BUILDING RESILIENT MANUFACTURING OPERATIONS

Applying the Theory of Constraints from Goldratt's *The Goal* in the Digital Age

MARK J. WOEPPEL

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In Memoriam

I wrote this book during my 67th year. When you get to the 16th hole on the back nine, you think about the holes you played earlier: which ones you birdied, which ones you double-parred, and your penalty strokes. That doesn't mean I only have two more holes to play; I'm a terrible golfer. I have at least 20 more strokes before I finish the game. Double par is my specialty.

In this light, I find myself reflecting on my career and the people who have had a lasting impact. This reflection is similar to thinking about the books that changed your life. I can think of a few people, but only two books. One of them is Eli Goldratt's The Goal.

I had the pleasure of knowing and working with Eli, a friend of mine. You rarely meet someone whose intellect and humanity are so striking that their insight and kindness in sharing leave you awestruck. His ideas about manufacturing turned my path toward a lifetime of learning and teaching. His direct teaching taught me the value of the scientific approach and intellectual honesty.

I would not have been able to write this book without him. I wish I could tell him, but that day has passed, so I dedicate this work to his memory.

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Preface

This book is my story—but not a story in the narrative sense, more of a distillation of what I have learned working in and with manufacturing companies. I assume you have read the book *The Goal* by Goldratt and Cox, and perhaps some other materials on the Theory of Constraints (ToC). So, forgive me if I introduce some terms before fully explaining them. If you are unfamiliar with ToC, read Chapter 2 and then return here.

MY EXPERIENCE WITH TOC

In 1986, while designing a scheduling system for a manufacturing firm in Tulsa, Oklahoma, I was handed a copy of *The Goal*. The timing felt providential. A chance meeting with my friend Dr. Donn Novotny at a trade show led to him gifting me the book and introducing me to Optimized Production Technology (OPT)—the early seed of ToC. I read it and thought, "This makes sense."

I shared the book with my production manager, and he agreed that the approach made sense (after all, his team had to follow the schedules I wrote). We synchronized everything to the motor winding department's capacity using IBM's MAPICS software and a custom scheduling program. The result? Smooth production—and I worked myself out of a job.

Next, I joined Valmont Industries to implement their homegrown MRP2 system[1] in a newly acquired Tulsa division. After 13 months of grueling 10- and 12-hour days, we hit Class A status, but the scheduling was a mess. My phone rang nonstop with shop supervisors venting—often in colorful language—about late

[1] Class A MRP (Material Requirements Planning) is a tool for detailed material planning in manufacturing component parts and their assembly into finished items. Class A MRP users implement MRP in a closed-loop mode, integrating material requirements planning with sales and operations planning (production planning), master production scheduling, and capacity requirements planning. After planning, the execution functions are incorporated. These include production control functions such as input-output (capacity) measurement, detailed scheduling, dispatching, anticipated delay reports from the plant and suppliers, and supplier scheduling.

orders, part shortages, and idle machines. We shipped the product, but it took constant firefighting.

Then fate stepped in again. My general manager (GM) sent me to Brenham, Texas, saying, "They're doing something down there with scheduling. They're making a lot of money. Bring some back for us." During my visit to the Brenham plant, I learned that they had adapted their MRP system to utilize Drum-Buffer-Rope (DBR), a ToC scheduling method, with the assistance of my friend Donn as their consultant. I brought him to Tulsa for a week of training, and we revised our Class A playbook.

It was like flipping a switch; the chaos vanished. My phone went silent, throughput jumped 20%, and excess inventory melted away. We generated so much cash that the GM, wary of corporate scrutiny, filled every reserve account. After three months, the numbers told an undeniable story of success.

That experience launched me into a deeper journey with ToC. I joined Eli Goldratt at the Avraham Y. Goldratt Institute, where I learned I was among the few with multiple successful DBR implementations. ToC evolved during this time, shifting from OPT's focus on scheduling bottlenecks to DBR's practical rhythm for production, to the Critical Chain project management method, and ultimately to a broader framework for managing companies by identifying and leveraging constraints. I became a certified *Jonah*, then a *Jonah's Jonah*, teaching managers to apply *The Goal*'s lessons—often in desperate turnarounds where a 33-year-old like me was their last hope.

Since 1986, I have led ToC implementations across the United States, Mexico, Canada, France, Norway, Singapore, and China—spanning plant turnarounds, product launches, construction projects, and throughput improvement initiatives. I have tackled everything from *house-on-fire* crises to *push-us-in-the-right-direction* nudges. Along the way, I designed scheduling systems, oversaw multi-plant operations, and headed Americas Consulting for the Scheduling Technology Group, the successor to Goldratt's OPT software firm, Creative Output.

This story is not about my resume, but what I have learned. ToC has grown, and I am proud to have played a small role in its evolution. This book distills decades of lessons into practical steps you can use, forged in the chaos of struggling plants and the triumphs of transformation. Every project delivered—some with jaw-dropping leaps, others with steady gains—proved that control, efficiency, and even happiness in work are within reach.

You don't have to stay trapped in chaos. The path forward is in your hands.

Introduction: Is Your Plant Out of Control?

Imagine a manufacturing plant where:

- Chaos reigns supreme—a pressure cooker of frustration and despair that weighs on every soul inside its walls.
- Inventory piles up in one corner and overstocked materials gather dust like forgotten dreams.
- Assembly and aftermarket sales scramble desperately for missing parts, their empty shelves a silent rebuke.
- Unfinished products stack up like a dam blocking a river, choking the heart of production as it stutters—starting, stopping, starting again . . .
- Bottlenecks roam unpredictably from one department to another, day after day, in a maddening game of chasing shadows with no clear culprit.
- Workers stand idle, their hands empty and their spirits crushed, unsure of what to do next as the weight of unmet goals looms overhead.
- Urgent jobs slip through the cracks, and the sting of missed deadlines erases any sense of accomplishment.
- Accomplishment is replaced by bitter arguments between departments that cannot agree on priorities.
- The air is thick with frustration—overworked employees are drowning, battling the same fires they faced yesterday.
- Each new day brings a relentless wave of problems to solve, leaving employees exhausted, demoralized, and questioning their future.
- Customers, once loyal, now seethe with frustration as every late delivery breaks another promise, chipping away at trust and pushing them toward competitors.
- The plant hemorrhages money, with late orders piling up, costs soaring, and revenues plummeting into a bleak abyss.

The management team at this beleaguered plant is not sitting idle—they are as trapped in the quagmire as the frontline workers, their hearts heavy with the same bitter frustration, careening from one gut-wrenching crisis to the next in a relentless storm of despair. It is a brutal place to lead, and they are throwing everything at the wall, desperate for something to stick: an enterprise resource planning system rollout that promises order but delivers only more confusion, a lean manufacturing initiative that sparks fleeting hope before fizzling out under the weight of entrenched chaos, or a frantic reshuffling of the organizational deck—pushing accountability down to the shop floor one day, only to yank it back up to the C-suite the next, swinging wildly between centralized control and decentralized dreams. Each effort feels like a lifeline, but the problems, those stubborn, soul-crushing problems, only shrink momentarily, lurking in the shadows, never truly vanquished. The team's spirit erodes with every false dawn; their efforts are a cruel mirage, as they are swinging at symptoms while the root cause festers unseen, mocking their every move with its unyielding grip on the plant's broken soul.

FROM CHAOS TO CONTROL: THE FIRST STEP IN TRANSFORMATION

Do you think all your problems are separate from each other? They are not. All those symptoms of chaos are connected. Mastering the flow of work begins with recognizing the system's constraint, which serves as the focal point for the team. When the heart of the factory beats steadily, the entire body thrives. Productivity soars, but more than that, the team breathes easier, confidently hitting their targets. It is not just about numbers—it is about reclaiming a sense of control and pride in their work. Gaining control of the order fulfillment process is the critical first step in using the Theory of Constraints (ToC) to transform chaos into control, setting the foundation for a far greater journey.

THE STRATEGIC GOAL: BUILDING HIGHLY RESILIENT AND RELIABLE OPERATIONS

Gaining control is only the beginning. This book takes you beyond firefighting to a strategic transformation of your enterprise, using ToC to create highly reliable and resilient operations that deliver competitive dominance. In today's hyper-competitive landscape, reliability is not just a metric—it is the cornerstone of market leadership. Research published in the Harvard Business Review (Corsten and Gruen, 2004) shows that retailers lose nearly half of their intended purchases due to stockouts, resulting in 4% annual sales losses—potentially $40 million for a billion-dollar retailer. Late deliveries erode trust, delay revenue, lose high-value clients, and relegate you to lower-margin business. By mastering reliable delivery with ToC, you become the supplier of choice, securing long-term contracts, boosting revenue, and enhancing profitability—an advantage competitors cannot easily replicate.

Mazda Motor Corporation halved product development time, reinvigorating team energy and transforming its culture. Sanmina SCI achieved 89% cost savings through ToC productivity projects, compared to less than 10% with Lean or Six Sigma alone. British Petroleum saved over $700 million during the Macondo oil spill cleanup. Spirit AeroSystems reduced overtime, saving $2.8 million annually while increasing resilience. FMC Technologies cut inventory by 50%, saving over $2.8 million annually while increasing throughput by $4.8 million. Brown Fintube achieved a 95% on-time delivery rate through ToC's production system, securing customer trust. These case studies, detailed throughout this book, demonstrate the versatility of ToC—it works in both crisis and stability, delivering immediate results and long-term resilience through reliable delivery.

THE NECESSITY OF RELIABILITY AND RESILIENCE FOR SUSTAINED SUCCESS

Reliable delivery must be underpinned by resilience—the system's ability to adapt, respond, and recover from disruptions, ensuring operational continuity under stress. Resiliency encompasses flexibility in the face of unexpected events, rapid recovery from failures, and adaptability to changing conditions. It is critical for financial stability, strategic planning, growth, employee morale, customer and supplier trust, and market competitiveness. The ToC Production System (ToCPS) prevents late orders, secures revenue, and demonstrates your ability to deliver outcomes to investors and customers. The service-profit chain research from the Harvard Business Review highlights that high-quality service, particularly dependable delivery, is directly linked to increased profitability, providing solid evidence that building reliability yields a strong return on investment. Timely delivery enhances customer loyalty, boosts market share, and improves financial performance, allowing you to command higher prices to strengthen your market position.

THE THEORY OF CONSTRAINTS: A STRATEGIC FRAMEWORK FOR TRANSFORMATION

Since my 1999 book, *The Manufacturer's Guide to Implementing the Theory of Constraints*, ToC has evolved from a scheduling algorithm targeting bottlenecks to a strategic framework for building resilient, profitable manufacturing systems.

Building on Goldratt's foundational work, I integrate insights from Orlicky's material planning, Juran's quality principles, and Drucker's management strategies, validated by scholarly research on supply chain resilience and continuous improvement, to create a unified manufacturing management system. Today, a *constraint* encompasses resource capacity, market demand, management policy, and managerial beliefs; however, in this book, I focus on the Capacity Constraint Resource (CCR) for production systems. ToC integrates seamlessly with Lean and Six Sigma, leveraging empirical data to drive strategic and tactical decisions while measuring cause-and-effect relationships to enhance plant resiliency.

ToC clarifies the purpose of production, which is often conflated with a narrow view of financial success through cost management. Typically, product costs are meticulously tracked via headcount, labor efficiency, resource utilization, machine uptime, and yield—essential metrics that focus on expenses rather than profit. Contrary to the belief of many, the production department does not generate profit; it consumes it. Only the enterprise can achieve profitability; production's sole purpose is to transform inventory into throughput—the rate at which your plant generates revenue through sales. ToC measures productivity as the ratio of throughput to operating expense, necessitating a delicate balance for assessing past performance and forecasting future profitability. Effective production, guided by ToC, drives throughput while managing expenses, positioning your organization for sustainable profitability. This clarity is transformative, aligning production with your company's goal of maximizing profits now and in the future, ensuring that resources are optimized for revenue generation and cost savings—a critical step in building a resilient and responsive enterprise.

HOW TO USE THIS BOOK

Building Resilient Manufacturing Operations is your definitive guide to mastering ToC, thereby turning chaos into control, whether you are a plant manager battling daily fires or a leader pursuing market dominance. My four decades of ToC implementations fill a critical gap in ToC literature, uniting its concepts into a comprehensive manufacturing management system. Structured in three parts, this book serves as a strategic roadmap and a practical workbook. Part One: Concepts and Foundations (Chapters 2–6) grounds you in core principles, such as the Five Focusing Steps and constraint identification, revealing your plant as a unified system. Part Two: The Theory of Constraints Production System (Chapters 7–13) applies ToC to production, equipping you with tools such as Drum-Buffer-Rope and Demand-Pull to achieve unshakable delivery reliability. Part Three: Implementing the ToC Production System (Chapters 14–18) delivers a step-by-step transformation plan, with case studies and templates to align teams and sustain results. Picture your plant transformed: inventory slashed by 50%, as FMC Technologies achieved, or throughput soaring with 89% cost savings, as Sanmina SCI did. With ToC, you will become the supplier of choice, commanding trust and premium prices. Start with the Gulf Spill case study in Chapter 1—where ToC saved $700 million in a crisis—and take control of your plant's future today.

Acknowledgments

I am deeply grateful to those who have contributed to this work. I stand on the shoulders of giants.

—Eli Goldratt and the team at Goldratt Consulting created the Reliable Delivery strategy and tactics trees.

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—Illustrative credit: Farhan Shahid.

About the Author

Mark Woeppel is an internationally recognized expert in the Theory of Constraints (ToC), with a distinguished career spanning over three decades in manufacturing, project management, and supply chain optimization. As the president and CEO of Pinnacle Strategies, a global management consultancy, he has driven transformative results for organizations ranging from Fortune 100 companies to small businesses across various industries, including graphic arts, automotive, oilfield equipment, and electronics. His innovative approaches, including the development of the Project Execution Maturity Model and Visual Project Management software, have delivered remarkable outcomes, such as a $700 million cost savings for BP during the Gulf spill cleanup and a 600% profit increase for Dixie Iron Works. Woeppel's thought leadership is evident in his extensive publications, including influential books such as *The Manufacturer's Guide to Implementing the Theory of Constraints* and *Visual Project Management*, alongside numerous whitepapers and articles on operational excellence.

A sought-after speaker and educator, Woeppel has shared his expertise through lectures at prestigious institutions, including the Kellogg School of Management and the University of California, Los Angeles, where he delivered courses on executive decision making and materials management. With a robust background in operations management, including roles as vice president of operations at Telsco Industries and director of operations overseeing multiple manufacturing sites, Woeppel has consistently delivered measurable improvements. Notable achievements include reducing Schlumberger's inventories by $7 million and tripling sales volume at Wilsonart International's specialty products division. This book promises to distill these insights, offering practical strategies for leveraging ToC to achieve manufacturing excellence.

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Downloads for *Building Resilient Manufacturing Operations* include how to set a battle rhythm using a buffer management tool, an order release policy, and an SAP replenishment guide.

1

How to Get Results Fast—Lessons Learned from a Disaster

"This is one of the most fascinating cases of continuous improvement that I have ever seen—and I've been in this business for 30 years. We had a job of building an operation so big that it would normally take years. But we had to do it in days—no leeway. And then we have to take it all apart. When you come out of an operation as intense as this, it's like demobilizing from a war."

—**Brian Wood**, Large Vessel Decontamination/Demobilization Director, Deepwater Horizon Response, British Petroleum

❖ ❖ ❖

I will never forget the Macondo spill command center—Coast Guard officers and oilfield hands hunched over folding tables, people rushing from station to station, fighting to contain history's largest oil spill. With the fire out and oil contained, we faced an impossible task: decommissioning 14,000 contaminated vessels and stemming millions of dollars of bleeding daily. It took my years of Theory of Constraints (ToC) training to crack this mess, saving $700M and shaving cleanup time by 30%.

This chapter explains how ToC turned disaster into results. If your plant is in chaos now, this information should help you to turn things around.

THE DISASTER

In April 2010, the world's eyes locked on a spot 50 miles south of Louisiana—an offshore rig exploded, burned for 36 hours, then sank into 5,000 feet of water. Crude oil gushed for weeks, leaving a 3,500-square-mile disaster threatening the Gulf's ecology and economy. British Petroleum (BP) launched the most immense containment effort ever—thousands of vessels, from the mammoth *Big Gulp* pollution skimming ships to vessels of opportunity, like family shrimp boats and coastal cruisers, costing $20M daily in rentals. Media swarmed, the U.S. government watched every move, and the Coast Guard demanded decontamination before vessels could return to service. It was similar to chaos I had seen before, but on a massive scale.

THE MESS

Each vessel faced unique cleaning nightmares: replacing wooden deck planks, scrubbing dangerous oil-filled interiors by specialists, or finding scarce dry docks for larger ships. The variety and scale of the tasks were mind-numbing.

Obstacles hit hard. Where were the multitude of vessels spread across 600,000 square miles of the Gulf? Their condition was unknown, the decontamination process was unexamined, no vessel washes existed, and skilled labor was scarce. A senior BP executive, Brian Wood, said, "We had to start a cleanup company from scratch and, basically, build a Fortune 500 company overnight." After decontamination, we planned to dismantle it. Although BP allocated over $1 billion, our ToC-driven strategy resulted in a $700 million savings. In the remainder of this chapter, I present the lessons we learned.

LESSON ONE: FIND THE CONSTRAINT

Challenge

We faced an overwhelming challenge: thousands of contaminated vessels, ranging from pollution skimmers to family shrimp vessels, were scattered across 600,000 square miles, with no clear records of their locations or conditions. Managing 20 decontamination sites hundreds of miles apart seemed insurmountable. The vessels' diverse needs—replacing wooden planks, scrubbing oil-filled interiors, or requiring scarce dry docks—created chaos. The lack of coordination left BP grappling with escalating costs of $20M daily, a problem as daunting as stalled automotive part lines or clogged heat exchanger processes.

The Solution

Our first step was to bring order to this complexity by standardizing vessel records and consolidating databases into a single repository. After careful analysis, this critical insight emerged: we needed to view the 20 Gulf sites as individual machines in the largest factory on the planet, spread across the Gulf of Mexico (see Figure 1.1). We identified dock space as the Capacity Constraint Resource (CCR), the constraint holding back the entire operation. There was an open checkbook to add capacity, including people, equipment, and other resources, but we couldn't add real estate. Productivity and throughput at the dock were our central organizing themes. For vessels requiring confined space work—a minority—we developed a parallel process, ensuring focus on the primary bottleneck (see Figure 1.2).

Payoff

Dock utilization rose from 50% to over 100%, and subsequently, we shifted to measuring the number of feet decontaminated daily, which drove a surge in vessel completions. This ToC approach saved $700M, mirroring how organizing a complex effort around a critical resource can transform manufacturing performance.

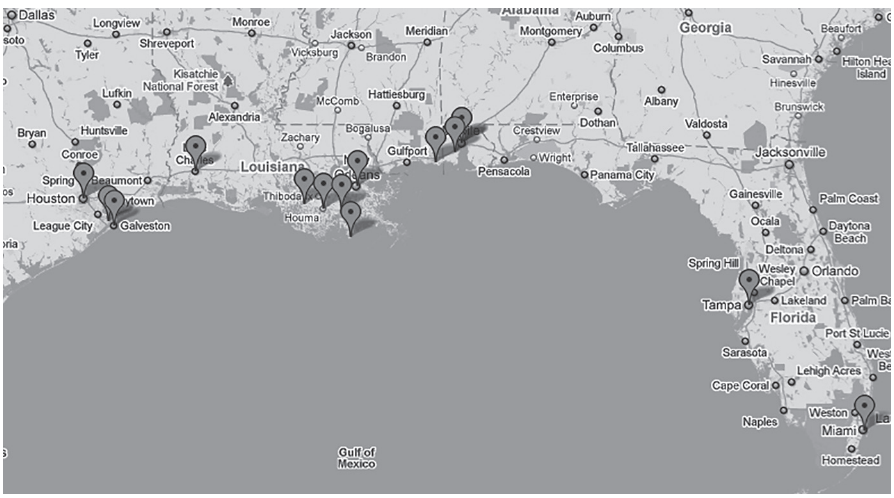

Figure 1.1 Decontamination sites

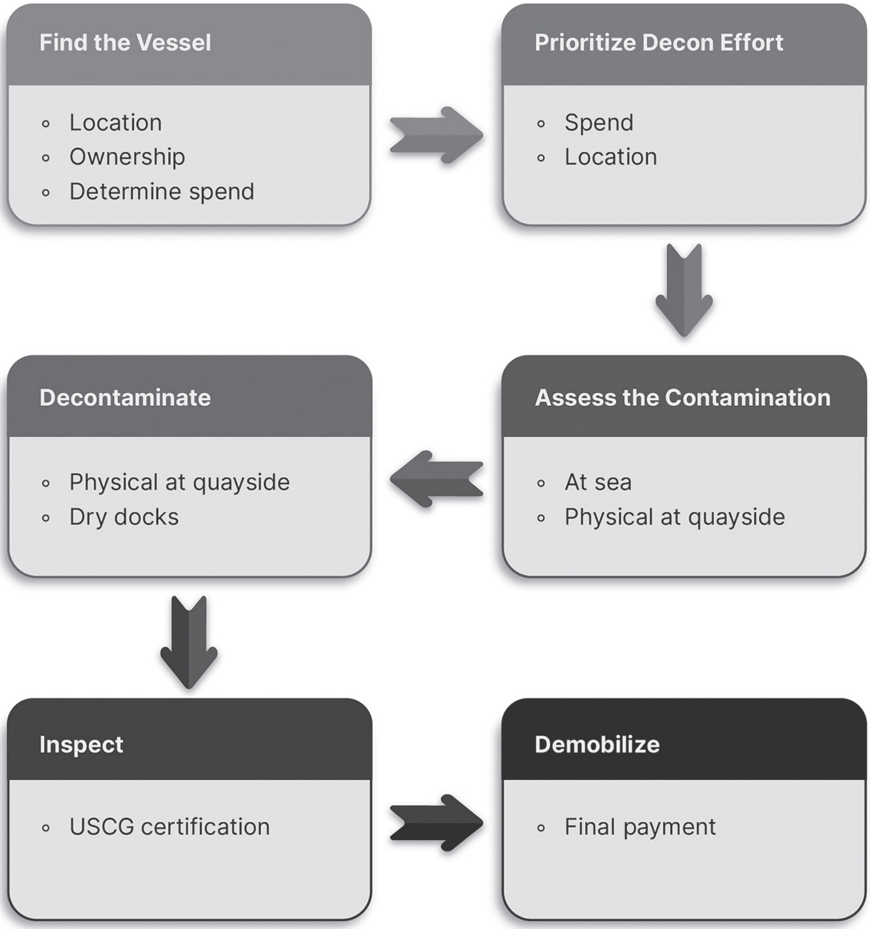

Figure 1.2 Vessel demobilization process

> ***Takeaway:*** Progress begins with pinpointing the system's constraint. By measuring the process's output and reinforcing that measurement, the team can more easily focus on the most crucial part.

LESSON TWO: SUBORDINATE TO THE CONSTRAINT WITH STANDARD WORK

Challenge

Vessel decontamination efforts were scattered, with dozens of contractors across Texas, Florida, Louisiana, Alabama, and Mississippi testing uncoordinated techniques. Vessels arrived at sites with varying contamination levels, resulting in time at the dock as they designed cleaning methods on the fly. The geographic dispersion, highlighted by the closest site at Port Fourchon, Louisiana (100 miles south of New Orleans), to a graving dock in Tampa, Florida (a 650-mile drive), compounded confusion, slowing down the effort.

The Solution

The process improvement teams collaborated with the site teams to implement process improvements, which they then rolled out as standard work across the remaining sites. Improvements made in Mobile, Alabama, were implemented in Port Fourchon the following week. By applying consistent methods, we shared lessons learned (e.g., faster techniques) and allowed new sites to ramp up quickly (see Figures 1.3 and 1.4).

Payoff

Standardization doubled site velocity, reducing chaos and effort, aligning with the constraint for smooth flow and rapid decontamination at every site.

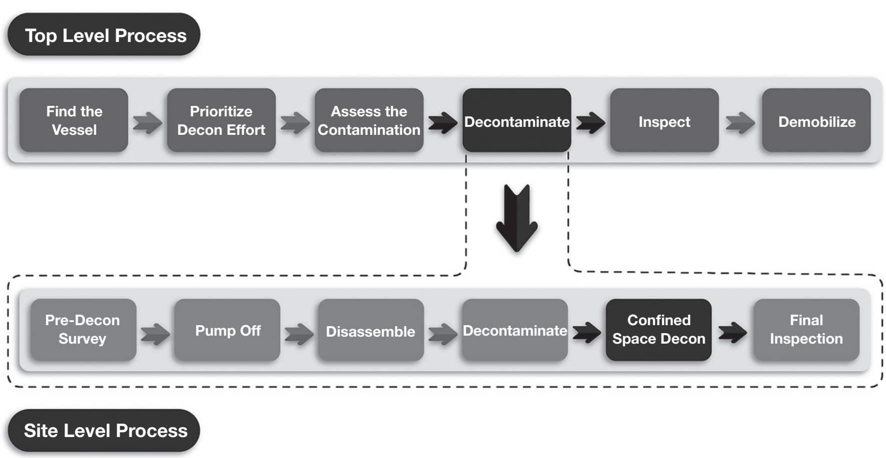

Figure 1.3 Site decontamination process

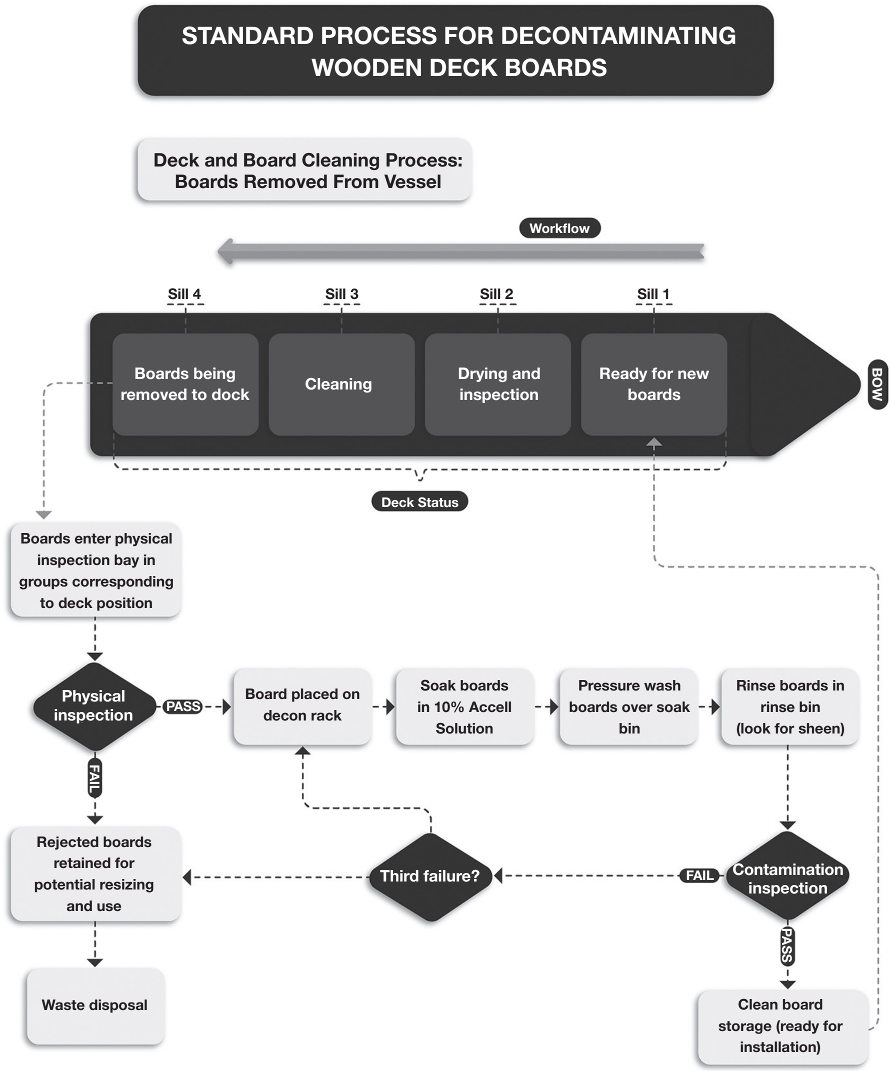

Figure 1.4 Standard decontamination process

Takeaway: Standard work ensures consistency of results and simplifies problem-solving.

LESSON THREE: EXPLOIT THE CONSTRAINT—MEASURE WHAT MATTERS

Challenge

Despite more vessels at the docks, progress lagged. Many idled, costing BP millions daily. The initial metric, dock utilization, hit 100% but did not boost completions.

The Solution

We refined our metrics to focus on throughput (i.e., feet decontaminated weekly) after defining five key measures:

- Dock utilization
- Vessel feet processed
- First-time quality
- Safety incidents
- The inverse of utilization, which is lost time at the dock

Shifting to lost time as the primary metric drove leadership action, exploiting dock space as the constraint to maximize vessel flow, which aligns with ToC's focus on the bottleneck (see Figures 1.5 and 1.6).

Payoff

Lost time at dockside dropped from 50% to 12%, tripling vessel completions and cutting costs.

The standardization and understanding of CCR performance gave the management team insight into the overall system's performance, addressing the following questions:

- Are we making progress?
- Are we speeding up or slowing down?
- Does any site need help?

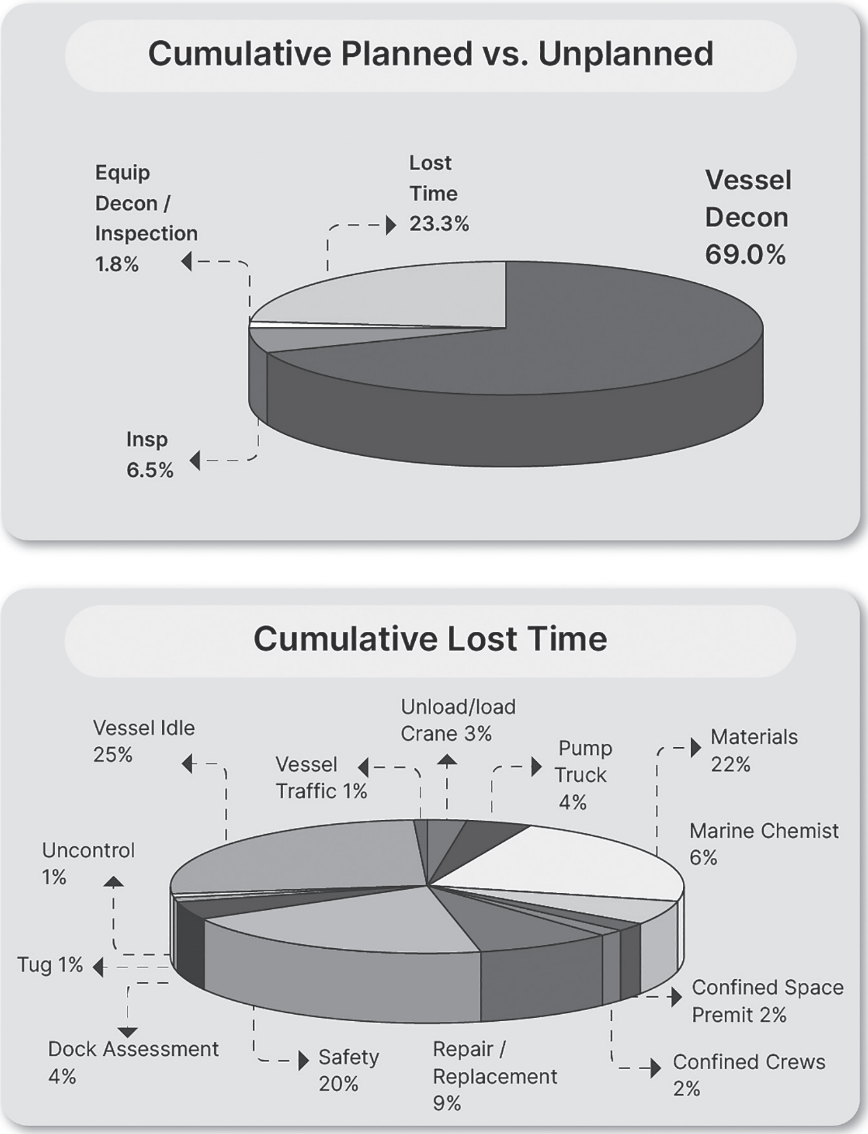

Figure 1.5 Lost time and causes

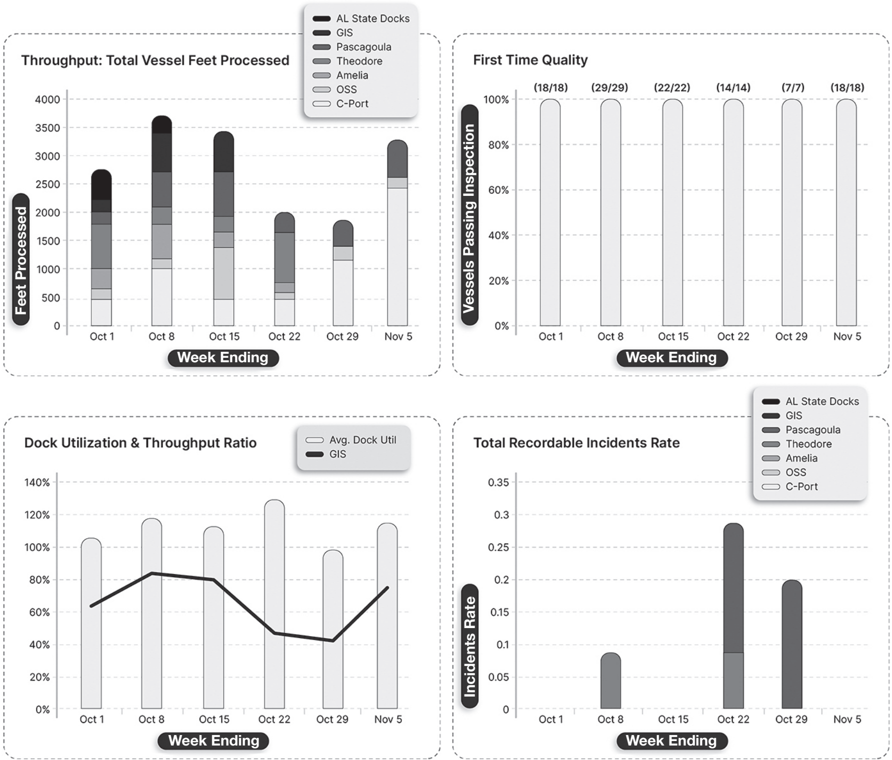

Figure 1.6 Decon site metrics

> ***Takeaway:*** Empirical information is essential for accurate decision making, but possessing the critical numbers to impact outcomes is vital. The CCR assesses the overall system's performance, so that is where you begin. What is well-measured is well-managed.
>
> The way you present measurements influences your team's reactions. While 90% productivity sounds appealing, saying that you have lost 10% of your capacity does not. The latter inspires action, whereas the former does not.

LESSON FOUR: ELEVATE THE CONSTRAINT—SMALL WINS, BIG FLOW

Challenge

Vessels arriving for cleanup revealed equipment and training needs during mid-process, causing days-long waits for tool and method approvals, multiplying delays and continued rental costs across idling vessels.

The Solution

We assigned ToC and Lean experts to each site to teach faster methods, thereby avoiding the need for workshops. In one instance, vessels would arrive in a dock area in the dry dock facility. The dock area would be closed, and water would be pumped out, leaving the ship *dry-docked*. Placing wood blocks under the vessel to keep it upright when the water was pumped out was a time-consuming task. The dry dock team spent considerable time determining which blocks were required and where they should be positioned under the vessel. Ed Kincer collaborated with the facility in Tampa to implement night shifts and staggered schedules. They sequenced the block placement by hull geometry, thereby reducing setup time from 72 hours for a block build to just eight hours.

Payoff

Decontamination rates doubled, resulting in a significant increase in the rate of vessel decontamination (see Figure 1.7).

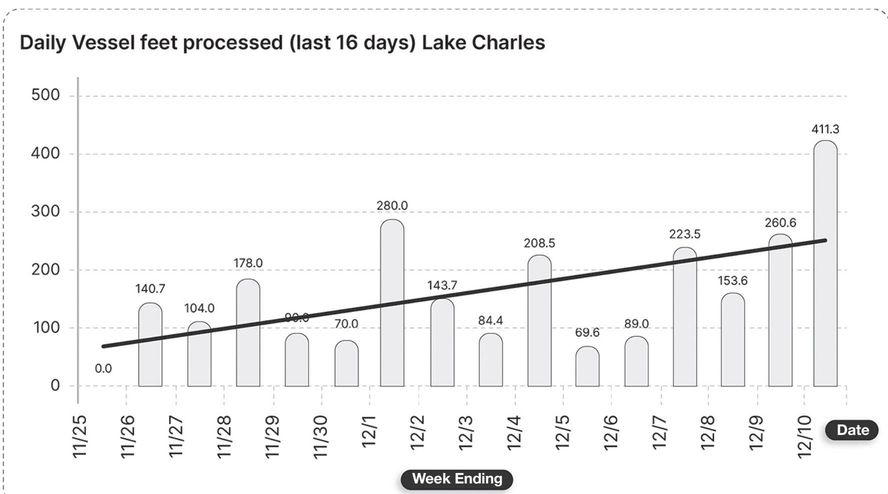

Figure 1.7 Measure of throughput at the Lake Charles site

Takeaway: It doesn't take a big team of experts to improve the plant's performance, just concentrated effort.

Identifying improvement opportunities is easier when process specialists are part of the production team.

Adopting new processes is effortless when the goals of continuous improvement projects align with the leaders' goals.

When the process owners participate in the problem/solution equation, new processes become standard practice.

LESSON FIVE: BREAK POLICY CONSTRAINTS—QUESTION THE STATUS QUO

Challenge

Confined space cleanouts were grueling and dangerous; divers in oily tanks risked explosions, halting vessels for hours, and incurring millions of dollars in delays. This policy-driven bottleneck was a significant obstacle to speed, the primary concern. However, we could not compromise on safety.

The Solution

We questioned, "How clean is clean?" and discovered that many vessels only needed oil removal, not a complete tank cleaning. According to the Coast Guard, only water-contact surfaces needed oil-free status, breaking the policy constraint and tripling cleaning rates.

Payoff

The cleaning staff was reduced by 10%, yet weekly completions doubled, resulting in a 12% decrease in lost time.

Takeaway: Often, product specifications are over-engineered. Tolerances are too tight, finishes are too smooth, and there are unnecessary functions, among other issues.

If you are losing time or have long durations, it pays to question the purpose of an operation. Does the customer need the outcome it produces?

The same applies to material specifications. For example, do you need that high-grade 416 stainless steel? Would a lower-carbon 304 stainless steel serve the purpose?

LESSON SIX: SYNC THE SYSTEM—FAST FIXES, NO NOISE

Challenge

Communication breakdowns crippled progress—delays in situation reports clouded the real-time status, costing critical hours to clarify decisions. Mistrust between competing contractors stifled open dialogue, while late identification of vessel needs (e.g., specialty crews or equipment) resulted in precious dock space being jammed and vessels idling. A dozen companies sat guarded at morning meetings, working at cross purposes, making it nearly impossible to gauge their performance.

The Solution

We templated reports and deployed whiteboards with progress charts to track progress. We implemented a *battle rhythm*—comprised of daily operations reviews, leadership meetings, weekly performance checks, and stakeholder updates—to synchronize operations across 20 sites and ensure dock space utilization. Night shift leaders updated real-time data 30 minutes before briefings, quickly enabling on-the-spot decisions, breaking mistrust, and clarifying vessel needs.

Payoff

Collaboration effectiveness soared tenfold; issues were resolved daily, resulting in significant time savings. Like andon lights in a production work center, they illuminate the critical issues blocking flow through clear, real-time communication, ensuring your plant meets its delivery promises.

> ***Takeaway:*** Managers are hungry for facts to make good decisions. Regularly report the critical factors driving performance. In the cleanup response, the execution speed was very high, and many eyes were on the job. It is no different in manufacturing.
>
> Communication and planning are standard work for leaders.
>
> Problems are raised for resolution, not blame.
>
> The battle rhythm sets expectations and holds individuals accountable for delivering results.

That is how my team and I applied ToC to increase the speed of decontamination and saved BP $700M. Now, move on to Chapter 2 and start learning how to hunt for your plant's constraint before it bleeds you dry.

Part 1

Concepts and Foundations

2

Why Your Plant Is a Mess— The ToC Wake-Up Call

> *"The fish trap exists because of the fish. Once you've caught the fish, you can forget the trap."*
>
> —**Zhuangzi**

❖ ❖ ❖

I have been where you are—standing in the middle of a manufacturing plant that feels barely in control despite my best efforts to keep it on track. I spent long days managing schedules and materials at my employer's, hoping each week's plan would hold together. But come Monday morning, my first call was always from Chuck—the ex-Marine running the gating operation—who would tear into me with salty complaints about the dreadful schedules. I felt the weight of those challenges: the constant pressure to deliver, the tension between departments, and the sinking feeling that no matter how hard I worked, the chaos would not let up. That was when I discovered the Theory of Constraints (ToC), which changed everything for me. My plant orders started shipping on time, the team found a steady rhythm, and I could finally lead confidently. I am sharing this with you because I know you can transform your plant, just as I did, by understanding your system through the lens of ToC.

Whether it produces steel structures or signs, every manufacturing plant faces challenges that feel all too familiar: bottlenecks that won't stay fixed, lead times that keep stretching, and inventory costs that rise despite your best efforts with Lean or enterprise resource planning systems. The solution isn't about working harder on individual processes—it is about seeing your plant as a complete system, where all parts, from workstations to material flows, collaborate to deliver value to your customers. ToC provides a way to understand the system, focusing on the one thing that truly matters: the constraint that limits your performance. This chapter will guide you through that understanding, demonstrating how ToC binds all production elements together so you can set your plant on a path to reliable delivery and profitability.

SEEING YOUR PLANT AS A SYSTEM

Think of your plant as a relay team, where each runner (i.e., each process) must pass the baton smoothly to the next. The team's performance doesn't depend on the fastest runner but on the slowest one because that is where the race slows down. In manufacturing, your plant's performance depends on the interactions between workstations, material flows, information systems, and your team's daily decisions. While working in industry, I saw this firsthand: we would push one department to speed up, thinking it would help, but instead, it created a pileup of parts that slowed everything down. That is the challenge of a system—improving one part without understanding the whole process can lead to unexpected problems, such as:

- Excess inventory that ties up space and capital
- Quality issues that don't show up until later
- Scheduling conflicts that delay important orders
- Overloaded processes that can't keep up with the extra work

ToC helps you see your plant as a relay team, where one runner—the constraint—sets the pace for the entire race. Instead of attempting to make each runner faster, ToC shows you how to concentrate on the slowest one, allowing the whole team to progress together. This perspective shift can make all the difference, enabling you to tackle the root causes of your challenges rather than just the symptoms.

WHY YOUR PLANT FACES THESE CHALLENGES

You have probably asked yourself why lead times keep growing, even when you do everything possible to shorten them. Why do I have too much inventory in some areas and not enough in others? Why do bottlenecks seem to move around, popping up in new places? I asked those same questions at Valmont, where we would see bottlenecks shift from the press to assembly, leaving us chasing problems without ever getting ahead. ToC provides the answers by revealing the underlying patterns in your system.

In a manufacturing plant, everything is interconnected—what ToC refers to as dependent events. If one process slows down, it affects the next, and then the next, in a domino effect. Add to that the natural ups and downs of production—statistical fluctuations—and you have a system where one slight hiccup can cascade through the system and cause considerable delays. ToC helps us understand that in systems like this, one factor—the constraint—has a disproportionately large impact on your results. It is not about the 80/20 rule, where 20% of your efforts drive 80% of your outcomes. In a manufacturing plant, it is closer to 99/1:

one constraint drives nearly all of your performance, whether that is your profit, your on-time delivery, or your ability to keep customers happy (see Figure 2.1).

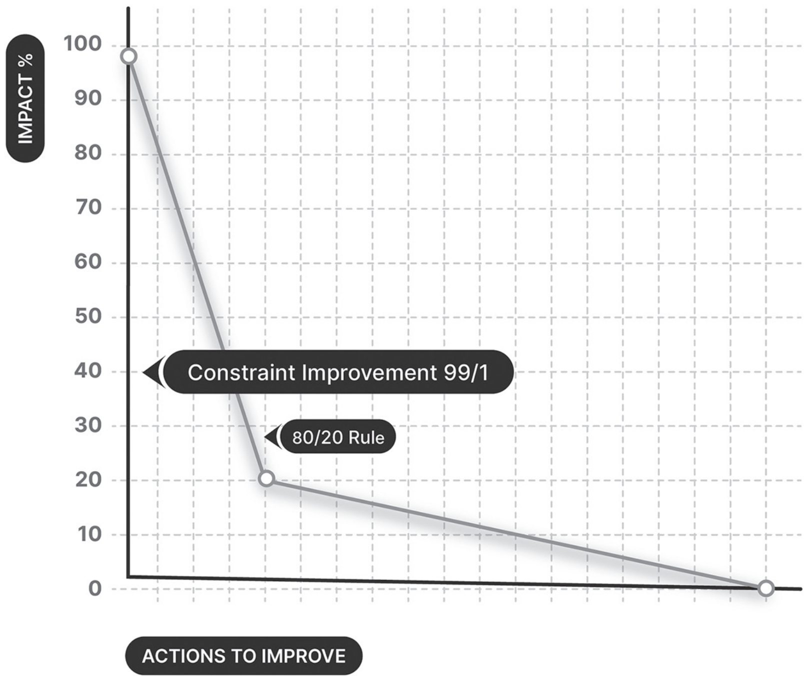

Figure 2.1 The 80/20 improvement rule versus 99/1 improvement

THE POWER OF THE CONSTRAINT

At the heart of ToC is a simple idea: your plant is like a chain, and its strength depends on the weakest link—the constraint. That constraint is the one thing that limits your plant from achieving its goal, which, for most companies, is to make money, both now and in the future. Eliyahu Goldratt introduced this idea in his book *The Goal*, aiming to change how we think about manufacturing by focusing on that one critical factor (Goldratt and Cox, 1984). At the Valmont plant, the constraint was often a press that couldn't keep up, limiting the number of orders we could ship. No matter how fast the other machines ran, that press set the pace for the whole system.

Picture your plant as a pipeline, with orders flowing like water, as shown in Figure 2.2. Each process—cutting, pressing, and assembling—has a specific capacity, such as the width of the pipe. If one process, for example, the press, can only handle 100 parts per hour, while the others can handle 150, the press becomes the constraint, capping your output at 100 parts per hour (see Figure 2.2). If you increase the press's capacity, the flow opens up, and you can ship more orders (see Figure 2.3). However, if you improve a different process, such as the cutting station, the flow remains the same, still stuck at 100 parts per hour (see Figure 2.4). That is the physics of your plant: only the constraint controls the flow (see Figure 2.5).

Understanding the relationships between the resources matters because value isn't created until your product ships to a customer. You might think that every step—cutting, pressing, and assembling—adds value, but ToC shows us that is

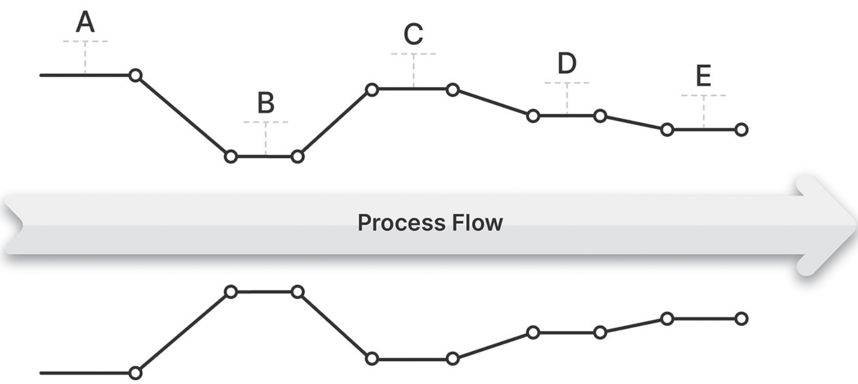

Figure 2.2 Parts flow through the factory like water through a pipe

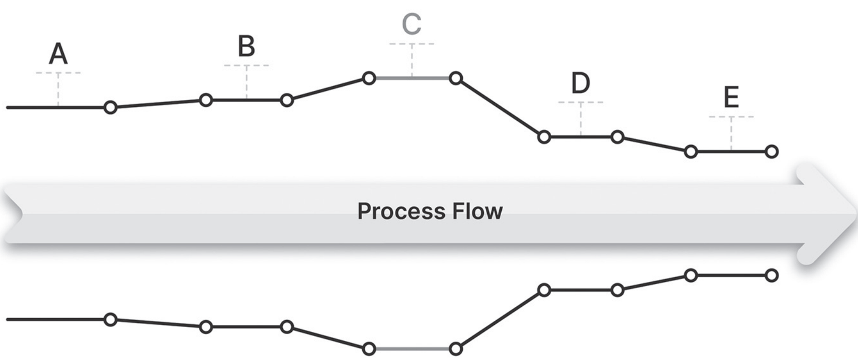

Figure 2.3 Increased capacity at resource B boosts flow, and the new constraint is resource E

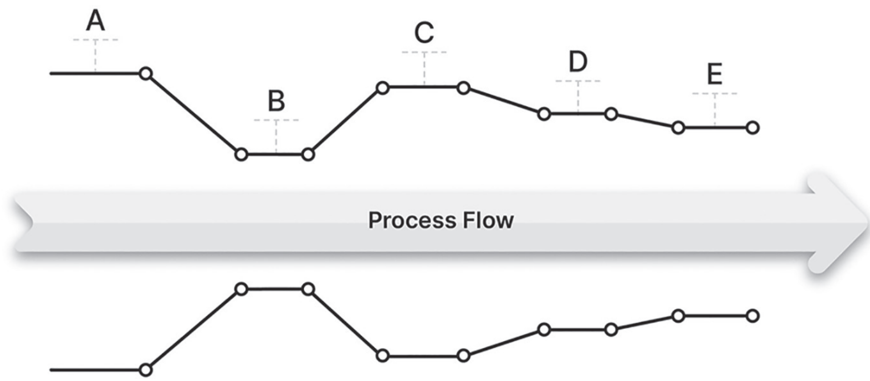

Figure 2.4 Increased capacity at resource A, a non-constraint, doesn't increase flow

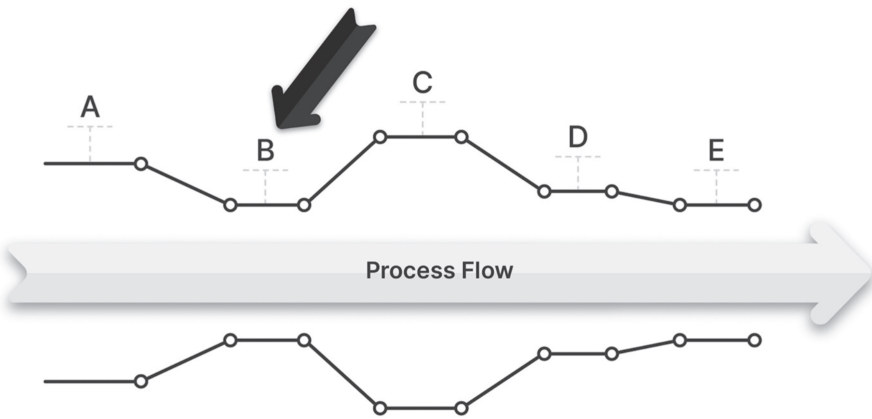

Figure 2.5 Resource B is the constraint—improving this resource improves the entire system

not true. Until the customer buys the product, all that work-in-progress is just inventory, tying up your resources. The constraint determines how fast you can ship; every hour it is idle is an hour of profit you have lost. In one plant where I worked, an hour lost at the constraint cost $14,706 in throughput, while idle time at other machines barely made a dent (see Figure 2.6). That is why we focus on the constraint: it is the key to unlocking your plant's potential.

$$(S - TVE) / H = T$$

Where **S** = Monthly sales

TVE = Monthly totally variable expense

H = Hours available at the constraint per month

T = Throughput (profit) per hour

Monthly sales	$4,000,000
Totally variable expense	$2,500,000
Throughput value add	$1,500,000
Constraint hours available	1032
Throughput per hour	**$14,706**

Figure 2.6 Financial impact of the Capacity Constraint Resource (CCR)

A PATH FORWARD WITH TOC'S FIVE FOCUSING STEPS

ToC gives you a clear path to manage your constraint and improve your plant's performance: the five focusing steps. These steps help you zero in on the constraint and make the most of it to deliver more value to your customers and grow your bottom line.

1. *Identify the constraint*: First, find the constraint—the process, machine, or rule holding your plant back. At Valmont, the constraint was often the press, but sometimes, a scheduling rule kept us from using it effectively. Knowing your constraint is the starting point for everything else. Chapter 4 will elaborate on this topic.
2. *Decide how to exploit the constraint*: Once you know your constraint, focus on getting the most out of it. Make sure it is never idle; staff it with your best people; and seek opportunities to boost productivity. I once worked with a plant making screen-printed decals, where the print line was the constraint. They had enough machines, but the operators kept leaving for better-paying jobs elsewhere in the plant. When we raised their pay to match the skill level, they stayed, and the plant's output soared.

3. *Subordinate everything else to the decisions in Step 2*: Make sure the rest of your plant supports the constraint's needs. If the constraint needs certain materials, don't let other processes overproduce and create pileups. At Valmont, we learned to release materials at the pace the press could handle—no more, no less—so we didn't end up with stacks of parts waiting around.
4. *Elevate the constraint*: If you have done all you can to improve the constraint and it is still holding you back, consider investing in more capacity—maybe a new machine, more staff, or extra shifts. But only do this after you have fixed any rules or policies that might be limiting it.
5. *Go back to Step 1 and identify the (new) constraint*: A new one will appear once you break the constraint. That is how continuous improvement works—always looking for the next area to improve, so your plant continues to improve.

LOOKING AHEAD: TURNING THEORY INTO ACTION

Understanding your plant as a system, with a constraint that drives its performance, is the first step to overcoming the daily challenges you face. ToC gives you the tools to focus on what matters most so you can stop chasing every problem and start making real progress. In the next chapter, I will highlight the practical tools, such as Drum-Buffer-Rope scheduling, that will help you implement these ideas, turning your plant into a place where orders ship on time, your team works together, and you can confidently lead.