

Using Critical Chain to Boost Business Jet MRO

3 RD AVIATION MRO SUMMIT

NOVEMBER 22-23, 2018 • FRANKFURT



Speakers



Fernando Bertrand

- IPSA, Expert in aeronautics and space engineering
- Responsible Airworthiness at Air Tahiti
- QM, Security and Human Factors Manager at CAP Sud Tahiti
- **Maintenance Engineering & Planning Manager at Embraer Executive Jets**



Philip Marris

- Theory Of Constraints expert. 33 years of TOC & Lean experience.
- >25 years of experience helping over 200 companies in all kinds of industry.
- **CEO of Marris Consulting**, based in Paris, France. © Marris Consulting
Motto: *Factories, People & Results*

■ Embraer Service Center at Le Bourget

■ Initial context

■ Critical Chain principles

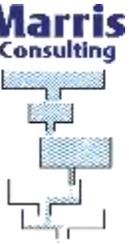
■ Approach and results

■ Conclusion

■ Questions & Answers

■ Annex





Le Bourget airport is just outside Paris and is the largest and busiest business jet facility in Europe

Phenom
100/300

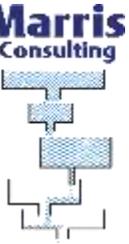


Legacy
450/500
/600/650



Lineage
1000





Maintenance support for Embraer Executive Jet fleet for the Europe Middle-East Africa (EMEA) zone

- Maintenance teams:
 - 2 shifts, 5 days/week,
 - A 4 on, 4 off, maintenance team dedicated to Line (scheduled maintenance) and AOG (Aircraft On the Ground) to ensure a 24h/7 service.
- The Hangar is fully booked all year.
- Good customer Service is mandatory.



- Embraer Service Center at Le Bourget
- Initial context
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- Annex



Initially very little visibility and reliability...

- Planning before and during the check is not efficient especially for the Check-C (major maintenance operation after 8 years of use).
© Marris Consulting
- Only 40 % of parts are delivered on time to the hangar.
- Customer validations for additional work arrive late.
- Technicians don't know their daily priority.
- Very poor visibility on the work progress.
- Management of the hangar's "slots" is not robust nor reliable.



- Embraer Service Center at Le Bourget

- Initial context

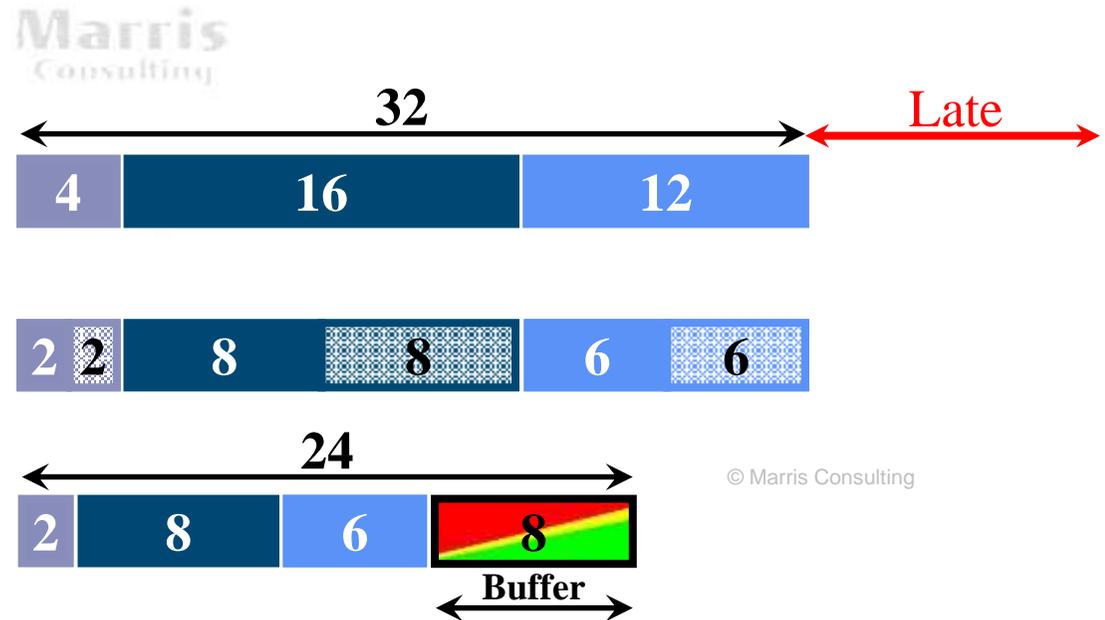
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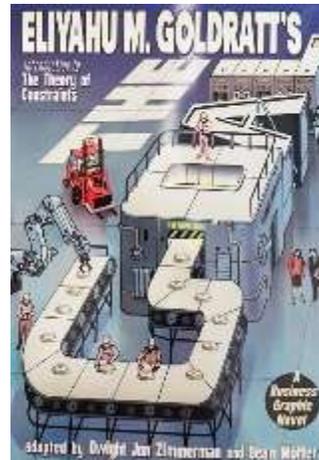
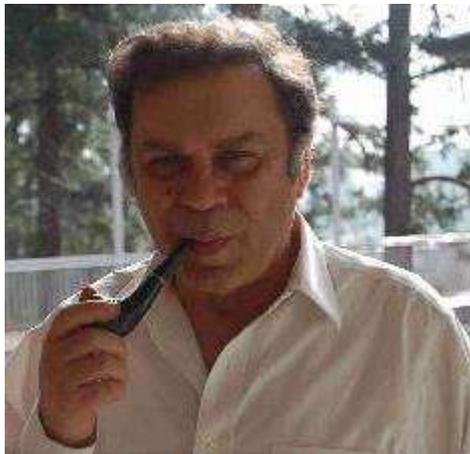
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Have you read The Goal ?

- Over 7 millions copies in 31 languages of the novel, or "business thriller ", *The Goal* sold.

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Includes bonus presentation by the author

Eliyahu M. Goldratt and Jeff Cox

THE GOAL

A PROCESS OF ONGOING IMPROVEMENT

30th Anniversary Edition

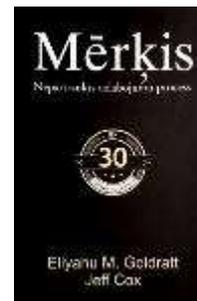
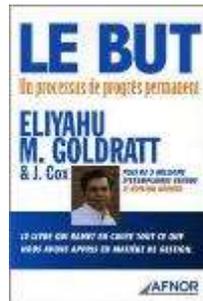
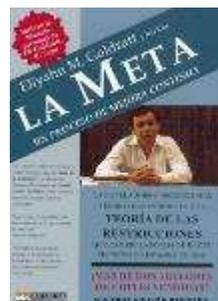
Eli Goldratt has been described by *Fortune* as a "guru to industry" and by *Business Week* as a "genius". His book, *The Goal*, is a gripping fast-paced business novel.

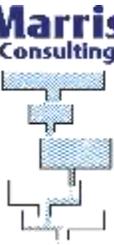
"Goal readers are now doing the best work of their lives."
Success Magazine

"A factory may be an unlikely setting for a novel, but the book has been wildly effective..."
Tom Peters

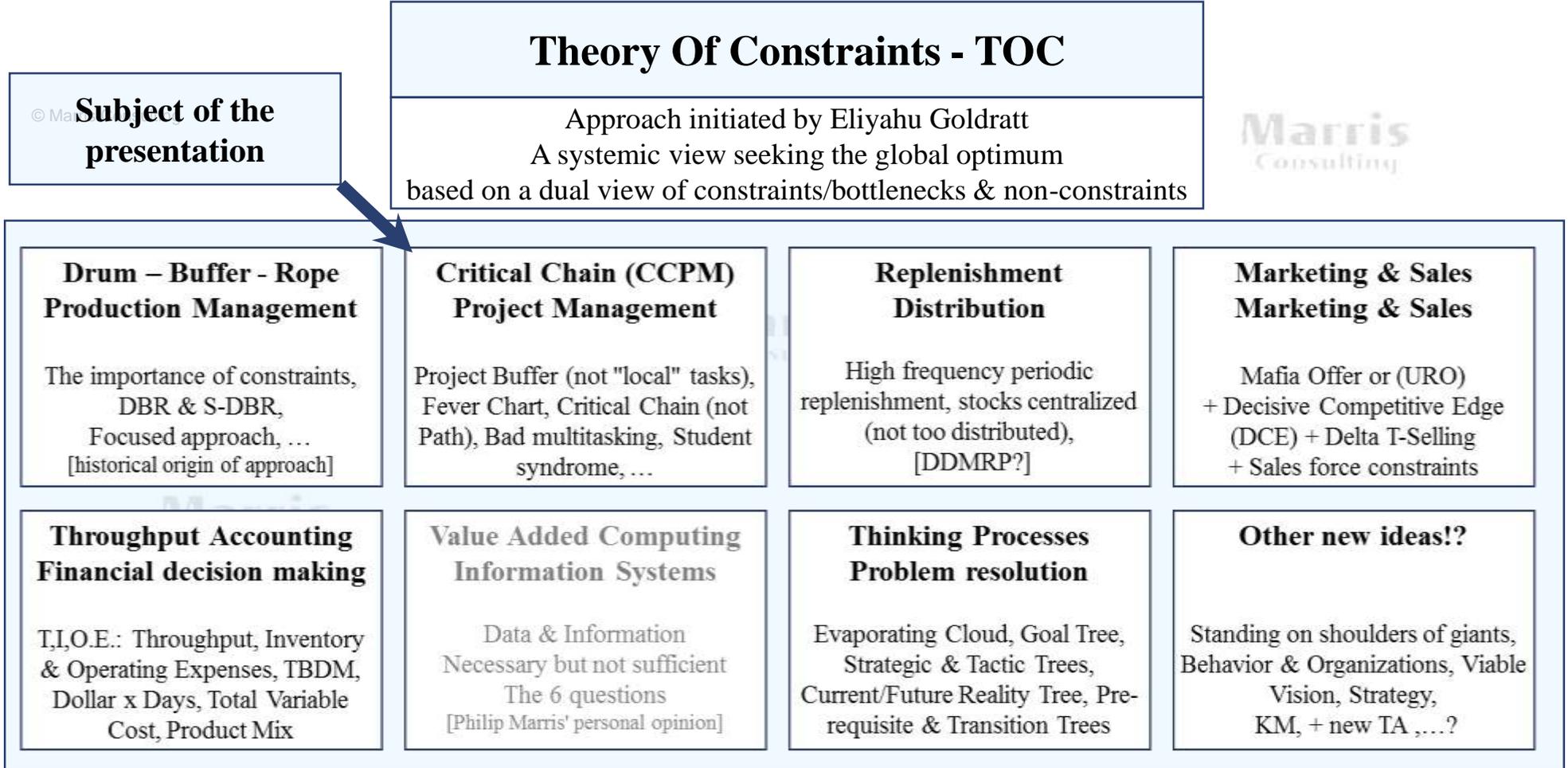
THE BEST-SELLING BUSINESS NOVEL THAT INTRODUCED THE THEORY OF CONSTRAINTS AND CHANGED HOW AMERICA DOES BUSINESS

OVER 6 MILLION BOOKS SOLD!





The different components of the Theory Of Constraints (TOC)

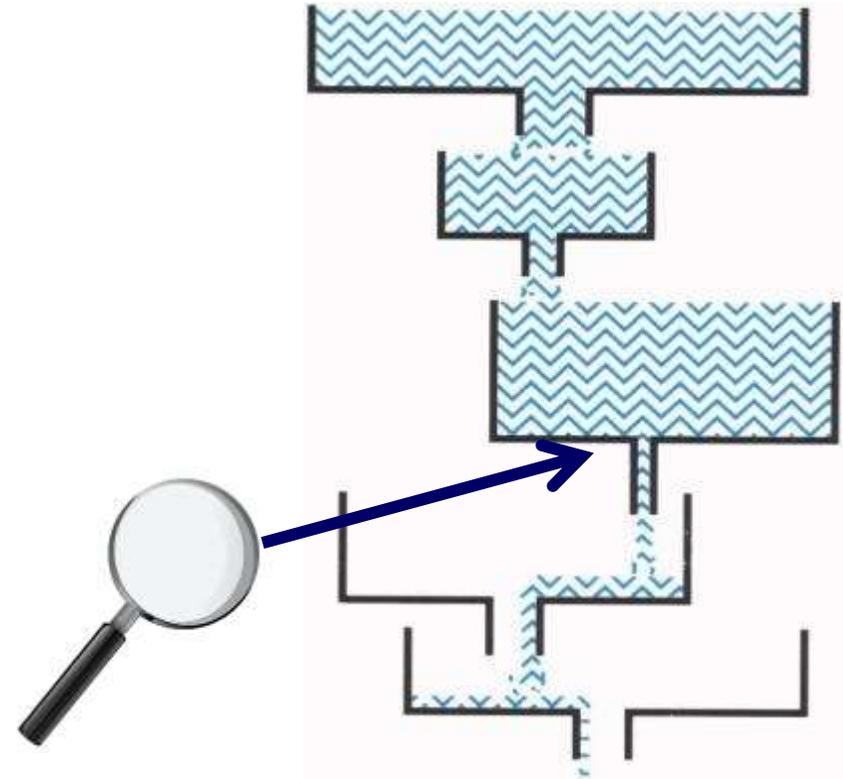


Organizations inevitably have unbalanced capacities, so there is always a constraint somewhere

- The bottleneck (constraint) determines the overall performance.

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- One hour lost on the bottleneck :
 - = one hour lost for the system,
 - = one hour of lost sales.
- One hour gained on a non-bottleneck resource is an illusion.
- Focus on improving the system constraints that determine the performance.

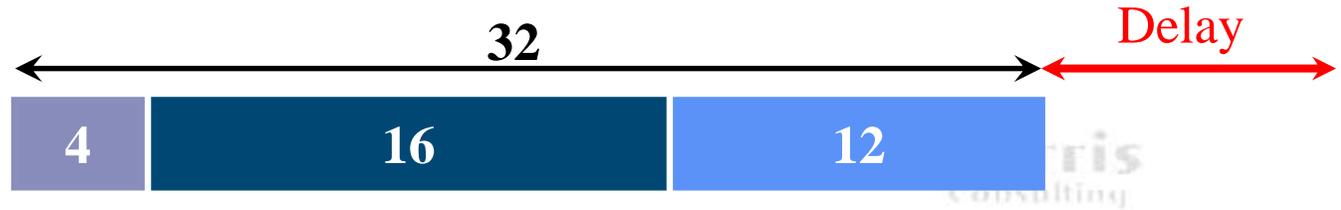


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The sum of local optimums is not equal to the global optimum

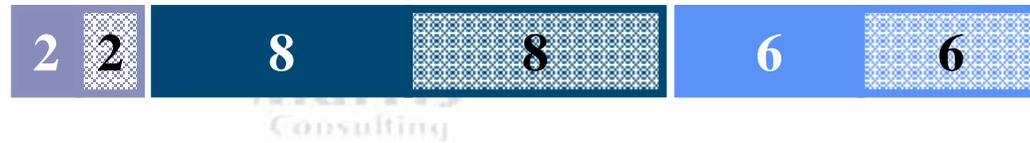


Critical Chain : Protect the project, not the single tasks

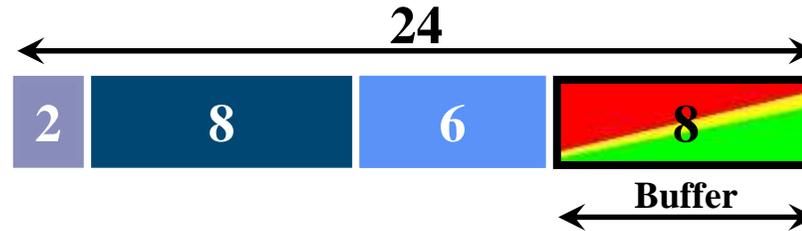


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With the traditional approach,
each task has its own margin

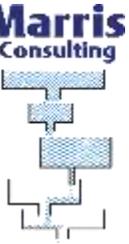


With Critical Chain,
margins are mutualized and
lead times challenged



The "Buffer" represents
1/3 of the project length

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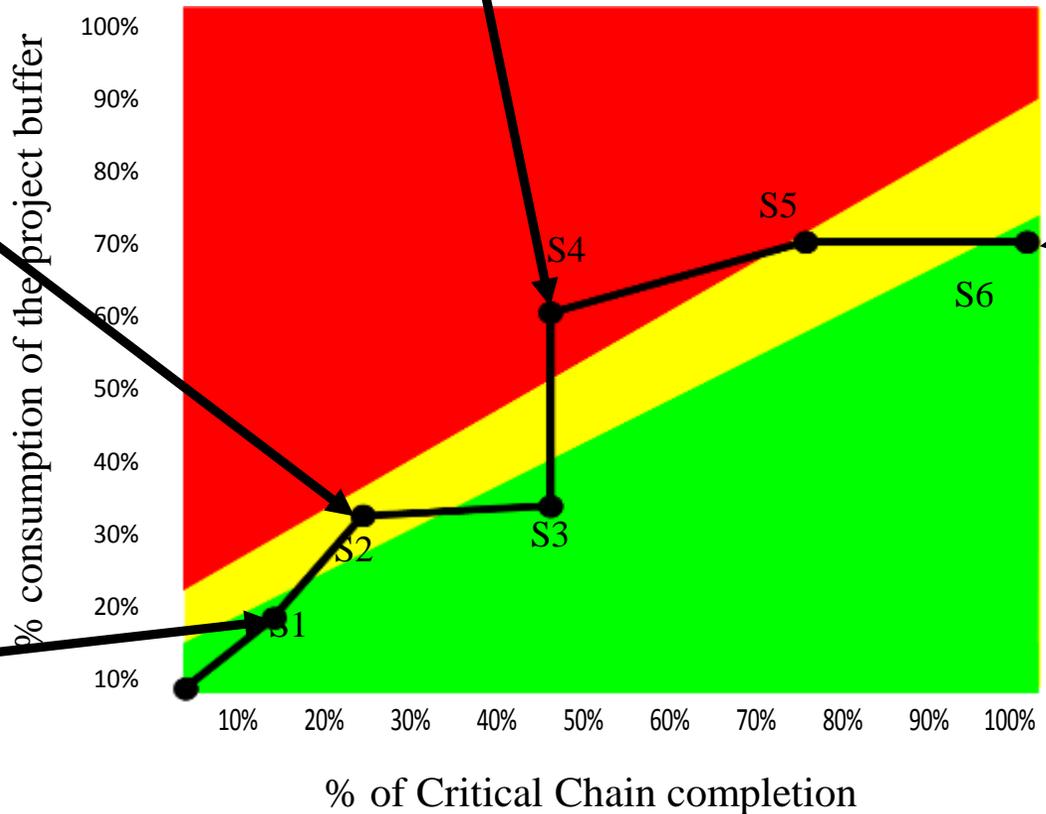


Project monitoring is much easier thanks to the **Project Fever Chart**

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

Red zone = risky zone → start right now corrective actions

Green zone = comfort zone → no action needed

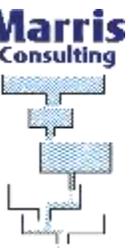


Finished project with project buffer not fully consumed

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

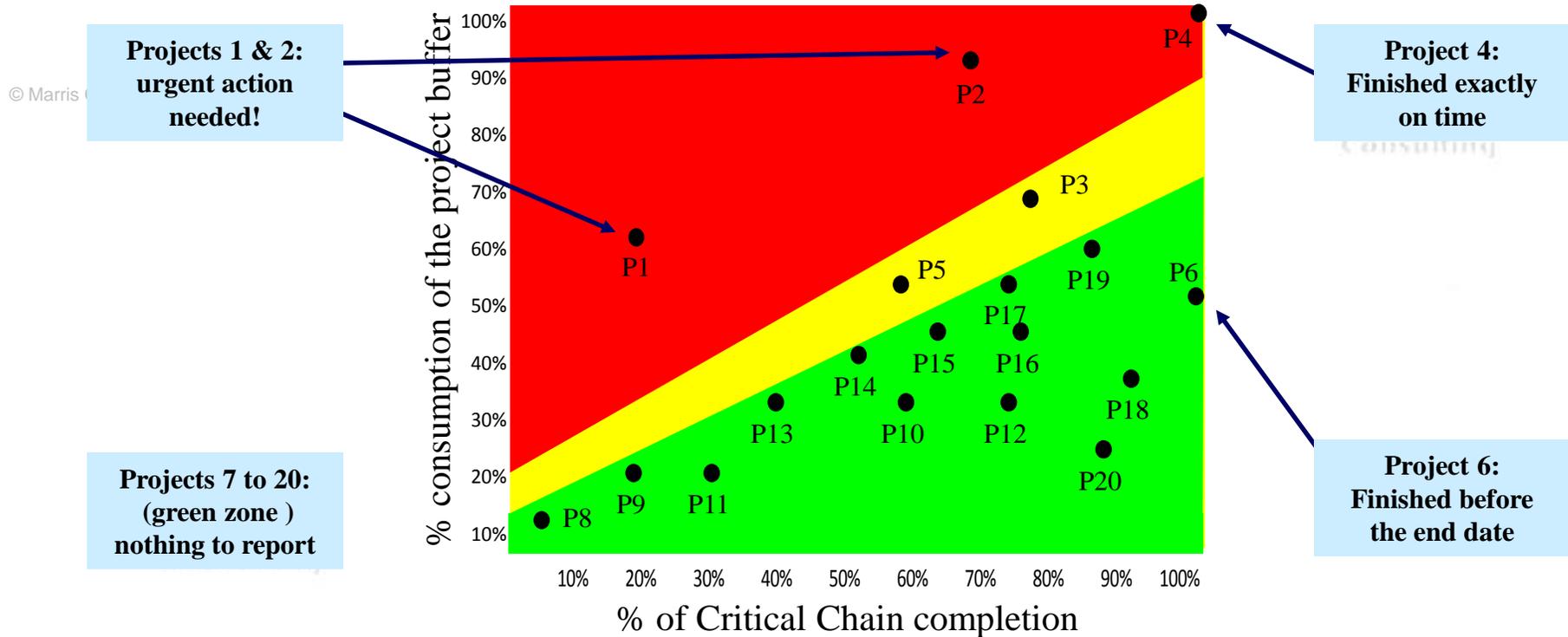
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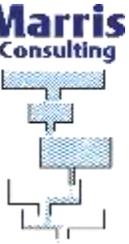


The Portfolio Fever Chart

greatly facilitates dynamic arbitration between projects



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



Critical Chain is particularly relevant to MRO because it takes into account variability and uncertainty

- It uses dynamic scheduling (it's like a GPS)
- It identifies the critical sequence of tasks – "The Critical Chain" – that determines overall duration
- Improvement actions can be focused on the Critical Chain





Critical Chain implementations in aeronautical MRO

■ TAP Maintenance & Engineering :

- 21 % decrease in aircrafts downtime, i.e. from 124 to 98 days.

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- Increase in aircrafts availability.

Source : Conference Aviation week MRO Latin America – January 2016.



■ DELTA TechOps :

- 23% increase in engine production (from 476 to 586 engines/year).
- 50% decrease in landing gear treatment time.
- Reduction spare parts in workshops, from 20K to 5K parts.
- Reduction of financial costs by 12.7%

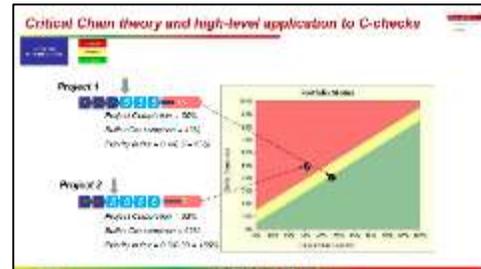
Source : Conference TOCICO 2008 .



■ Lufthansa Technik :

- Critical Chain deployment for Hangar's Check-A and Check-C.
- TAT 18% decrease for Check-C.

Source : Connection – The Lufthansa Technik Group Magazine – July / August 2013





Other aeronautical MRO case studies

- **U.S. Army Fleet Support :**

- 32% reduction in Boeing CH-47 Chinook treatment time and
- 52% decrease in treatment time for H-60 Black Hawk.

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- **Aeronautical industrial service :**

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- 15% decrease in downtime.
- More than 1000 hours of additional flights per year.
- A maintenance dock released.



- **Helisota :**

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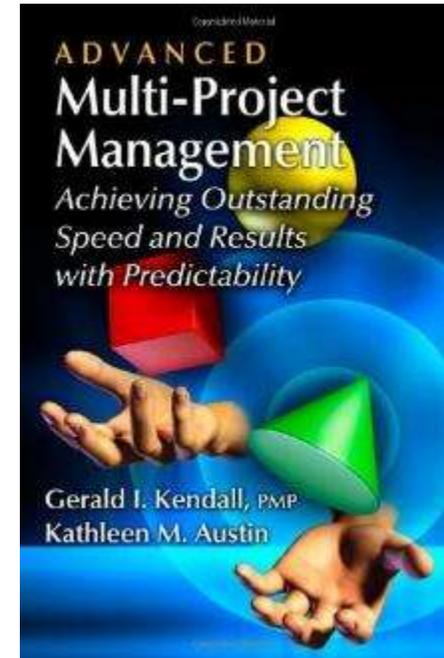
- From 20 to 40 helicopters per year.
- 52% decrease in TAT



- **Etc.**

>350 CCPM references worldwide, all kind of projects

3M, ABB, "ABB AG, Power, Tech. Division", ABB Cordoba, ABB Halle, Abbott Labs, Acccoat, "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, 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, Ismecca Europe Semiconductor, "Ismecca, 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, Lucent Technologies, M&M Precision Systems, Marshall Industries, Marvell, McKee Foods, Medtronic, 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
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- Initial context
- Critical Chain principles
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The first step was to build a macro-schedule

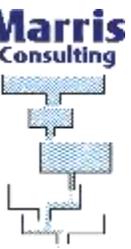
- Creation of a macro-schedule with short-term objectives. Example: Jacking – Day 5.

© Marris Consulting

- Analysis of previous Check-C:
 - Priority is given to aircraft areas that generate the most "findings"*.
 - Supply of the most recurring parts.
- Definition of a mini/maxi number of resources per area.
- Training of all employees on Critical Chain.

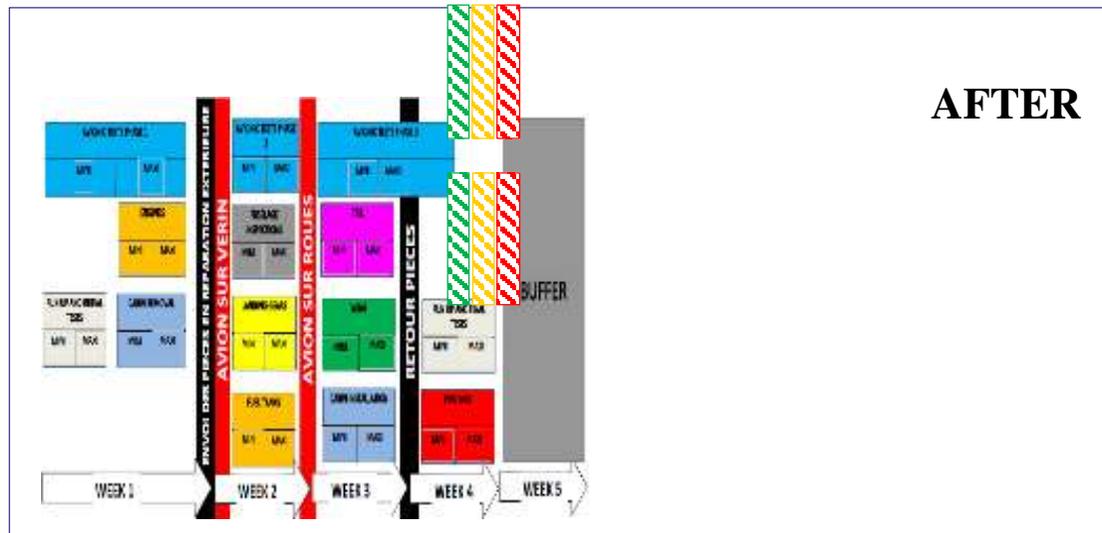
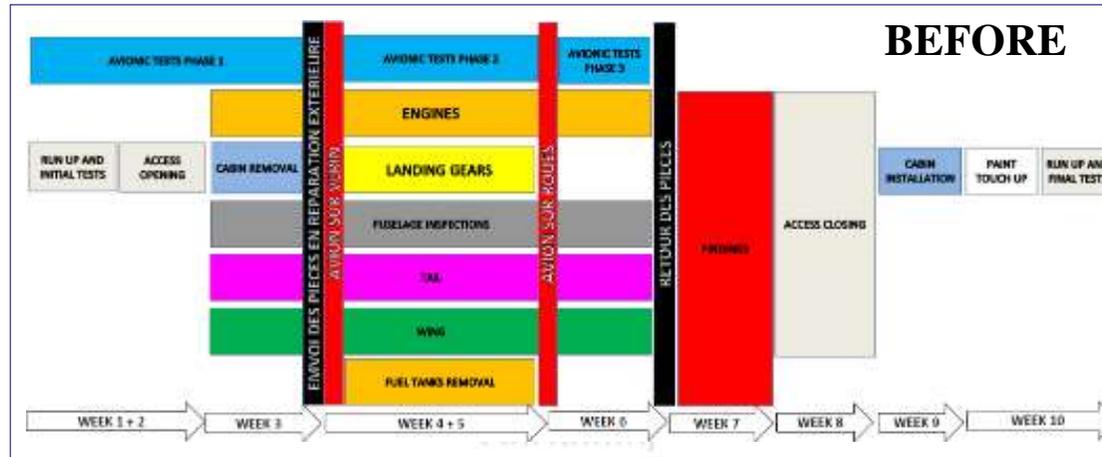
Note: Findings = Unexpected problems found while inspecting the airplane and it's equipment.





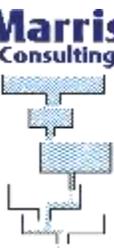
Macro-schedule for achieving a C-Check in 5 weeks

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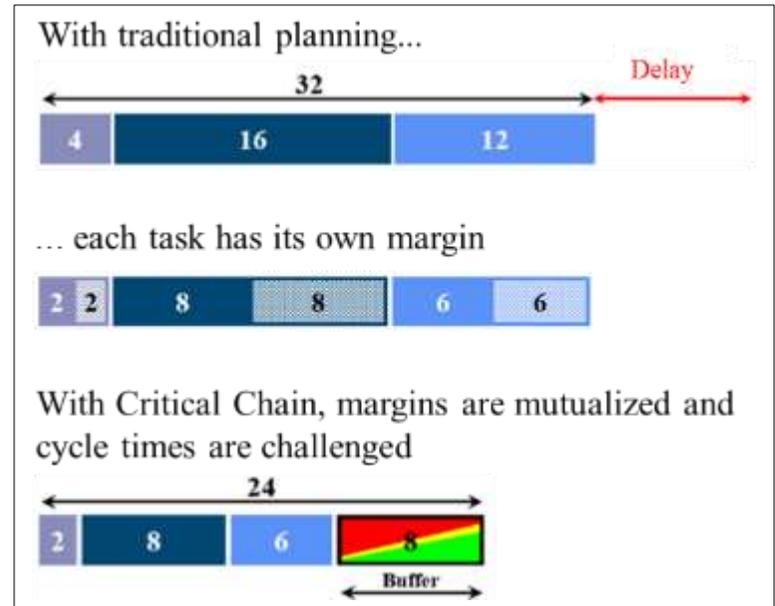
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The Critical Chain approach was applied #1/2

- Schedule for the aircraft is created in MS-Project (with an add-on for Critical Chain) in line with the macro-schedule.
- Reduction of the number of work cards thanks to work "packages" (from 1,200 cards to 170 packages).
- Schedule adjustment with aggressive durations and a protection for the whole project through a final buffer.
- (../..)



The Critical Chain approach was applied #2/2

- Establishment of a “Findings Buffer” to model the load due to the discovery of defects during the check.
- Ensure that the schedule respects the basic principles of Critical Chain.
- Analyze and optimize the Critical Chain to ensure a 5-week check.

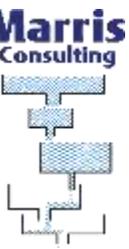
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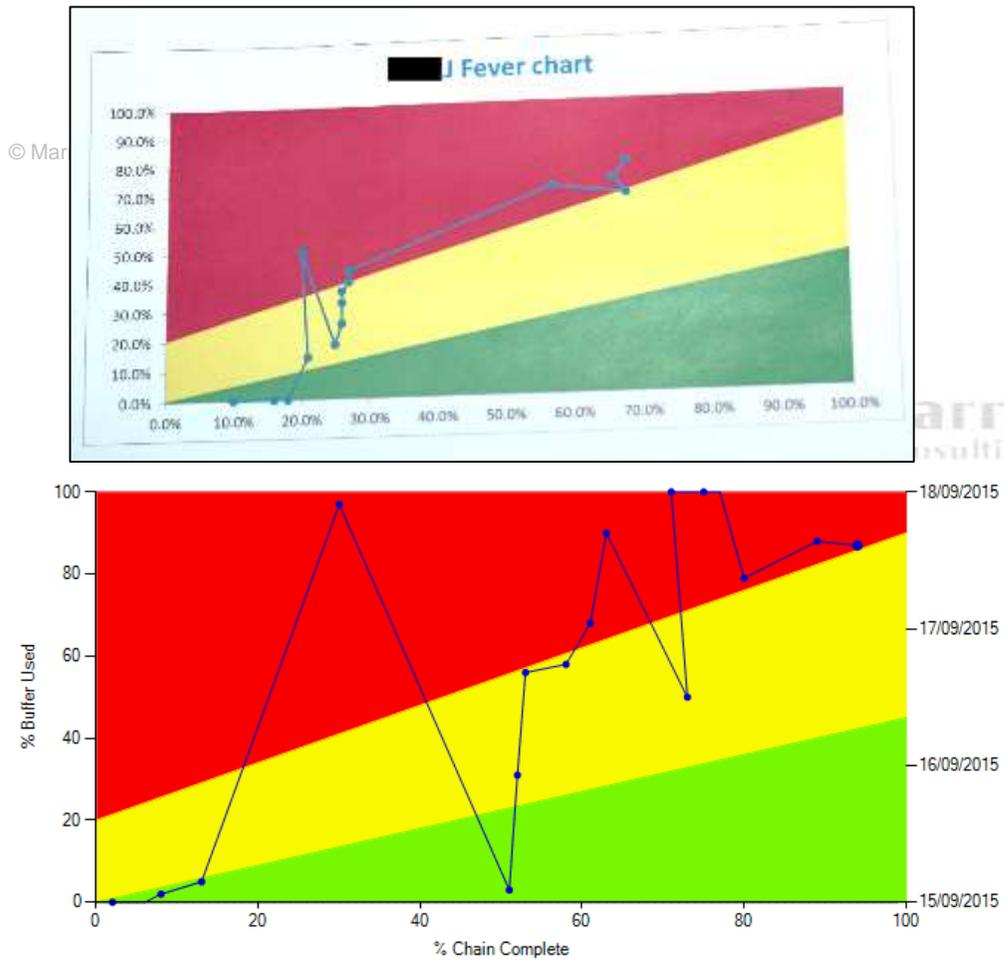
During project execution, new behaviours were implemented

- At the end of each shift, the planner and the team leader prepare the work cards for the following team.
© Marris Consulting
- Independently from their status, at the end of the shift, all the work cards are handed over to the team leader, so they can be rescheduled.
- In order to keep a low work-in-progress, the planner only gives new work cards when he gets a closed work cards.
- (.../...)

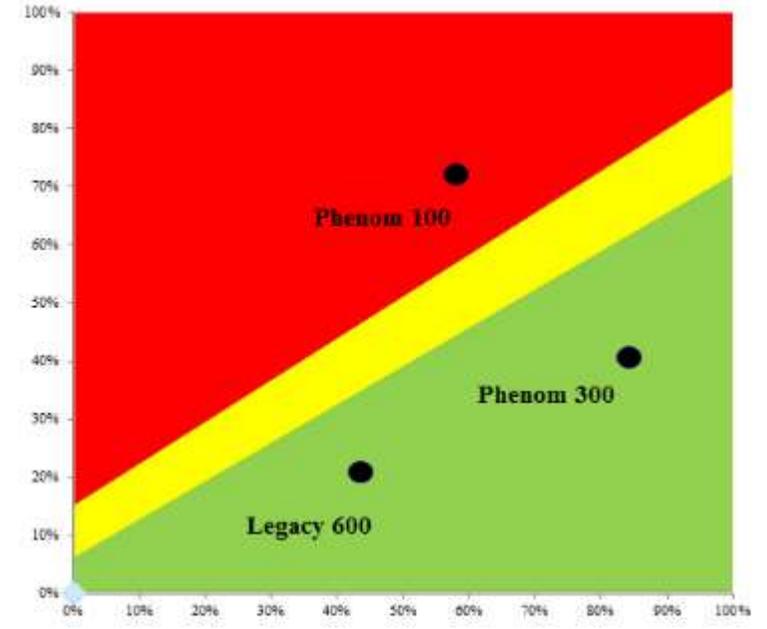




The Fever Chart was used to manage execution



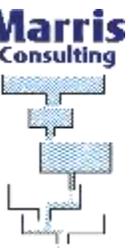
Example of an Aircraft Fever Chart



Example of Hangar Fever Chart

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Visual management was used to facilitate the monitoring of daily activities

- Modification of the “control room” to optimize the monitoring of the check as well as the monitoring of couple of checks simultaneously.

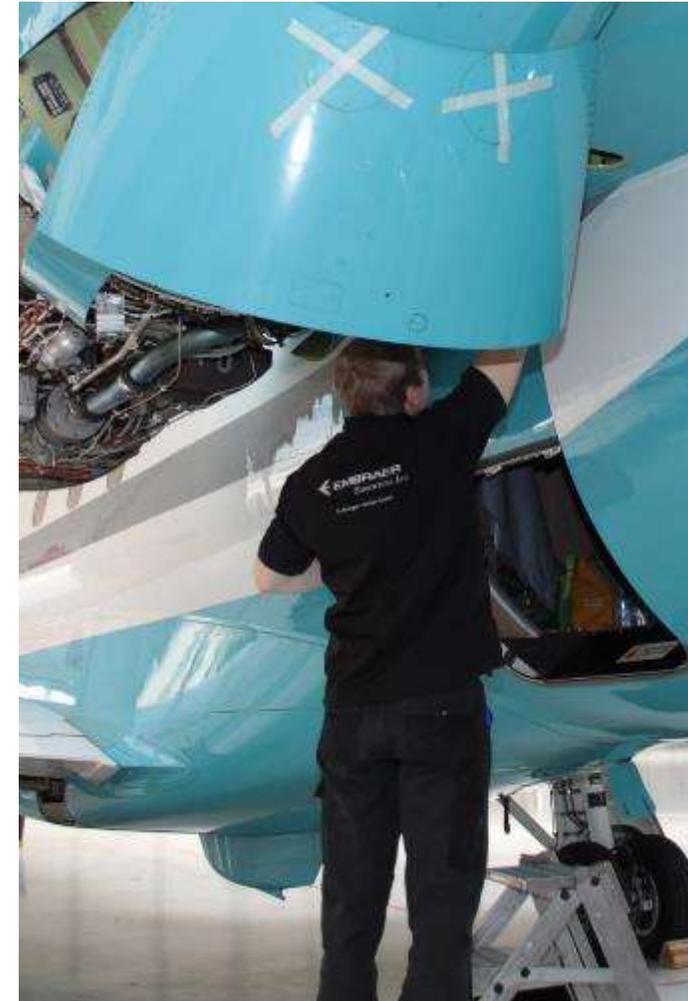
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Managing execution becomes much easier

- The impact of problems (late parts delivery, internal or external intervention,...) is easily visible on the Fever Chart.
© Marris Consulting
- Critical Chain allows "what if" simulations and the effects on the aircrafts' delivery date.
- Managers don't need to know the details for all activities. Only aircrafts in the Red Zone.
- During the check, the progress and remaining work is much clearer and shared with everyone.



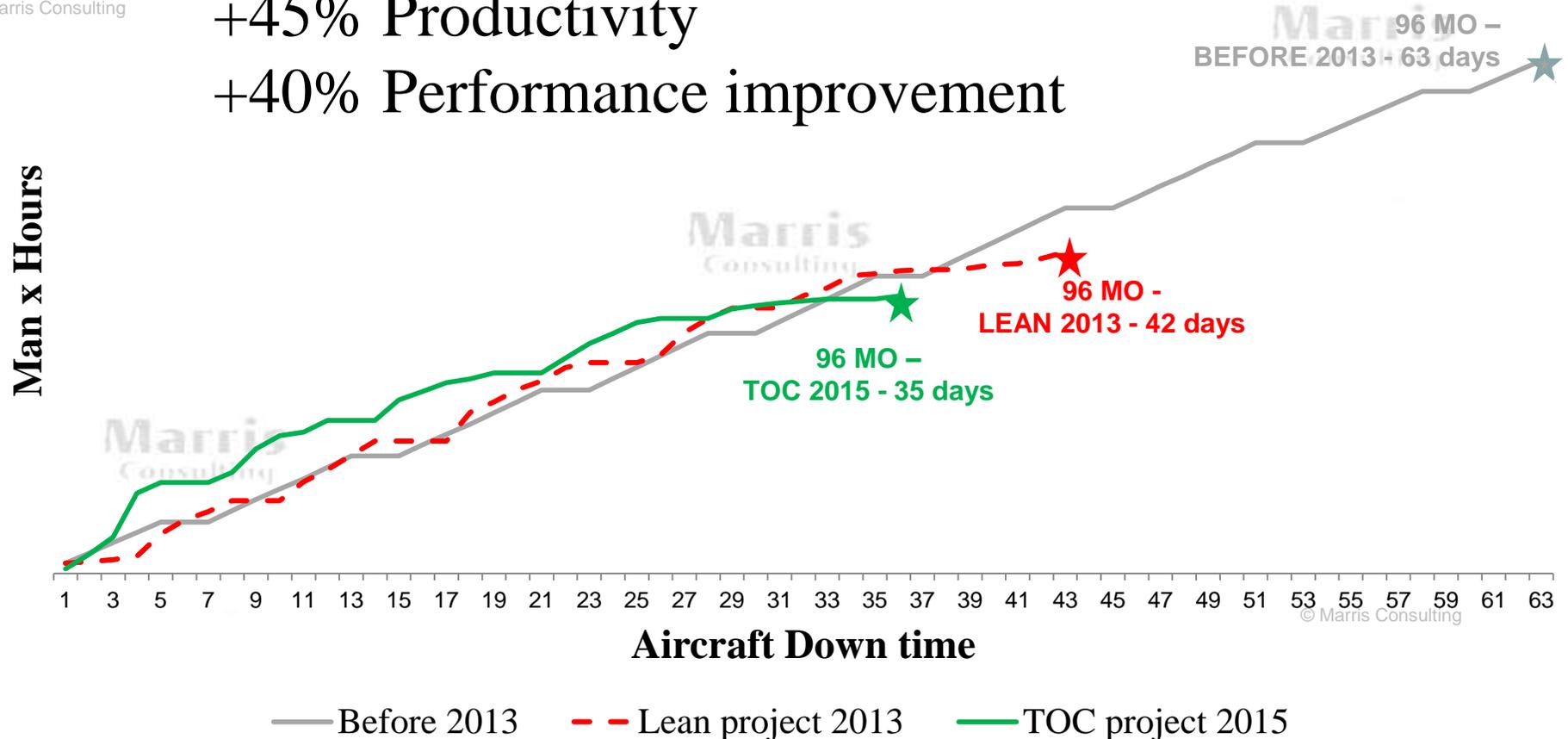
Now we fix airplanes twice as fast...

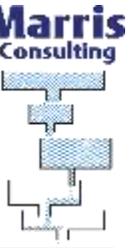
Before / After:

+45% Productivity

+40% Performance improvement

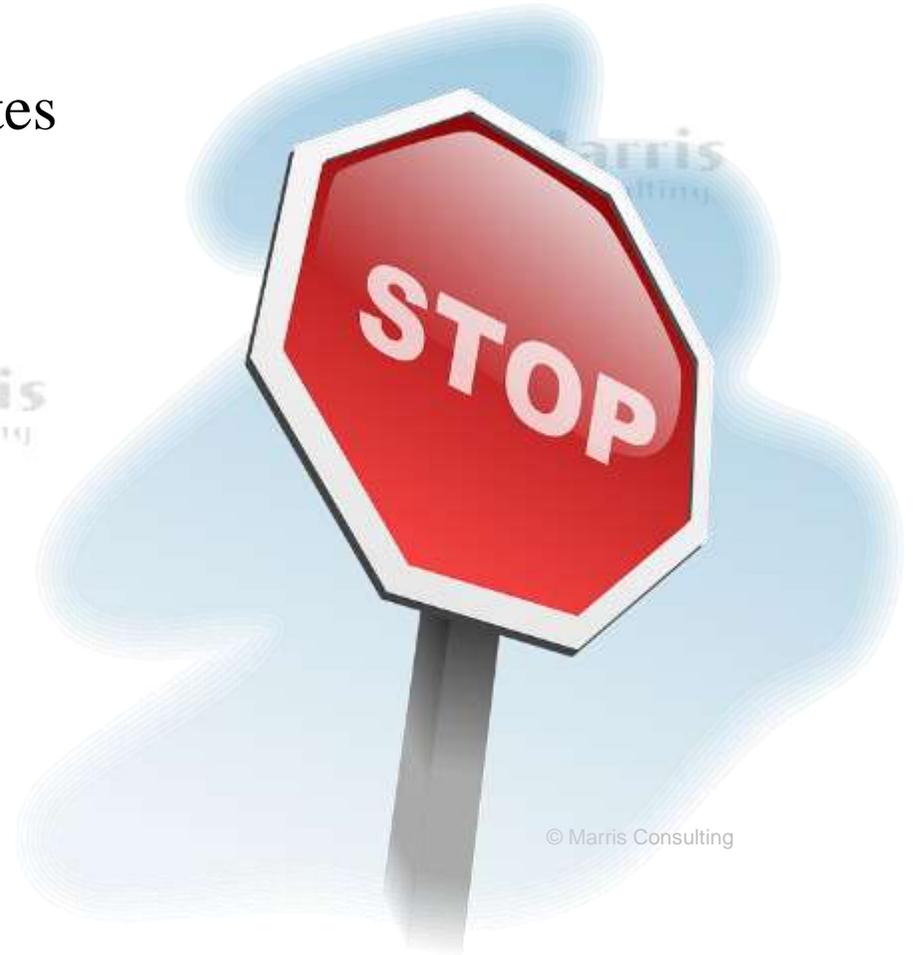
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...and many undesirable effects have disappeared

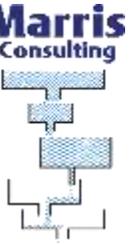
- Late deliveries
- Lack of visibility on aircraft release dates
- Important workload for planners
- Constantly changing priorities
- Forced multitasking
- Stress caused by work environment



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Conclusion

- Since 2015, Critical Chain is embedded in Embraer Le Bourget practices.
- We are currently discussing how to implement Critical Chain in our other maintenance centers in USA and Brazil.

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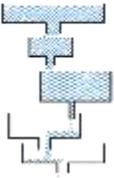
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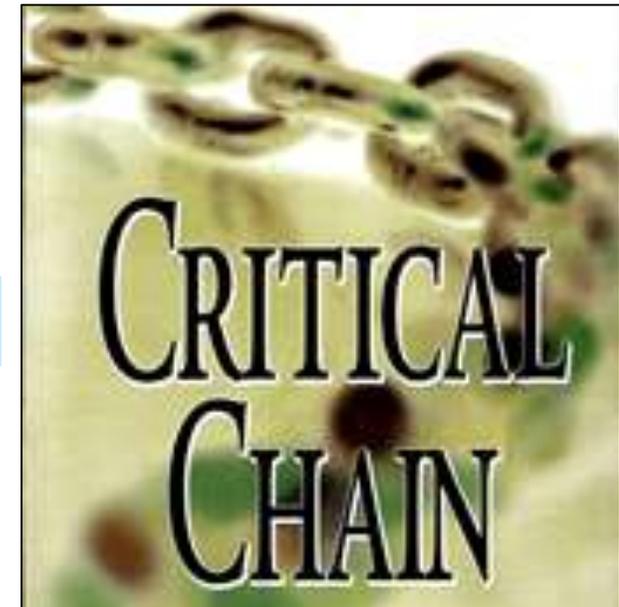
Any questions?

FOR THE JOURNEY |  **EMBRAER**

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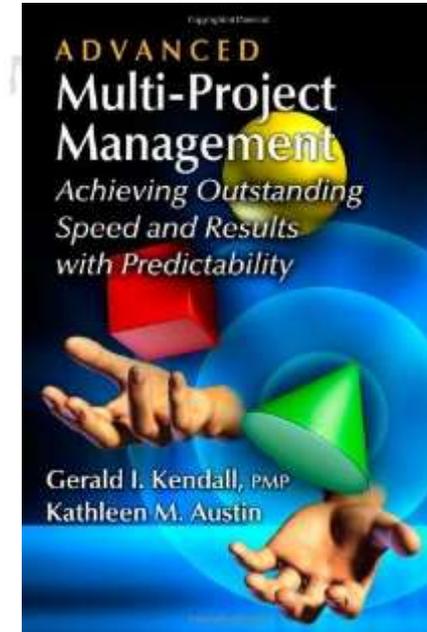
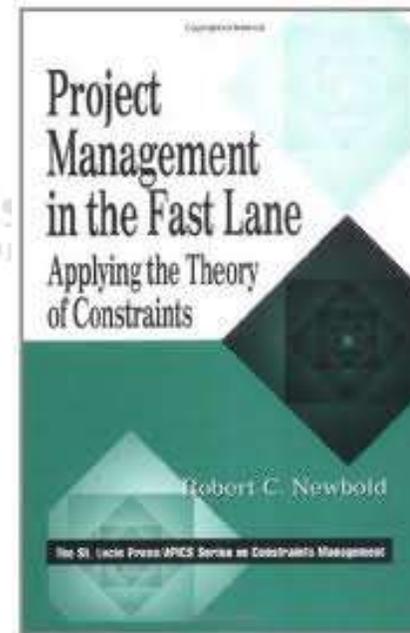
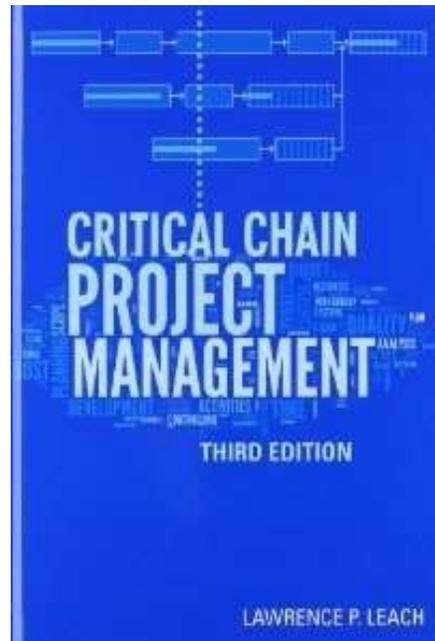
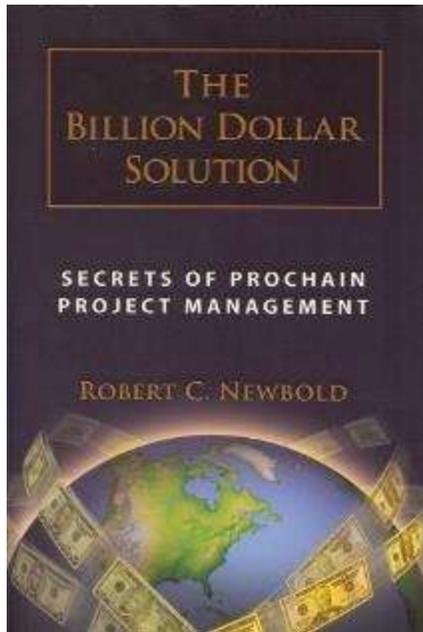

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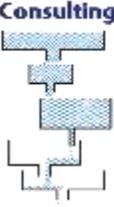


The CCPM reference books

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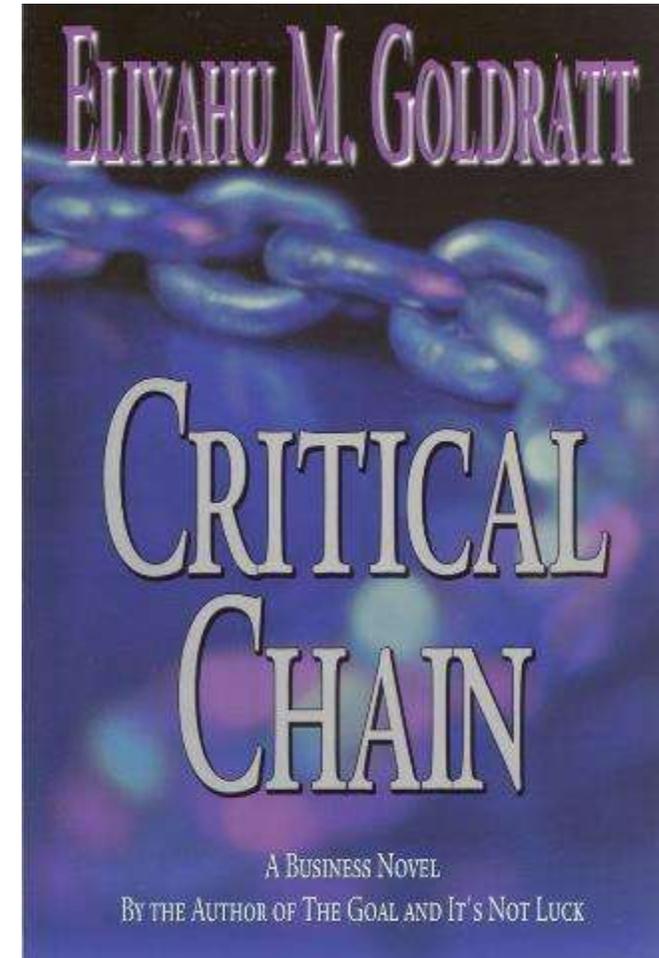
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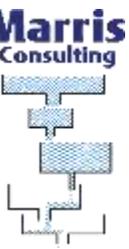


The original book that started it all

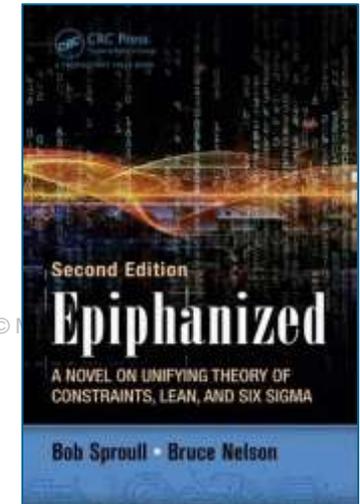
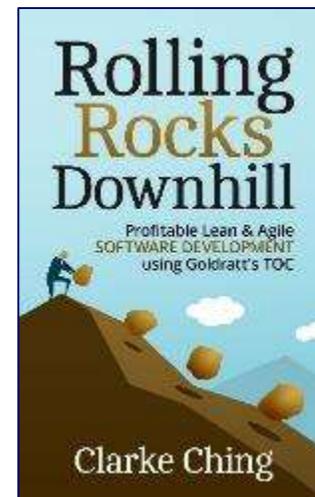
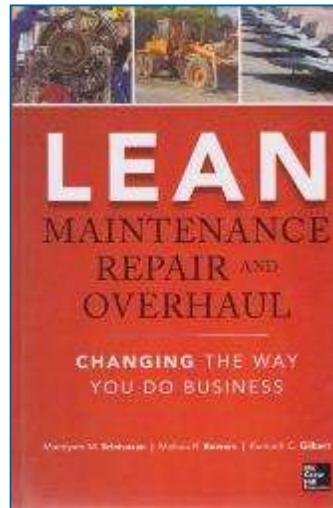
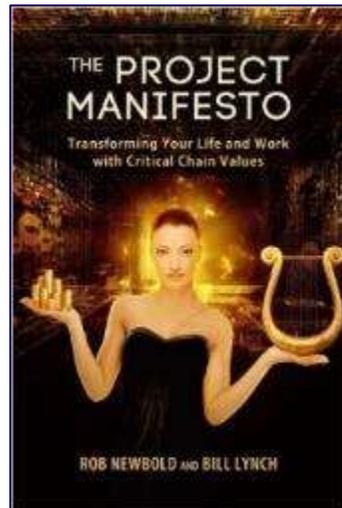
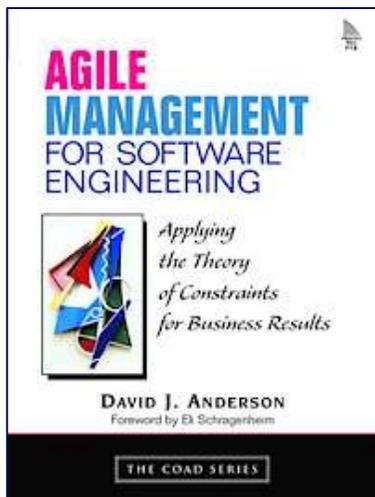
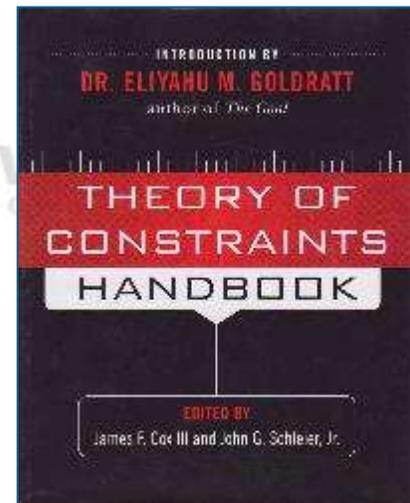
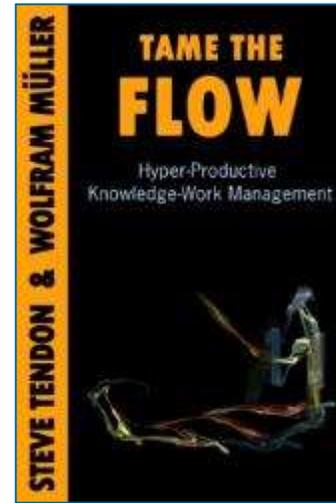
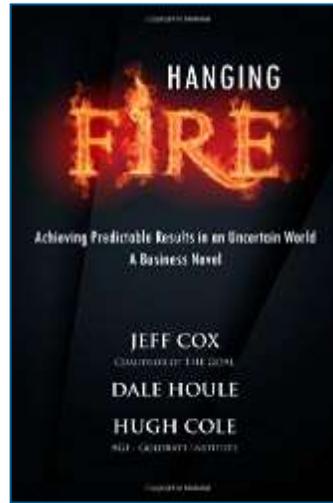
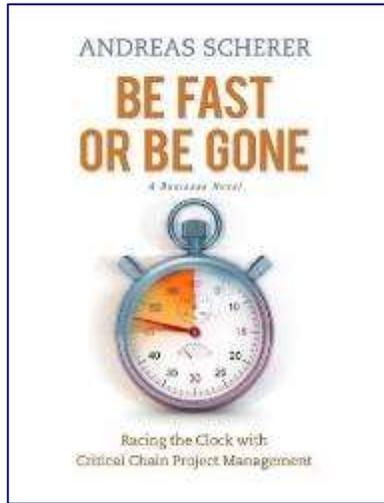
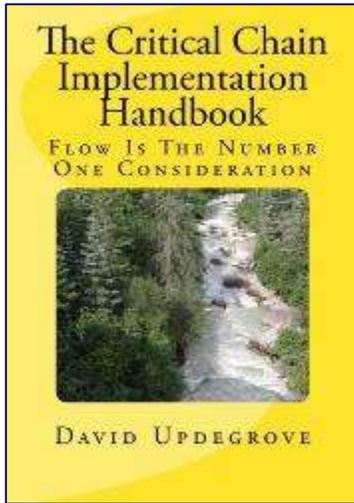
- This is the original book written by Eli Goldratt who "invented" CCPM
- Eliyahu Goldratt
- Exists in several languages
- Scenario
 - An MBA professor gives a project management course in which they "discover" the Critical Chain way. He uses the "Socratic" technique. By addressing a class comprised of many different project environments (building, New Product Development, Software, ...) it conveys how generic the solution is.
 - It is not Eli Goldratt's best book. For instance part of the book covers the problems of MBAs and higher education.
- It is mandatory reading for anyone seriously envisaging or involved in CCPM.

Warning: this book is incomplete since it only covers single project management. It does not deal with project portfolios.





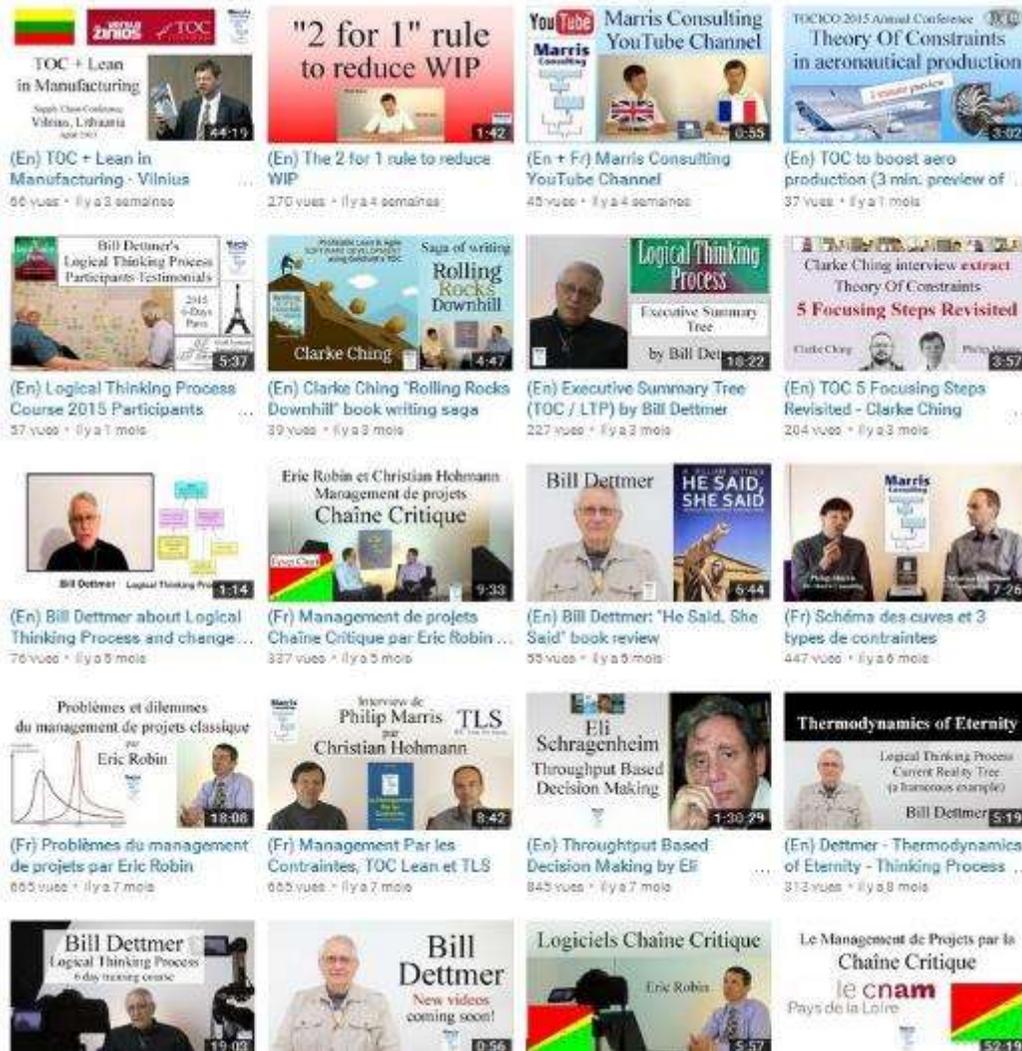
Other CCPM books





Marris Consulting's YouTube Channel

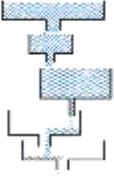
<https://www.youtube.com/user/marrisconsulting/videos>



To facilitate viewing and video selection use the playlists:

- English videos
- Critical Chain videos
- Etc.





Theory of Constraints

marketing & awareness activities



- >250 free videos (YouTube Channel)



- 5 Permanent news websites (www.Scoopit.com)

- Theory Of Constraints (English & French)
- Critical Chain in (English & French)
- TLS: ToC + Lean + Six Sigma



- Discussion Groups (LinkedIn)

- Critical Chain
- TLS: ToC, Lean and Six Sigma



- Others:

- Twitter, Facebook, dedicated websites in French, etc.



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TOCICO CCPM Portal

(Theory Of Constraints International Certification Organization)

https://tocico.site-ym.com/?page=project_portal

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Welcome to the TOC in Project Management Portal

Success Stories » Project Management Portal



We're excited to provide free access to 6 of the 87 (and growing) Theory of Constraints (TOC) project management presentations ranging from a workshop presenting the basics of critical chain project management (CCPM) to its use in information technology and software development projects, to and implementations in the Lithuanian government Department of Economy, in a pharmaceutical research and development center and in a massive maintenance, repair and overhaul center for a large airline. These selections illustrate the universal use of CCPM across industries and across geographically separated and

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The screenshot shows a list of articles and presentations on the right side of the website. Each item includes a thumbnail image, a title, and a brief description. The items are:

- Introduction to TOC**: A presentation explaining the Theory of Constraints (TOC) and its application in project management.
- TOC in the Lithuanian Government Department of Economy**: A presentation detailing the implementation of TOC in a government department.
- TOC in the Lithuanian Pharmaceutical Research and Development Center**: A presentation describing the use of TOC in a pharmaceutical R&D center.
- TOC in the Lithuanian Massive Maintenance, Repair and Overhaul Center for a Large Airline**: A presentation illustrating the application of TOC in a large-scale maintenance center.

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

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Logical Thinking Process



Lean Management

Theory of Constraints

Critical Chain Project Management



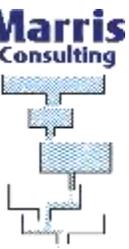
Lean Engineering





Marris Consulting is honoured to have been able to help...

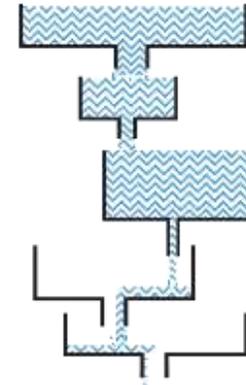




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