

Theory of Global Optimization - The Science Behind the Theory of Global Optimization in the Printing Industry

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Abstract

Increased throughput with existing resources is the key to increased profitability, and the negative trends of today's economic and digital realities are forcing printing businesses to reevaluate their management strategies. This paper describes how applying the Theory of Global Optimization (TGO) and TGO-designed software tools remedies the problems of decreased profitability due to a changing world, a changing demand for print, changing production processes, shorter runs, lower prices, higher costs, shorter lead times, increased make-readies, too much waste, and increased variety and complexity of products produced.

The Theory of Global Optimization is the science of managing a printing or packaging operation with a global view. The three foundation principles of TGO recognize that a manufacturing operation is a chain of interdependent links; that only a few constraints control the throughput, on-time delivery, and cost of the entire operation; and that by identifying and removing or managing the constraints, you increase throughput and profits. By identifying the constraints proactively, the impact of those constraints is minimized, resulting in better processes, improved capacity utilization, higher throughput, and improved profitability.

The TGO theory is put into effect with a unique software tool that employs an interactive, graphical approach to provide a global view of the company in real time. Using business and production rules to automatically minimize switchover and setup times, TGO-designed dynamic scheduling software communicates with

all other systems in the workflow, including JDF-enabled equipment, to synchronize and optimize every aspect of production. This leads to higher profit margins through improved on-time delivery; optimized capacity utilization; reduced waste in time, materials, and processes; and increased throughput using existing resources.

TGO is not a production strategy; it is an end-to-end workflow improvement strategy that yields benefits in acquisition, administration, planning, production and delivery. When TGO is implemented with big-picture training and motivation, the culture of the company is transformed; everyone performs with the global view in mind, and everyone performs smarter.

Introduction

Lean manufacturing is defined by Wikipedia as “a systemic method for the elimination of waste within a manufacturing process.” For many businesses, the Lean philosophy was a paradigm shift in the 1990s; and for some, it provided significant value. The printing and packaging industries, however, never really embraced Lean successfully as the next big iteration of process improvement. For many reasons, some of which we’ll address here, the paradigm shift experienced by Toyota didn’t yield the same value in our industry. The products and processes of the printing industry varied so much from the products and processes of the automotive industry that much of the science of Lean either did not apply to print or the application was incomplete in its execution. You might say that, for print, the Lean paradigm shift was stuck in low gear.

While many attempted to wedge Lean into the printing industry, one team recognized its limitations and shortcomings and looked for a better mousetrap. That team was led by Udi Arieli, and the science they developed would evolve into the Theory of Global Optimization (TGO).

The Evolution of a Theory

To fully understand TGO and its value to the printing and packaging industries, we must look at the evolution of the theory and how it has become a working, proven science for process improvement.

The Theory of Global Optimization was developed by Udi Arieli and his team and was first applied to print management in the development of PrintFlow® Dynamic Scheduling. Arieli grew up in the printing industry in Israel. He worked in the family printing business, became a third-generation owner/operator and was active in printing organizations in Israel. Although printing was in his blood, even as a child he aspired to be an inventor, “Every day I was thinking, what could I invent and how can I change the world? I enjoyed challenging and rethinking known theories.” Printing and creative thought would become his career and his passion.

In 1977, Arieli became the vice chairman of the Printing Industry of Israel. The minister of Commerce and Industry in Israel asked him to join a special committee to find better ways to calculate hourly rates because of low profitability in the printing and other small plant industries. Many believed that the reason for low prices and unfair competition were due to the fact that companies did not know their real costs. Arieli became an hourly-rate expert, implementing new costing and pricing practices in his own company and teaching many printing businesses how to better manage their operations.

Through this experience, he realized that printing businesses needed two things: a more advanced business theory and smart software tools to manage the complex challenges they faced. He said, “In 1979, while serving my yearly army service, I had some free time and I started thinking about the whole profitability subject more and more. I soon realized that profitability was not determined by an hourly rate. It was the direct result of the efficiencies of manufacturing. And, the best opportunity for a business to succeed lies in its ability to optimize its operation on a global basis.” It was these revelations that led to his development of the foundations of TGO.

Arieli saw that the modern printing establishment (like many manufacturing businesses) had multiple, interdependent processes – some were serial and some were parallel – making manual or analog-based decision making nearly impossible. To address these challenges, he explored the teachings of the leaders in process improvement and control.



1801: Eli Whitney
Mechanization in farming • *Interchangeable Parts*



1913: Henry Ford
Automotive assembly lines • *Lean*



1950: Edward Deming
Process control for industry • *Just in Time*



1984: Eliyahu Goldratt
Constraints Manufacturing • *TOC*



1978 to Present: Udi Arieli
Global Optimization in Print • *TGO*

Each major leap forward was the result of an innovative thinker

Arieli was inspired by the work of these predecessors, including Goldratt's *Theory of Constraints (TOC)*. But he learned that all of them still fell short of providing a solid, implementable solution for print. None understood the unique workflows and complexities of a printing business. Lean, for example, focuses on reducing Work-In-Process (WIP), not realizing that printing businesses can actually increase capacity utilization with larger queues. Additionally, queues that are organized (synchronized) according to production characteristics can reduce setup/make-ready time, further increasing throughput. Because print jobs are typically priced based on operational standards, any process that increases throughput and/or minimizes the work required will have a positive impact on profitability.

Arieli also understood that many attempts to apply Lean principles to the shop floor fell short due to lack of tools designed to support the theories. In 1984, he founded a company dedicated to the development of intelligent production management solutions for the printing industry. After developing a print-specific Management Information System (MIS), he concentrated on advancing the development of TGO with the development of dynamic scheduling software. Thirty years later, the foundation principles he developed still hold true, and both the theory and the tools have been refined and improved.

The Principles of TGO

The Theory of Global Optimization is the science of managing a printing or packaging operation with a global view. The three foundation principles of TGO recognize that:

- A manufacturing operation is a chain of interdependent links.
- Only a few constraints control the throughput, on-time delivery, and cost of the entire operation.
- By identifying and removing or managing the constraints, both throughput and profits are increased.

Since throughput is far more important than job costing or cost accounting, profitability is created by the sum of all jobs, not the theoretical profitability of individual jobs. Likewise, higher productivity in a single cost center does not necessarily lead to higher profits. In fact, the highest level of profitability occurs when your entire workload is orchestrated to avoid constraints, maximizing throughput and improving productivity across the board.

The Foundation of TGO

In summarizing Lean, Wikipedia boils the philosophy down to this statement: *“Essentially, lean is centered on making obvious what adds value by reducing everything else.”* This is a philosophy that is more easily applied to a linear manufacturing process, where each step can be critiqued and evolved or eliminated. In the printing and packaging industry, where the workflow is redefined with virtually every job, the ability to focus on a single task or work center is limited by the very nature of the operation. The printing press may add the highest level of value to a job, but the value is only realized if every other process defined for the individual job performs at an optimum level. (A chain is only as strong as its weakest link.) Poor performance in the finishing process, for example, could essentially eliminate all value added at the printing press.

TGO begins and ends with a wider yet more focused perspective of the printing process.

The global view: The wider perspective of the plant must prevail over the narrower focus of a single job, customer, or cost center. We must manage capacity in the most logical and systematic order possible. Our focus must be on the identification and resolution of constraints before they decrease capacity and throughput.

Optimization: Our management process must recognize that any change in the planned workflow for a single job can affect all other processes planned for that job and for all other jobs. Therefore, all steps for all jobs must be optimized and synchronized in all areas to produce the highest level of performance and throughput. We cannot schedule a single department and expect optimum performance from all departments. We must schedule and optimize every work center, not just constraint work centers.

TGO addresses business and production processes as a single system: Many businesses separate business and production processes, utilizing a management system for the office and production forms or other processes for collecting data on the shop floor. Production management is separate from office management and, in most organizations, sales operates as a separate entity as well. Each group operates almost as an autonomous organization and has its own processes and priorities. Their differences are often argued in a daily production meeting. TGO rec-

ognizes that silos of operations create constraints. To succeed, these silos must be eliminated and data must flow seamlessly throughout the business. As the salesperson works with the customer, the data he or she collects must be validated and shared, eliminating the need to rekey or recreate the information downstream. When we use smart software as the vessel for sharing this information, everyone is using the same data, we eliminate re-interpretation of the information and potential errors—and possibly rework—that can occur as a result, we eliminate communication-related non-chargeable work, and we improve overall office and shop floor performance.

Cultural changes: The successful implementation of TGO requires engagement at all levels in the printing and packaging business, from the C-level to middle management, to every person in the office and on the shop floor. TGO is not a production strategy; it is an end-to-end workflow improvement strategy that can yield benefits in acquisition, administration, planning, production and delivery. When TGO is implemented with big-picture training and motivation, everyone starts to think differently... everyone performs smarter.

The heart and soul of an organization is its culture. If you capture that in conjunction with the global view, you can take any company to heights you never imagined. If your workforce does not understand the global view and how each of them is an interdependent link within that view, they will constantly be pushing and pulling each other in the wrong direction. A negative culture usually has a negative output and does not concern itself with the greater good. A positive culture that believes all links in the view must work together to optimize and maximize output will typically deliver a positive result. This almost always results in a stronger bottom line as well as a workforce that is more agile, capable of adapting to the fast pace and ever-changing world of print.

Constraint management versus bottleneck elimination: On-time delivery is not determined by the most efficient cost center, but by the largest constraint. It is important to distinguish between bottlenecks and constraints – they are not the same. Bottlenecks are not always bad. Certain bottlenecks (queues) can be beneficial as long as they do not create constraints. Don't focus on eliminating bottlenecks. Instead, focus on managing the bottlenecks that cause the constraints.

On the production line, a bottleneck occurs when you have many jobs in the queue (waiting to be manufactured in a designated cost center) and you don't have enough time (available capacity) to manufacture all of them. Bottlenecks are positive in most cases, because they allow your business to group similar jobs together. Since all the jobs in the queue are available to be manufactured, this allows smart software like EFI PrintFlow® Dynamic Scheduling to look for similar operations, sequencing them to reduce setup/adjustment time between jobs.

A bottleneck becomes a constraint when it is so large that it is predicted to cause some job to eventually be late, either in the current cost center or in another one downstream. Of all the cost centers participating in the production of a job, the one with the largest queue is the biggest constraint but it may not be the weakest link. The weakest link can often be a downstream cost center or even a planning or management policy. In fact, many bottlenecks occur because the focus is on the production floor and not on the end-to-end workflow. The global scope of TGO must begin with the acquisition process and follow a job through estimating, planning, scheduling, production, delivery and billing. Optimization of all processes will yield a high and sustainable return.

Smart scheduling: You can't get sustainable results without understanding all of the pieces of the puzzle. You can't get results with just a theory or a view. TGO requires the implementation of global, automated processes. For example, a dynamic, smart scheduling model that takes into consideration the entire workload, including in-house and outsourced operations, can provide your business with its best opportunity to succeed. Manual scheduling processes (including scheduling boards and spreadsheets) lack the rules-based logic necessary to process the thousands of pieces of information that must be considered in real time throughout the work day. PrintFlow Dynamic Scheduling from EFI, for example, puts TGO into practice by applying both production rules and business rules to the schedule.

Examples of production rules are obvious: for example, a color job is not run on a B/W press; or if a job requires inkjet heads and you have a pool of four inkjet heads that can be used on six binding lines, the job is automatically scheduled to be sent to the binding lines only when the inkjet heads will be available. Examples of business rules are less obvious, but are ubiquitous in the software's toolset, from parallel cost center load balancing to employee skill constraints.

Why cultural changes

A change in one department can affect all other departments. For example, cost center profitability is no longer the basis of job costing. The costing method, which has been accepted as increasing profitability, actually does the opposite because it works against optimization: measuring performance in individual cost centers is done at the expense of the overall health of the business. The natural result of this change is that everyone in the company is focusing on the global view and not on their own isolated piece of the puzzle.

Smart scheduling is also a huge driver of the change to TGO culture. When the schedule is graphically displayed throughout the company in real time, and when schedulers can spend their time managing the workflow in advance rather than tracking down the latest job status, these fundamental changes ripple throughout the organization, increasing transparency, accountability, and communication.

For example, one company who implemented TGO had been a traditional commercial shop, using mechanical and manual systems. This company had very little automation from an equipment standpoint and had significant staffing levels (170 employees). The company posted sales of approximately \$18.5 million during 2007. By the end of 2008, it had successfully implemented TGO along with the EFI Monarch workflow system including PrintFlow Dynamic Scheduling. Even though there have been significant changes to the industry since then, the implementation of TGO has enabled this company to navigate those changes, improve its operations and streamlining workflow. Today this company produces nearly double the volume with 30 fewer employees. The employees are working less, schedules and workflow are optimized and product quality has increased.

For them, automation and TGO has impacted a number of areas of the business. Each department in the organization can provide a different list of how optimization has affected their specific areas of responsibility. The Vice President of Operations states that the biggest and most important impact has been to the bottom line, The entire company has felt the impact of TGO.

Oftentimes companies that struggle just buy new software. Typically they don't implement the TGO thought process into a workflow system. Many times they just seem to get hung up on the minutia and attempt to make a new workflow system process the work the same way they always used to do everything.

*"If you do what you have always done,
you will get the result you've always gotten."
Tony Robbins*

The most successful companies have process mapped their current workflow and start from scratch, using TGO to build a global view as the foundation for new optimized production processes. They then use their newly acquired workflow software to manage the newly defined processes.

This plan requires educating your team and building TGO into the company culture. Getting the management team to understand and accept TGO helps them to think more about maximizing throughput throughout your entire process and not just working in departmental silos. It's a long process to establish a culture of change in an organization, it is doable, and TGO is a huge part of making it happen. Business owners and managers need to understand that when implementing TGO, there is no final completion date. Getting TGO engrained into a company's culture and then building a business that is proactive and responsive to both market and processes changes is a continually evolving process.

Management supported by software intelligence

Throughput management cannot be the result of a static schedule developed early in the production process; it comes as the result of a flexible solution capable of real-time adjustments based on real-world changes within the system.

TGO is unique in that it is the only business development strategy supported by a foundation of smart software. In the real world, the printer doesn't have enough time or resources to manually manage a workflow that includes many jobs and thousands of operations. Smart software is a critical component of any effort to optimize such an environment. The software must be:

- Intelligent (rules-based)
- Dynamic
- Real time
- Integrated with all support processes

Arieli and his team first developed PrintFlow Dynamic Scheduling under the umbrella of TGO. PrintFlow includes optimization and synchronization logic to analyze literally thousands of pieces of information about jobs, promised dates, job paths, operations, setup times, run times, inventory availability, equipment and staff capabilities/availability – orchestrating the best production schedule with the highest level of capacity utilization and throughput.

Additionally, the software has the ability to reanalyze your workflow in the form of a “what-if” scenario based on whatever situation the real-world throws at you. This capability is a critical part of the TGO strategy, giving businesses the ability to proactively respond to situations with a level of business intelligence that is absent in manual or disconnected systems.

Going beyond Lean and TOC

Lean is still popular today. There are literally dozens of books on the strategy, each with its own approach to the science, but its essential elements do not substantially differ from the techniques developed and implemented by Toyota as far back as the 1950s, continuing to focus on the systematic elimination of waste at every level (material, time, idle equipment, inventory, etc.).

The foundation of the science is solid, but its application to print is difficult. While Lean manufacturing looks at specific processes, TGO optimizes the production of the entire company with a global view.

“As noted earlier, the development of TGO was influenced in part by studying other theories like Lean and the Theory of Constraints (TOC), which sparked new ideas for Arieli based the concepts behind these theories and his deep knowledge of print manufacturing.”

The Theory of Constraints is a set of holistic processes and insights. The Theory of Global Optimization refines these processes for the printing and packaging industries. This refinement provides a level of automation and process control capable of maximizing process and profit potential.



Lean	TOC	TGO
Focuses on individual processes within a linear workflow.	TOC focuses on constrained cost centers.	TGO recognizes that all cost centers must be managed and optimizes.
Lean recognizes a process delay as waste in the system.	TOC recognizes one primary constraint that is fixed, or made permanent for a period, allowing you to place large buffers in front of it.	TGO recognizes that the workflow has more than one constraint and that the constraint can be constantly changing. The strategy must include a process for monitoring, identifying and addressing constraints in a fluid system.
Lean does not recognize the impact of a constraint.	TOC does not know the difference between a bottleneck and a constraint.	TGO distinguishes between a bottleneck (potentially beneficial) and a constrained cost center (causing jobs to be late).
Lean manufacturing looks at individual processes.	TOC utilizes Drum-Buffer-Rope (DBR) to balance the flow of the system.	TGO utilizes smart software with scoring algorithms to balance the flow of the system and to maximize bottom-line impact.
Lean focuses on systematic elimination of waste as its primary goal.	TOC only understands the primary constraints, ignoring all other goals.	TGO recognizes that we must find a compromise between all conflicting constraints and goals.

Table 1. Point of View: Lean, TOC and TGO

When theory becomes a science

The first TGO-based product was PrintFlow Dynamic Scheduling. The impact potential of this product has been proven worldwide. EFI is now developing its productivity software under the umbrella of the Theory of Global Optimization.

Algorithms for multiple concurrent constraints use business rules for automatic load balancing on parallel (group) work centers, switchover/make-ready minimization, and capacity utilization and optimization. Algorithms for production rules govern such elements as employee skills and calendars; cost center capabilities, calendars, and tools; and proof dates, material dates, and outside vendor dates.

The TGO process improvement strategy identifies the constraints in a system and focuses resources on the elimination or control of the constraints to improve efficiency and throughput. This process control is critical to the success of the end-to-end management and production workflow, allowing for the delivery of integrated, automated systems that leverage smart software for constraint management in all phases of acquisition, management and production. By identifying the constraints up front, the impact of those constraints are minimalized, resulting in better processes, better capacity utilization, higher throughput and improved profitability.



Figure 1. The global view.

Customer Comments

“I preach TGO all the time, and this document really highlights that TGO is no longer a theory but with PrintFlow has become a true scientific method. If you can understand TGO and deploy it, you can change any company. TGO has challenged me to think beyond the norm. Udi and TGO were probably some of the most important influences in my life; it has changed me and how I think about manufacturing, and it has allowed me to help my company grow almost forty percent in two years. If you approach everything with the global view and create a culture that supports this, success can be achieved at a more rapid pace.”

— **David Baldree**, Director of Operations, Valtim Marketing Solutions

“Having known Udi for more than 30 years, it still amazes me how he is always open and thinking about anything that will improve production process and has never stopped thinking outside the box! While the rest of us get drawn into the day-to-day details, he is an invaluable constant presence in the printing industry, drawing us back to thinking of the global view and TGO.”

— **Judi Hansen**, Director of IT, J.S. McCarthy Printers

“I have known Udi Arieli since 2007. He has long been a proponent for both this industry and manufacturing optimization. We have implemented TGO throughout our operation through the use of PrintFlow. Our experience here at Freeport has been phenomenal. Our business continues to grow, our margins continue to increase, our productivity in our entire operation continues to improve - all this in what many consider to be some of the most challenging times in history for the printing industry. Thank you, Udi.”

— **James Pilcher**, VP of Manufacturing / General Manager, Freeport Press Inc.

Conclusions

For today's printing company to be profitable, cultural and process changes are required due to the trends in both our economic environment and the transition to digital print. These trends can be summarized as follows:

- Economic environment: Lower prices, higher costs.
- Disruptive digital technology: Shorter runs and lead times; increased make-readies, waste, and variety and complexity of products produced.

The goal is to increase profitability, and the only options to achieve this are to increase efficiencies and cut costs. The Theory of Global Optimization rests on the insight that increasing throughput with the same or fewer resources increases profitability. To put the theory into practice requires automated dynamic scheduling that:

- Optimizes production;
- Synchronizes tasks based on operational intelligence;
- Uses business rules to minimize switchover and setup times;
- Provides all employees with a global view of the business;
- Provides all employees with a real-time view of the business; and
- Supports proactive versus reactive management.

This leads to increased profits through better on-time delivery; optimized capacity utilization; reduced waste in time, materials, and processes; and increased throughput using existing resources.

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