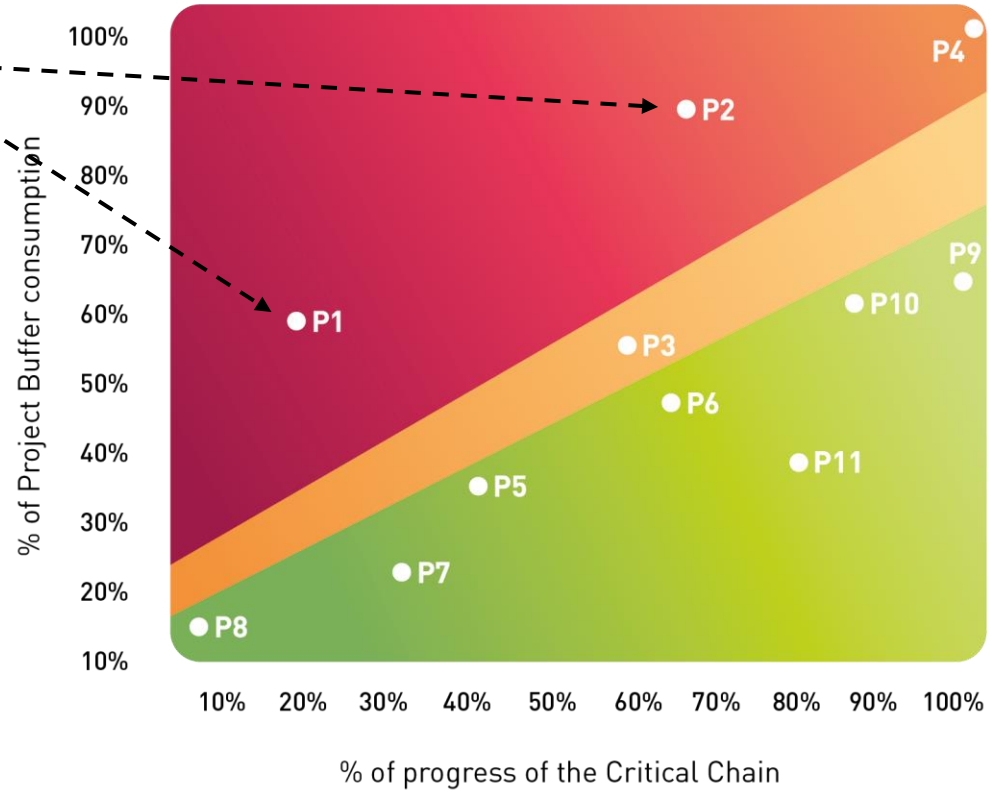
→ = staggering of the start date

The staggering of projects reduces the work-in-progress

The **Portfolio Fever Chart** greatly facilitates dynamic arbitration between projects

Projects 1 & 2:
urgent action needed!

Project 4:
Finished exactly on time



Projects 6 to 11:
(green zone)
nothing to report

Project 9:
Finished before the end date

The Portfolio Fever Chart helps to quickly track all the projects in the portfolio with objectivity and transparency

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Critical Chain can improve any type of project

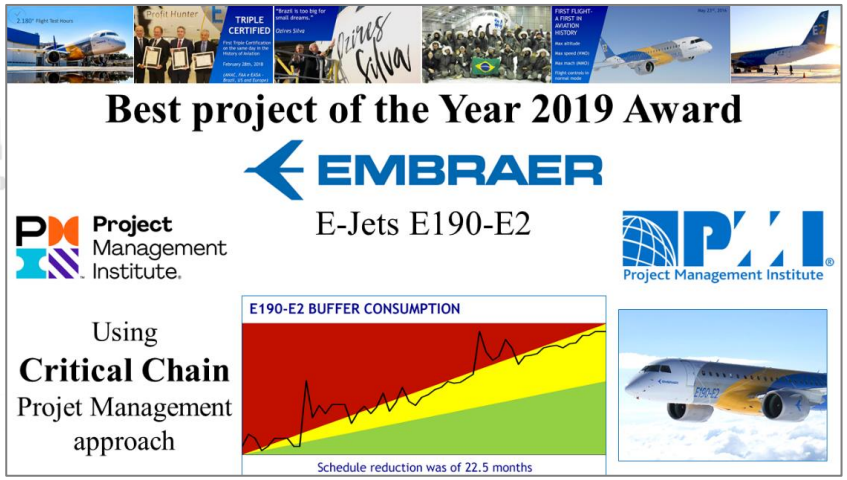
- New product or service development (project or portfolio)
- Non-repetitive Engineering To Order (ETO) and Make To Order (MTO)

- Construction projects, public works and large engineering projects
- Maintenance, Repair and Overhaul (MRO)
- Software development
  (often associated with an "Agile" approach like Scrum)
- ERP implementations
- Etc.

Extract

In October 2019, the PMI awarded Embraer's E190-E2 as the best project of the year

- Embraer adopted the Theory of Constraints in 1990 and have implemented the Critical Chain approach from 2009.
- The E190-E2 aircraft is the first to have been entirely developed following the principles of the Critical Chain.
- Right from the planning stage, they succeeded in reducing the duration of the project by 22 months.
- Thanks to the follow-up via the Fever Chart, they were able to react quickly to drifts and finish about a month before the scheduled date.



PMI: Project Management Institute, biggest association of project management professionals worldwide, 500 000 members..

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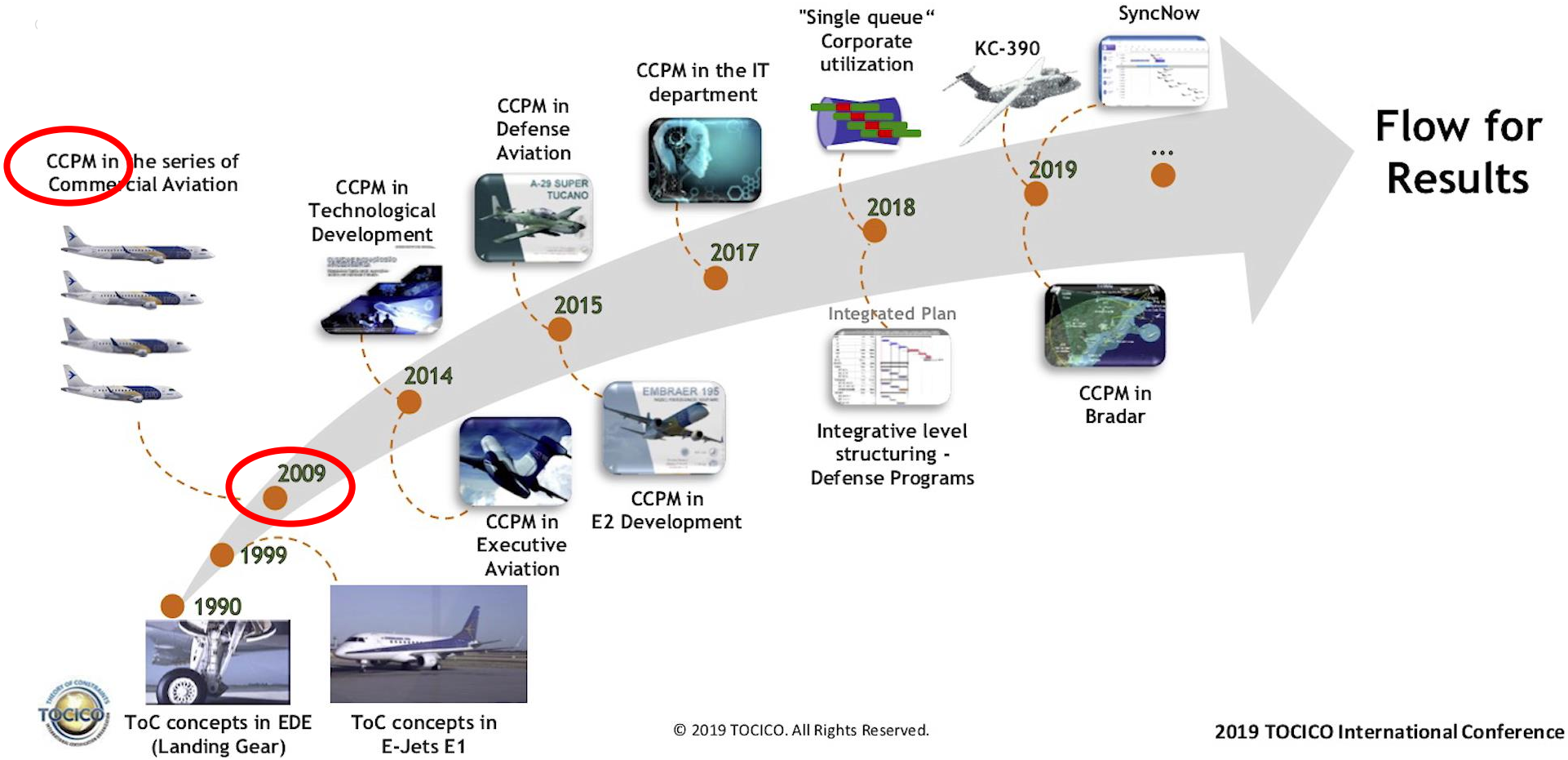
This tremendous success is the result of project management efforts, including Critical Chain, over the last 10 years

ToC 30 Years @Embraer

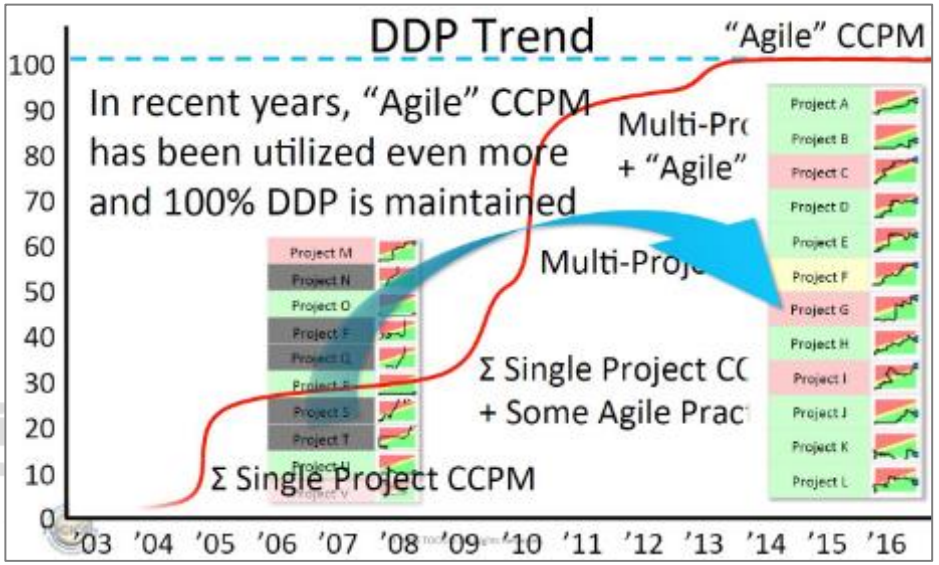


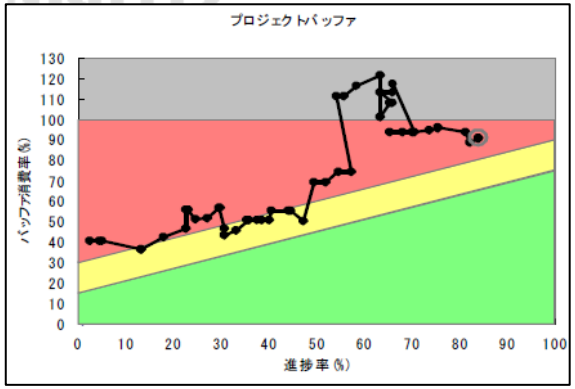
2019 TOCICO International Conference

Extract

Mazda, car manufacturer
After a 10 year roll out the first complete cars "Made by ToC" are now available

- Initially used to develop a new engine family, SKYACTIV.
- Project duration was divided by 2 and cars using that engine (CX5, Mazda 6, …) won 73 rewards around the world in 2012 and 2013.
- Notable increase of New Product Development capacity & increase in productivity.
- CCPM then rolled-out to all the company's development projects.
- Note: This is not a Marris Consulting reference.





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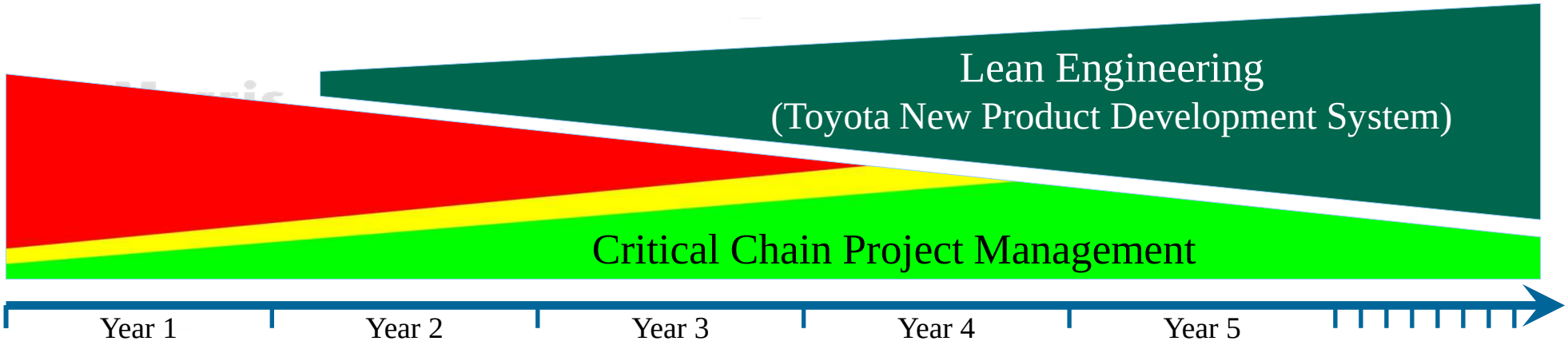
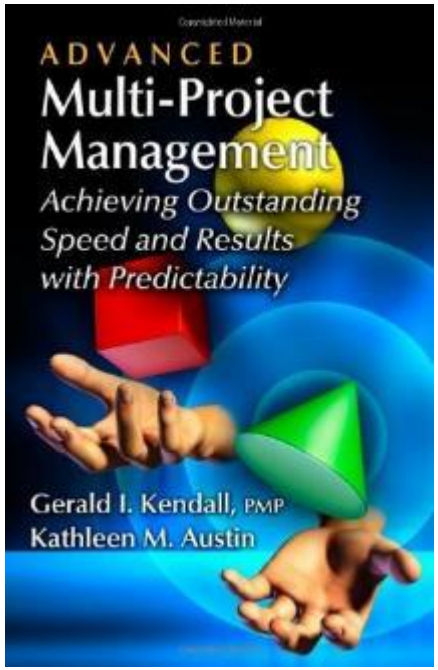
For New Product Development projects, CCPM is an ideal predecessor to Lean Engineering

- Today the main strength of Toyota is no longer in its production system but in its New Product Development (see "The Machine That Changed the World" and TPPDS book by Allen Ward, etc.)
- But "Lean Engineering" is only possible once permanent fire fighting has been more or less eradicated. Otherwise people will never find the time to "do" Lean Engineering.
- We recommend that companies start by putting their development process under control using the Critical Chain and then begin their Lean Engineering journey.
- Critical Chain to finish your projects on time and efficiently
  + Lean Engineering to develop good products.



Appendices



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KISHIRA Yuji	WA - *Transformation Management By Harmony*	North River Press [2009]

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Appendices

11. Appendices

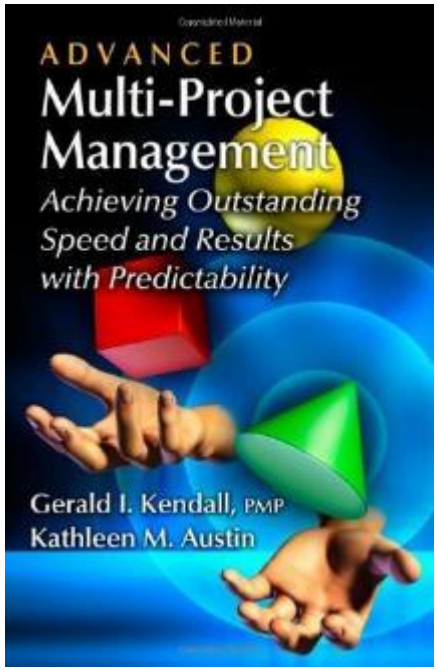
a. Exercises & solutions

b. Recommended readings

c. References

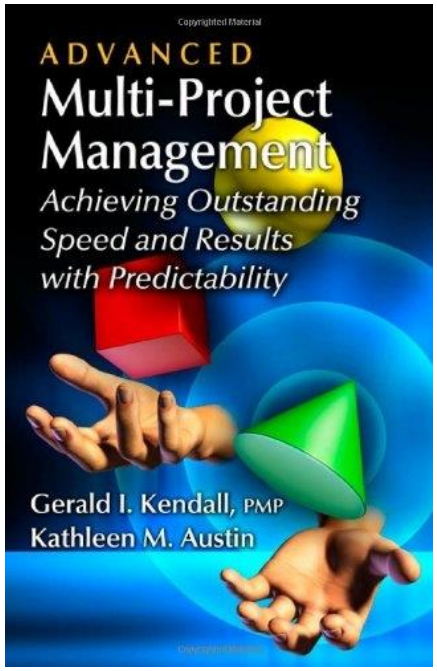
d. Other sources of information

e. Marris Consulting



A list of >350 companies using Critical Chain

3M, ABB, "ABB AG, Power, Tech. Division", ABB Cordoba, ABB Halle, Abbott Labs, Accoat, "Action Park, Multiforme Grupo", Adirondack Oral & Maxillofacial Surgery, Advanced Energy Technology, Advasense Technologies, Aerojet Corporation, Agilent Technologie, AHIS-St. Vincent Health, Air Force Institute of Technology, "Airgo Networks, (Qualcomm)", Airshow Inc., "Alcan Alesa, Technologies", Alcatel, Alcatel-Lucent, Alfa Lava, Alna Software, AMCC, AMD, Amdocs, American Rubber Products, AMGEN, Andover Healthcare Inc., Applied Plasmonics, AREVA, Arterain Medical, Atomic Energy of Canada Ltd., Avaya, Avitronics, BAE Systems, Balfour Beatty, Barco, Baxter, Bell Canada, BHP Billiton, Bimba Manufacturing, Boeing (Military), Boeing Space & Intelligence Systems, "Boeing Wing, Assembly", Bosal, Bosch Rexroth Ltda., Boston Scientific, Bovis Pharmaceuticals, BP Oil, Brice Manufacturing, BT Radianz, BVR Technologies Company, C.F. Roark Welding & Engineering Co. Inc., C.N. Cotrentes, CAE USA, "Californie, Department of Corrections", Callaway Golf, Celite Corporation / World Minerals Columbia Industries, Celsa Group, Central Dupage Health, Central Nuclear Almaraz Trillo, Chrysler, Clopay, Coca-Cola, Colgate Palmolive, Computer Sciences Corp, Confluence UK, Conoco, Converge Medical Inc., Corning Cable Systems, Cray, Inc., Cueros Industrializados del Bajio S.A., Cytori Therapeutics, Inc., DaimlerChrysler UK, Danfoss, Danisco (Genencor), Del Monte Foods, Delta Air Unes, Inc., Delta Faucet Company, Detroit Diesel Reman-West, Dr. Reddy's Laboratories, DuPont, e2V Semiconductors, Eastman Kodak Company, ECI Telecom Ltd., Eclozion Informatique, Edwards Lifescience, eIRcom, eIRcom, Embraer, emcocables, Emesa, Erickson Air-Crane, Ericsson, Estonian Telephone, Ethicon, ExxonMobil Chemical, Fairchild Semiconductor, Fisher Controls, Fluid Brasil Sistemas E Tecnologia, Fluke Corporation, FMC Technologies, Fonterra, French Air Force, Fuel Cell Energy, Gambro Healthcare, GE Industrial Systems, General Dynamics, Gillette, GlaxoSmithKline, Graftech, Hach, Halliburton, "Hamilton Beach, Brands, Inc.", "Harris, Semiconductor", Hawker Beechcraft, Heineken, Heineken, Spain, Henkel, Hewlett Packard, Hitachi Computer Products, Honda, Honeywell, "HP Digital Camera, Group", IBM, IKEA Trading und Design, Ismeca Europe Semiconductor, "Ismeca, Semiconductor", ITT Canon, ITT Corporation, ITT Space Systems, Johnson & Johnson, Kawasaki Heavy Industries, Ltd., Kraft Foods, L-3 Communication Systems, "LeTourneau, Technologies Inc.", Lockheed Martin, Lord Corporation, LSI Logic, LSI Logic, Lucent Technologies, M&M Precision Systems, Marshall Industries, Marvell, McKee Foods, Medtronic, Medtronic, Medtronic, Europe, Medtronic, Inc., Merck Medco Managed Care, Merichem Chemicals & Refinery Services, Microsoft, Milwaukee Forge, Motorola, NASA, Nike, Northrop Grumman, Numonyx, Oregon Freeze Dry, Owens-Illinois, "Oxford-Radcliffe, Hospitals, UK", P&G Pharmaceuticals, Pharmacia, Philip Morris, Philips Semiconductors, Pioneer, Portsmouth Naval Shipyard, Puget Sound Naval Shipyard, Qualcomm, Railcare Wolverton, UK, Raychem, Raytheon, Rex Materials Group, Roche Diagnostics, Rolls Royce, RSA Security, SAAB Avionics, SanDisk, Sapient, Seagate Technology LLC, Shea Homes, Siemens, "Siemens Generator, Engineering", Skoda Power, Skye Group, Sony Ericsson Mobil Communications, Spectranetics, Spirent Communications, Spirit Aerosystems, Sprint, Sun Microsystems, Sylvania, Symbian, Tadiran Spectralink, Tata Steel, Tecnobit, Tektronix, Tellabs, Tenet Health Care, The Boeing Company, ThyssenKrupp, Timco, Tripod Data Systems, Inc., TRS Refrigeration, TT Technologies, Tundra Semiconductor, Tyco Electronics, Tyco Healthcare, U.S. Air Force (multiple bases), "U.S. Army Fleet, Support", "U.S. Army, Corpus, Christi", "U.S. Marine Corps, (Multiple bases)", Unilever, United Behavioral Health, UPC Technology, US Air Force, Valley Cabinet Works, Vascore Medical, Ventana, Volvo, Von Ardenne, Workscape, Xerox Corporation.



Source: "Advanced Multi-Project Management Achieving Outstanding Speed and Results with Predictability" 2013 book by Gerald I. Kendall & Kathleen M. Austin. Appendix

References of Critical Chain implementations throughout the world (#1/16)

Industry	Project Type	Company	Results	Reference
Capacity expansion	Chemical industry	Aarti Industries	Ambitious capacity expansion projects were finished on time. 30%-40% improvement in projects timeline and some teams doubled their speed of execution without adding resources.	www.realization.com
Power	Engineering	ABB AG, Power Tech. Division	Throughput increase over 33% from 300 Bays to 430 Bays per year.	www.realization.com
Power	Engineering	ABB Cordoba	Engineering cycle time reduced from eight months to three months.	www.realization.com
Power	Repair	ABB Halle	Number of projects completed per year increased from 42 to 54, >25%.	www.realization.com
Construction	Theme park design, install, and commission	Action Park Multiforme Grupo	Increased number of projects completed from 121 to 153.	www.realization.com
Aeronautics	All types of projects	Aerosud	Control of the portfolio of new product development projects in less than a month. >98% of projects delivered on time. Industrialization projects lead time reduction of >30%	Marris Consulting
Aeronautics	Aircraft Maintenance	Air Nostrum	Reduction of the average delay by 10% with greater number of aircraft reviewed.	CMG Consultores
Telecommunication	ETO satellites	Airbus Defense and Space,Telecommunications Division	+33% in Throughput (installation drawings per week) & -85% engineering cost overrun	www.realization.com
Communications	Product development	Airgo Networks (Qualcomm)	Cycle time improved from 19 months to 8 months.	www.realization.com
Airpot terminal administration and management	Various building projects	Airplan (Colombia)	2 pilot projects : Control tower project & project of terminal extension finished on time	www.tocpractice.com
Aluminum	Engineering	Alcan Alesa Technologies	Number of projects completed increased over 30%.	www.realization.com
Communications	Telecom switch design	Alcatel-Lucent	Increased throughput by 45% per person.	www.realization.com
Software	Software development	Alna Software	Cycle time reduced by 25% and project completions increased 17%.	www.realization.com

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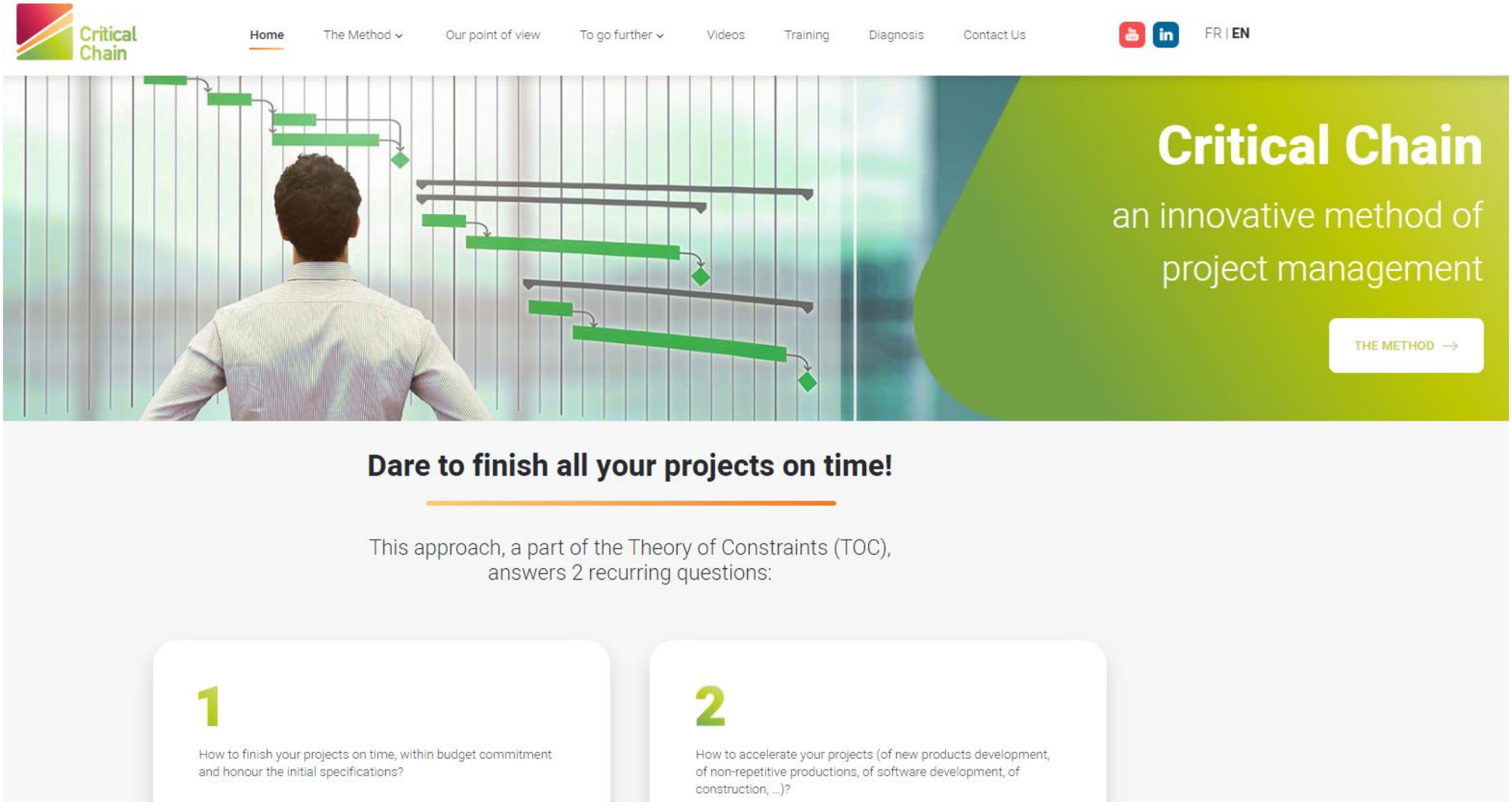
Appendices

A dedicated Critical Chain website: *www.critical-chain-projects.com*



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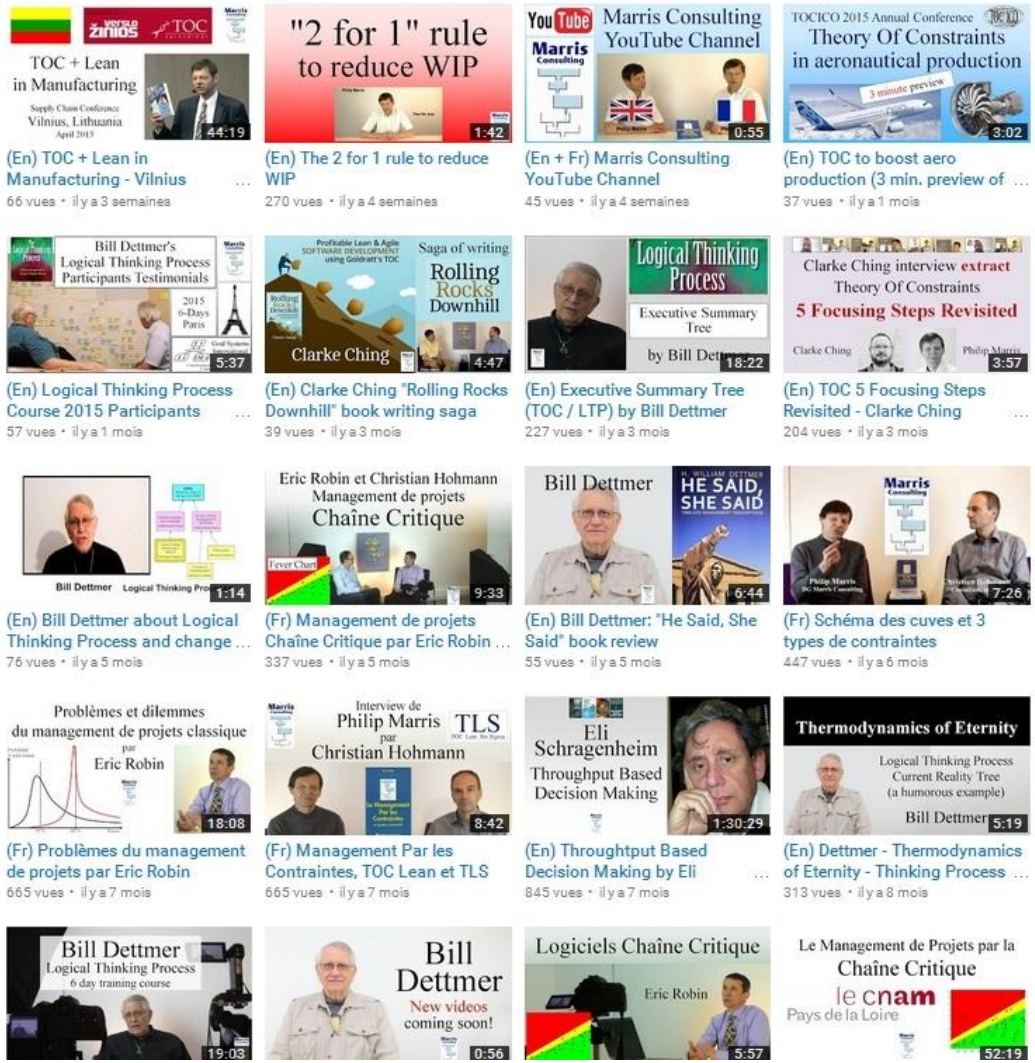
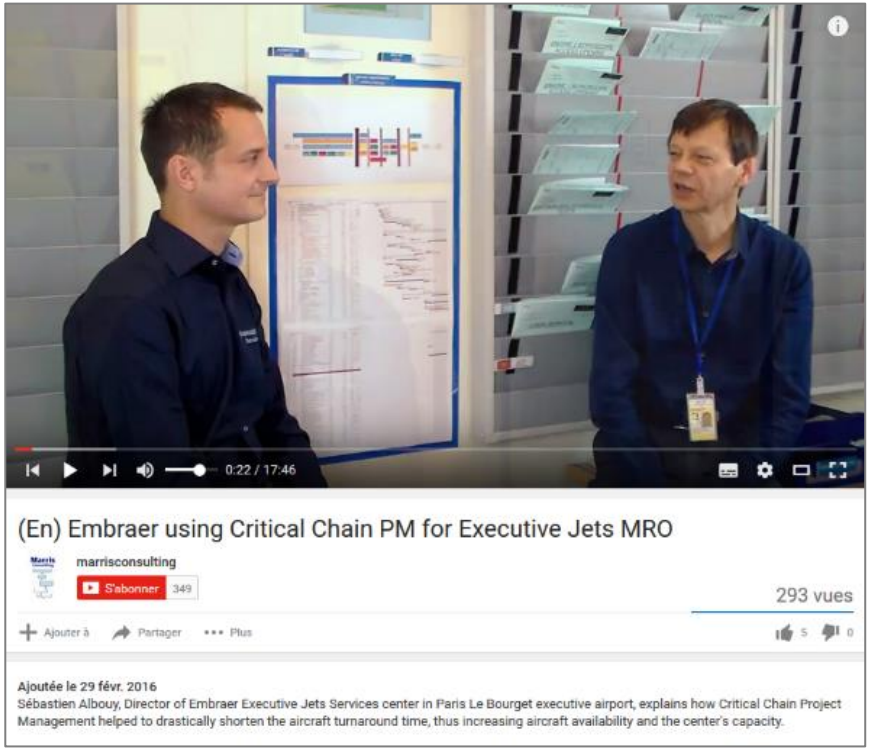
A video website: Marris Consulting's YouTube Channel

https://www.youtube.com/user/marrisconsulting/videos





To facilitate viewing and video selection use the playlists:

- English videos
- Critical Chain videos
- Etc.

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Article on CCPM applied to the pharmaceutical industry:
The Critical Chain to reduce the time to market and increase productivity

- 12 page article in English and French by Philip Marris.
- STP Pharma Pratiques - October/November 2011.

- PDF available here:
  http://www.marris-consulting.com/medias/fichiers/article_pharma_pratiques_ccpm_pour_site_mc_v32_201.pdf
- Abstract:
  - Critical Chain is a new approach to project management that has demonstrated over the past 10 years its ability to significantly reduce the duration of projects, to ensure that projects are completed on time, and to increase resource productivity. It has been successfully used to reduce the Time To Market of new pharmaceutical products especially in the United States. Today, Europe is beginning to implement this approach. Drug development costs are of the order of 1 billion euro and take about 10 years. Generic products invade the initially captive market as soon as the patents expire. We spend more and earn less. An approach such as the Critical Chain, which can reduce the product development time by as much as 40% while increasing the productivity of resources is therefore particularly relevant.

PHARMA PRATIQUES

La chaîne critique pour réduire le "time to market" et accroître la productivité

P. Marris

La chaîne critique est une nouvelle approche de la gestion de projet qui a démontré ces dix dernières années sa capacité à réduire fortement la durée des projets, à faire en sorte que leurs délais soient beaucoup mieux respectés et à accroître la productivité des ressources. Elle a été utilisée avec succès pour réduire le "time to market" des nouveaux produits pharmaceutiques, surtout aux Etats-Unis. Aujourd'hui l'Europe se lance. Le développement d'un médicament coûte de l'ordre d'un milliard d'euros et prend environ dix ans. Les produits génériques reprennent le marché quelques années plus tard lorsque les brevets expirent. Nous dépensons plus et gagnons moins. Une approche comme celle que propose la chaîne critique, qui permet de réduire de 40 % les délais tout en augmentant la productivité des ressources, est donc particulièrement d'actualité.

Mots clefs : Recherche et développement, Gestion de projets, Portefeuille de projets, Chaîne critique, Théorie des contraintes, "Time to market".

The critical chain to reduce the time to market and increase productivity

Critical chain is a new approach to project management that has demonstrated over the past 10 years its ability to significantly reduce the duration of projects, to ensure that projects are completed on time, and to increase resource productivity. It has been successfully used to reduce the time to market of new pharmaceutical products especially in the United States. Today, Europe is beginning to implement this approach. Drug development costs are of the order of one billion euro and take about ten years. Generic products invade the initially captive market as soon as the patents expire. We spend more and earn less. An approach such as the critical chain, which can reduce the product development time by as much as 40 % while increasing the productivity of resources is therefore particularly relevant.

Key words: Research and development, Project management, Project portfolio, Critical chain – Theory of constraints, Time to market.

I Le constat

Dans le secteur pharmaceutique, les délais de développement des nouveaux produits sont devenus un sujet « stratégique ». D'une part, les délais des projets se rallongent du fait entre autres de l'accroissement des contraintes réglementaires. Les durées de « *time to market* » sont désormais souvent de huit à douze ans et chaque projet coûte environ un milliard d'euros. D'autre part, la durée pendant laquelle le produit peut être vendu avec une bonne marge sur le marché est de plus en plus réduite car les produits génériques s'imposent dès la fin de la protection apportée par les brevets. Il faut dépenser plus tout en ayant moins de temps pour récupérer sa mise. Pour aggraver encore les choses, les entreprises sont obligées de lancer de plus en plus de projets. Les ressources concernées par le développement des nouveaux produits se retrouvent en conséquence avec de plus fortes charges,

I The context

In the pharmaceutical sector the development times for new products has become a "strategic" subject. The duration of projects is increasing due to increased regulatory constraints in particular. The time to market of a new drug is now of the order of eight to twelve years and costs approximately 1 billion euro. At the same time the window of time during which a new drug can be sold at a reasonable margin is getting smaller and smaller since the generic manufacturers appear as soon as the developer looses his patent protection. We must spend more and yet we have less and less time to recover the investment. To make matters worse, companies are obliged to launch more and more projects to get one new viable drug onto the market. As a result the resources are overloaded even if they are reinforced since they are rarely increased in sufficient proportion. There are more

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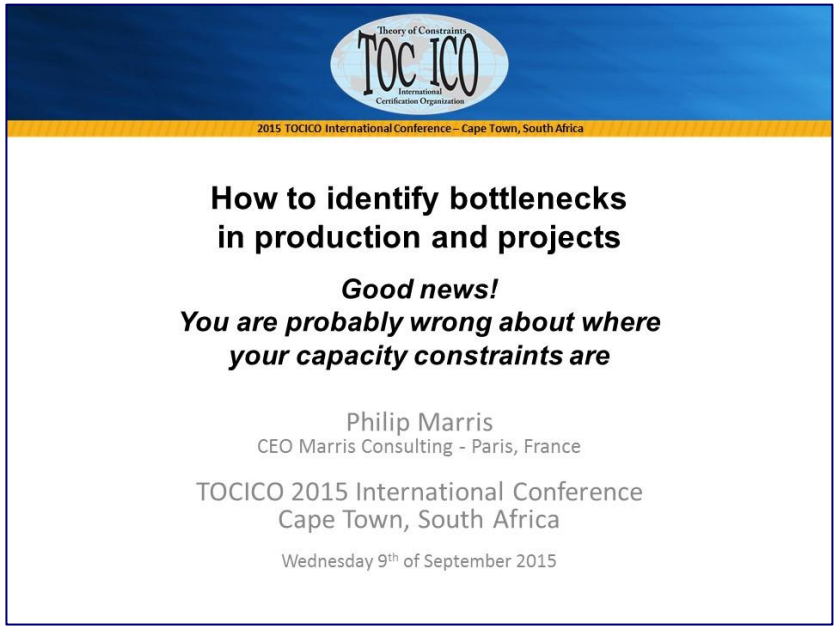
2015 Conference:
How to identify bottlenecks in production and projects

- TOCICO Annual Conference in Cape Town South Africa by Philip Marris.
- PDF available here:
  http://www.marris-consulting.com/medias/fichiers/tocico_2015_toc_bottlenecks.pdf
- Video here:
  https://youtu.be/ulXqO86OfpU?list=PLuB3wmjsgiunMLT_rrMFfHfQ33X3yft4S



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Appendices

11. Appendices

a. Exercises & solutions

b. Recommended readings

c. References

d. Other sources of information

e. Marris Consulting

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Marris Consulting hosts over 30 public or internal training sessions every year

Logical Thinking Process

Lean

Critical Chain Project Management

Theory Of Constraints

Lean Engineering

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