TLS
Theory Of Constraints + Lean + Six Sigma
- Point of View -
TLS: Theory Of Constraints + Lean + Six Sigma
Combining the best of each approach

- Theory Of Constraints (TOC)
  - Focus on improving the system constraints that determine overall performance…
  - …and in this way significantly boost the return on investment and success of Lean & Six Sigma programs
  - Increase profits by increasing sales rather than by cutting costs and hence avoid headcount reductions
  - Developed by Eliyahu Goldratt in the 1980s

- Lean Manufacturing / Toyota Way
  - By far the most widespread approach in industry throughout the world
  - A focus on eliminating all forms of waste
  - A multi-dimensional approach: management, Just-In-Time, 5S, Lean Engineering, …
  - Developed by the Toyota Motor Company in the 1950s, called “Lean” since 1990

- Six Sigma
  - Reduce process variability to 3.4 defects per million occurrences
  - Mostly implemented using certified experts Green Belts, Black Belts, …
  - Includes a powerful tool to be used on important and complex problems (Design Of Experiments / DOE)
  - Promoted by Motorola & General Electric in the 1980s.

- TLS: TOC + Lean + Six Sigma
  - Developed in 2006
TLS: a winning combination

Industrial improvement efforts over the past 20 years have been handicapped by quarrels concerning the relative merits of the different approaches and of the supposed incompatibilities or fundamental differences among them.

TLS considers, on the contrary, that we should seek to combine them thereby creating a system that contains the best aspects of each movement.

Each school of thought
– Lean, Six Sigma & TOC –
has proven its effectiveness,
otherwise they simply wouldn’t exist

In combination they are formidable.
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The Theory Of Constraints gained its global recognition because of the success of the best selling “business thriller” *The Goal* by Eliyahu Goldratt

- Over 5 million copies sold in 26 languages. Mandatory reading in most universities/MBAs/…
- Written by Eliyahu Goldratt the founder of TOC & Jeff Cox.
- The first book of its kind, a novel to explain a new approach to management.
- Chosen as one of the 25 most influential business books by Time magazine in September 2011.
Focus on improving the system constraints that determine overall performance

- Factories, companies and other organizations inevitably have unbalanced capacities; 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 less of finished goods (lost sales)

- One hour gained on a non-bottleneck is an illusion.

**Sometimes referred to as:**

“99% - 1% focus”

(i.e., more focused than the 80/20 Pareto principle)

**The sum of local optimums is not equal to the global optimum**
TLS suggests different rules for bottlenecks and non-bottlenecks

<table>
<thead>
<tr>
<th>Rules for bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The capacity of the bottleneck determines achievable due dates and paces release of work into the system for maximum throughput.</td>
</tr>
<tr>
<td>• Improvement actions (Lean &amp; Six Sigma, …) and eventually investments are focused on the bottleneck.</td>
</tr>
<tr>
<td>• The bottleneck is protected from problems in the environment (with a buffer of products) so that it is never starved for work.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Rules for non-bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Adapt and regulate their activity to the requirements of the bottleneck.</td>
</tr>
<tr>
<td>• Launch improvement actions on these resources when they are the cause of delays in feeding the bottleneck or generate quality problems.</td>
</tr>
<tr>
<td>• Convert their excess capacity into flexibility so that the Work In Progress (WIP) and the production cycles can be further reduced.</td>
</tr>
</tbody>
</table>
Control the product flow with the Drum Buffer Rope (DBR) mechanism

Sets the pace of the system

**Drum**

**Non-Bottlenecks**

**Bottleneck Resource**

**Non-Bottleneck**

**Raw Materials**

**Y**

**Y**

**Y**

**X**

**Y**

**Y**

**Y**

**Finished Goods**

**Rope**

Defines when to release work into the system (avoids the build up of excess WIP and its associated costs)

**Protection**

**Buffers**

Defines when to launch a product into the system (avoids the build up of excess WIP)
The 5 step process of on-going improvement of the Theory Of Constraints

1. Identify the constraint (bottleneck)
2. Decide how to exploit the constraint
3. Subordinate all other decisions to the above
4. Elevate the performance of the constraint
5. If the constraint has moved (changed) go back to step 1.

Warning:
do not let inertia slow down or halt this improvement process
The “Throughput World”:
increasing profits by increasing sales rather than focusing on reducing costs

- TOC identifies 3 key business indicators:
  - *Throughput*: the money produced by sales (sales minus Total Variable Cost)
  - *Inventory*: the money invested in the system (not just materials)
  - *Operating Expenses*: the money required to convert Inventory into Throughput.
  - There are referred to as: *T, I & O.E.*

- This aspect of TOC is often referred to as the difference between the “Cost World” and the “Throughput World”.

- The Theory Of Constraints recommends increasing sales to improve profitability rather than by focusing on cost reductions. It is especially critical of reduction in headcounts (direct or indirect labor).

- This aims, among other things, to avoid the vicious downward spiral of improvements in productivity triggering reductions in personnel which then discourage the remaining staff from generating further improvements.

- TOC is a growth model. This is too often ignored by companies on a Lean journey.
The history of the Theory Of Constraints

1970
A production scheduling software and a « Thoughtware »
OPT

1984
A first novel
The Goal*

1988
A new name for this approach
Theory Of Constraints
or TOC

1994
A sequel to The Goal
It's not luck*

1997
A book that presents
a new approach to
Project Management
Critical Chain*

2005
A new TOC service offering
Viable Vision

2010
The Choice*
The TOC Handbook

2008
Isn't it obvious*
TOC applied to
Distribution

2011
Death of
Eli Goldratt

• Eliyahu Goldratt’s main books

NB. The author Philip Marris joined Eli Goldratt’s organization (Creative Output at that time) in 1986, he helped translate the novel The Goal in to French, later in 1994 he published a book in French (Le Management Par les Contraintes) on TOC applied to manufacturing.
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The 7 possible sources of waste: the 7 *mudas*

<table>
<thead>
<tr>
<th>Source of Waste</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rework</strong></td>
<td>Repeating a process or correcting a faulty process</td>
</tr>
<tr>
<td><strong>Over Production</strong></td>
<td>To produce too soon or in excessive quantities with regards to the market requirements</td>
</tr>
<tr>
<td><strong>Unnecessary movement</strong></td>
<td>Unnecessary movement of products or people</td>
</tr>
<tr>
<td><strong>Unnecessary transport</strong></td>
<td>Unnecessary transport of products</td>
</tr>
<tr>
<td><strong>Waiting</strong></td>
<td>A product that sits idle awaiting the next operation</td>
</tr>
<tr>
<td><strong>Excess stocks</strong></td>
<td>All products, parts and materials over and above what is strictly necessary to fulfill client orders in the quantities required and at the date specified</td>
</tr>
<tr>
<td><strong>Excess work</strong></td>
<td>An action or operation that does not add value to the product</td>
</tr>
</tbody>
</table>
The TPS (Toyota Production System) “house”

- **Client Satisfaction**
- **Employee Satisfaction**
- **Teamwork**
- **Right first time**
- **Quality At the source**
- **Continuous improvement**
- **Waste reduction**
- **Just In Time**
- **Production leveling (Heijunka)**
- **Stable and standardized operations**
- **Visual Management**
- **Shared values throughout the organization**
Kaizen, a process of on-going improvement through small incremental steps

| 1. Results | • Small changes with long lasting benefits |
| 2. Pace | • Small but regular improvements |
| 3. Time frame | • Continuous and ever growing |
| 4. Changes | • Gradual but constant change |
| 5. Participation | • Everyone participates |
| 6. Approach | • Team oriented systematic approach |
| 7. Method | • Maintain and improve performance |
| 8. Implementation | • Common sense changes quickly implemented |
| 9. Practical demands | • People commitment but little or no investment |
| 10. Orientation | • People |
| 11. Success criteria | • Results are measured in terms of efficiency |
| 12. Advantages | • Functions well in a slowly growing economy |

|  INNOVATION |
| • Quick and significant |
| • Big stops |
| • Intermittent and discontinuous |
| • Abrupt and major |
| • Driven by Champions for Improvement |
| • Unshakeable individualism, passion for new ideas, and persistence |
| • Tear down and rebuild |
| • Technology breakthroughs, new inventions, and new theories |
| • Large infrastructure investment |
| • Technology |
| • Results are measured in terms of profit |
| • Better adapted in a rapidly growing economy |

Source: KAIZEN by Masaaki Imai, [refs]
The Toyota “Model” or “Way” has many different facets including a philosophy

The history of Lean

- Lean manufacturing is attributed to the Toyota Motor Company. In the 1950’s Toyota developed the Toyota Production System or TPS which is generally acknowledged to be the basis of Lean.

- The most well known founders of Lean are: Sakichi Toyoda, Kiichiro Toyoda, Eiji Toyoda, Taiichi Ohno and Shigeo Shingo.

- Lean had the support of W. Edwards Deming in the domain of quality.

- The name “Lean” first appeared in an MIT book *The Machine that Changed the World*

- Today Lean is used in industries throughout the world.
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Six Sigma is comprised of 3 elements

- A goal to reduce process variability to less than 3.4 defects per million occurrences* (Six Sigma references six standard deviations form the mean. The mathematical symbol for a standard deviation is sigma (\(\sigma\)))

- A system of certification of experts: Green Belt, … Master Black Belt.**

- A process improvement cycle: DMAIC: Define, Measure, Analyze, Improve and Control

\[ f(x) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}} \]
The objective of Six Sigma is to reduce the width of the standard deviation.

As the standard deviation decreases the number of defects decreases.

The quality of delivered products is improved.
DMAIC: Process of on-going improvement
Define, Measure, Analyze, Innovate/Improve, Control

- **Define:** All stakeholders, including the customer, agree on the problem and the objective of a solution.
- **Measure:** Measure and record key elements of the process to establish a baseline and gain an understanding of the process.
- **Analyze:** Analyze the data and verify that the cause and effect relationship has been established. Find the root cause of the problem. (causes, not symptoms)
- **Improve* (or resolve)** develop and present logical, documented plans for resolving the problem based on the data. Some standard solutions exit: (Taguchi) for complex problems, or (Poka Yoke, MSP, standards, …) for less complex problems.
- **Control:** Monitor the new process to be sure the problem does not reoccur.
Six Sigma Belts (Levels of expertise)

- **Champion or sponsor**
  - Takes responsibility for Six Sigma implementation across the organization
  - Is a member of the senior management team

- **Master Black Belt**
  - Act as in-house coaches and mentors for Six Sigma activities
  - 100% of their time is committed to Six Sigma

- **Black Belt**
  - Requires 4 weeks of training spread out over 4 months time
  - Is an expert on Six Sigma tools and is an expert on statistics
  - Manages significant process improvement projects
  - 100% of their time is committed to Six Sigma

- **Green Belt**
  - Requires 2 months training on Six Sigma methods
  - Works under the supervision of a Black Belt on large projects
  - Conducts smaller projects independently
The history of Six Sigma

- Motorola developed Six Sigma en 1986.

- The method became well known in the 90’s when, under the leadership of Jack Welsh, General Electric successfully applied. Many large American companies soon followed suit.

- As with *Lean, Six Sigma* inspired W. Edwards Deming notably in his “wheel of quality” cycle but more significantly in his development of Total Quality Management / TQM (Shewhart, Juran, Crosby, Ishikawa, Taguchi, etc.).

- Today, Six Sigma and Lean are used in combination and referred to as Lean Six Sigma or LSS.
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Focus and Leverage:
Concentrate on the 1% of the system that determines 99% of its performance

- By focusing Lean and Six Sigma activities on the constraints that directly impact global performance, the return on investment for these efforts is necessarily higher.
- This method avoids the discouragement that arises when non-constraints are improved without significant impact on global performance.
- TLS provides results that are not only significant, visible in bottom line results, but also very rapidly attained. See for example the scenario in *Epiphanized* (see Appendices)
“Thinking Processes” in TLS

- The “Thinking Processes” of TOC help to:
  - Make the logic of the solution clear and to get buy in for the solution. For example see the “Intermediate Objectives Map” opposite.
  - Clarify situations in which the constraint is not a physical bottleneck but rather a policy constraint that can be eliminated by changing the rules or behaviors.

- See Appendices 3 & 4 in *Epiphanized*. (Sproull et Nelson)
Injecting TOC into a Lean process:
An enterprise, already very Lean achieved a 15% improvement in just one hour

- Case: A worldwide supplier of automotive components already very Lean
- TOC was injected into their Lean system:
  - “One piece flow” was challenged and a buffer of a dozen pieces was implemented in front of the bottleneck in order to protect this resource from minor disruptions (3 minutes or less) in the upstream processes,
  - Management attention was focused on the bottleneck resource (no stoppages for lunch breaks, rapid 5 whys on reoccurring production problems, priority for maintenance, ...).
- Results: >15% improvement in total output of the line in less than one hour.
Metallurgical Enterprise: >20% improvement in sales in 3 months

- Case: a metallurgical factory with more than 1,500 workers.
- TOC identified the bottleneck process as heat treatment (and not the other expensive processes such as the rolling mill)
- Improvement efforts were focused on the bottleneck:
  - SMED (or rather “Process SMED”) was used to significantly reduce the (temperature) change-over times,
  - Six Sigma was used to greatly reduce the variability and reduce the scrap and re-work.
- The Drum-Buffer-Rope method greatly reduced the amount of WIP (>50%).
An excellent case study of TLS in France: les Verreries Brosse

- This case study was written up in the April 12, 2012 issue of l’Usine Nouvelle, an influential French business magazine.

- The enterprise fabricates glass containers for cosmetics and perfumes.

- This is probably the best example of TLS in action in the world today. All three components are fully exploited in the solution:
  - TOC to focus on the bottleneck,
  - Lean in all areas of management and methodology,
  - Six Sigma (Taguchi, Design of Experiment (DOE), etc.) was deployed on the bottleneck.
The history of TLS

- The origin of TLS could be attributed to a seminal article published in the March 2006 issue of APICS* magazine:
  - Continuous Improvement Trio: The top elements of TOC, lean and six sigma make beautiful music together by Russ Pirasteh & Kimberly Farah

- Since then several books on TLS have been published. (see the bibliography in the Appendices)

- Today, the principle supporters and developers of TLS around the world are: Robert E. Fox, Bruce Nelson, Russ Pirasteh & Bob Sproull.
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TLS books: 2 business novels

- *Epiphanized* by Bob Sproull & Bruce Nelson (2012)
  - While taking the form of a novel to get the ideas across there are also 1100 pages of technical material which explain in detail the principles of TLS, Throughput Accounting, the Thinking Processes, the Replenishment Model, DBR (Drum – Buffer – Rope), & Critical Chain Project Management, etc.

  - A business novel which describes how to combine the three approaches. This novel lays out an interesting case of a double bottleneck. During the course of the novel the actors solve both a managerial constraint as well as a production constraint.
TLS reference books:

- *Profitability with no boundaries* by Reza Pirasteh & Robert E. Fox (2010)
  - Written by two well respected authors this book is principally a reference book for exploring the details of integrating TLS into an enterprise. It introduces iTLS® a systematic method for integrating the three components.

- *The Ultimate Improvement Cycle* by Bob Sproull (2009)
  - Written by one of the co-authors of *Epiphanized*. Recent (2009). The author is probably the most experienced implementer of TLS in the world.
Theory of Constraints books:

- *The Goal* by Eliyahu Goldratt
  - The first use of the business novel as a format for explaining a management process. It has sold more than 3.5 million copies in 29 languages and is required reading in most MBA programs.
  - Eli Goldratt is the founder of the Theory of Constraints (TOC) approach. His book The Goal was selected by Times Magazine in 2011 as one of the 25 most influential business books ever written.
  - Required reading

- *Viable Vision* by Gerald Kendall
  - An excellent executive summary that presents many aspects of TOC that are important in understanding TLS including: Critique Chain Project Management, the Thinking Processes, Mafia offers, Replenishment, etc.
Lean Manufacturing books:

- *The Toyota Way* by Jeffrey Liker
  - The reference book on the Toyota way, recent and well written. It describes the complete approach as used by Toyota. Liker has written several other books for those who wish to go even deeper in the Toyota method Toyota Culture, Toyota Talent, Toyota, Toyota Continuous Improvement, …

- *The machine that changed the world* by J. P. Womack, D. T. Jones & D. Roos
  - In spite of its age (1990) it is still pertinent and is worth rereading for the wealth of comparative information it contains on Lean development in Europe, the United States, and Japan. The first known reference to the term “Lean” for this method of production is found in this book.

- *Toyota Kata* by Mike Rother
  - A recent (2009) book, well appreciated by practitioners of Lean, it goes well beyond the fundamentals.

- *The Toyota Spirit* by Taiichi Ohno
  - Written by Taiichi Ohno and originally published in 1990, this book is no longer in print. It marked the debut of Toyota’s Lean philosophy in France. Taiichi Ohno is one of the founders of Lean.
Six Sigma books

- *The Six Sigma Way* de Pande, Neuman & Cavanaugh
  - One of the best reference books on Six Sigma.

- *Six Sigma* de Maurice Pillet
  - Actually, the French reference that present exhaustively the approach
On www.linkedin.com:
Group: TLS – TOC Lean Six Sigma
The oldest and most established LinkedIn group on the topic of TLS. Almost all of the world’s experts on TLS are members of this group.
Useful web link: a information website dedicated to TLS
To get the latest news and use the best web sources when surfing

www.scoop.it/t/tls-toc-lean-six-sigma
Topic « TLS – TOC, Lean Six Sigma »
The combination of Lean, Six Sigma and Theory Of Constraints. How to build your own system by choosing what works for you.
Useful Web Links: Sites and blogs

- Blog « *Focus and Leverage* » de Bob Sproull
  - www.focusandleverage.blogspot.fr

- Site *iTLS* de Russ Pirasteh
  - www.itls-iso.com

- Article « *Increase Lean Six Sigma’s Power with TOC and Systems Thinking* » de Michael Higgins

- Article « *The Theory Of Constraints: To accelerate your Lean program and generate growth* » by Philip Marris
Philip Marris, the author of this document, is the founder and Managing Director of Marris Consulting.

Marris Consulting conducts regular training courses in TOC, TLS, Critical Chain project Management, and other related areas of practice. The courses are delivered in Paris but can be arranged to be conducted at other sites.

Marris Consulting has conducted over 100 engagement in transforming industrial enterprises in France and around the world.

The firm is recognized as an expert in Theory of Constraints. Philip Marris is the author of the TOC reference book in French: *Le Management Par les Contraintes*. A new edition of this book is in the works. Philip is English and worked extensively with Eli Goldratt in the formative years of TOC.

Company websites (English versions of these sites will be available soon)

- www.management-par-les-contraintes.com
- www.chaine-critique.com

Founded in 2005 Marris Consulting augments its in house staff with a large network of TOC practitioners around the world.

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