Metrics the TOC Way
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"Tell me how you measure me, and I'll tell you how I will behave. If my measurements are not clear, no one can predict how I will behave, not even me." This adage, from Dr. Eli Goldratt[1], gives the direction for a metrics solution, according to a methodology called the Theory of Constraints, or TOC for short. TOC assumes that there are very few factors governing the Throughput of any organization, and that the best results come from finding the simplicity in the midst of all the complexity we face.

What is the problem with most metrics today? There are really two problems:

- Encouraging people to do the wrong things
- Not driving people to focus on doing the few right things

If you find yourself in a hole, the first thing to do is to stop digging. The TOC approach recognizes that human beings are probably NOT going to be driven correctly by 8 or 12 measurements, such as advocated in a Balanced Scorecard system. In such a complex system, measurements are almost always in conflict with each other. Whenever you put efficiency or cost reduction measurements on the same scorecard as Throughput or getting work done, the person being measured will frequently find themselves in a conflict. This person has the perfect excuse for missing a number of measurements in any time period. At the same time, the boss has the perfect reason to crucify someone, because in any time period, it is likely that 1 or more measurements will be missed. As Jim Collins points out in his bestseller, Good to Great[2], the difference between good and great companies is that the great companies get rid of their bad

[1] Goldratt is the author of the multi-million bestselling book, The Goal and several others, including Critical Chain, Necessary But Not Sufficient, It's Not Luck, The Haystack Syndrome and The Theory of Constraints.
[2] Jim Collins, Good to Great, Harper Collins Publishers Inc., 2001. Collins calls "great" companies those that outperformed their peers by an average of at least 7 times over a 15 year period.

measurements, the ones that de-motivate or confuse people.

The TOC approach is a holistic approach. It advocates simplicity over complexity. 1 primary measurement and 1 secondary measurement are usually enough to drive the correct human behavior in any given situation. This chapter introduces the TOC metrics for senior management, for support organizations in a supply chain and for project management.

Characteristics of Good Metrics

A good measurement should drive a person in any function to do what is good for the organization as a whole. While this may sound obvious, some further background and examples show why in many organizations, people in functional areas are actively encouraged to do things that are NOT good for the organization as a whole.

The problem really begins with how organizations deal with today's complex world. One way to deal with complexity is to divide the organization into "manageable pieces", which are usually functional areas. The senior management then gives specific metrics to each functional area. Most functional areas are cost centers (e.g., production, engineering, finance, administration, I.T.). Therefore, when measuring these areas, it is natural to see a strong emphasis on cost or its equivalent, efficiency.

One real life example comes from the armed forces of a country that I will, kindly, leave nameless. The sergeant responsible for equipment maintenance for his unit, which was active in the field, noticed that one of the missiles was not functioning. Further diagnosis found a part that was bad. The sergeant called the parts manager, who said that he had the part in stock but couldn't ship it to the sergeant. "Why not?" asked the bewildered sergeant. "Because this is my last part, and if I ship it to you, it will show up on a report as an out of stock situation, which

gives me a bad rating." So the sergeant had to leave his unit partially defenseless for two weeks, until the parts manager was able to fully stock up.

To illustrate that this is not an isolated case, but in fact very common throughout industry, consider this story, which is also true. A procurement manager who was primarily measured on cost of materials was very proud that he had saved his company $1.3 million per year by changing vendors. At the same time, the plant manager proved that the new materials, which were causing dozens of problems daily on the shop floor, were costing the company over $25 million per year in lost sales.

The problem with these metrics is that they only consider the impact of any decision on one part of the organization, not on the organization as a whole. Therefore, one of the most important characteristics of any good measurement system is that it reflects the impact on the entire system, not on one isolated piece.

This brings home the second problem with many measurement systems today – the distortion of cost accounting and cost allocations. Two examples will illustrate the distortions.

Cost Accounting Distortion Example 1 – Judgment of the System as a Whole

One of the distortions of Cost Accounting is how it measures the performance of the system as a whole. As just one example, ask yourself why companies in so many industries, such as communications, automotive and computers, continue producing at a high rate, long after the end consumers stop buying. One reason is that Cost Accounting measures the Production silo on efficiencies, encouraging them towards high utilization of their resources. The higher the machine and labor utilization, the greater the efficiency reported. Cost Accounting also lists the resulting excess inventories as "Assets" on the company's financial report. Cost Accounting then

reports these burdensome inventories as artificial higher company profits, by reducing the cost of goods sold[3].

Also, when one company in the supply chain, such as an automotive manufacturer, is able to pass their inventory off to the dealers – the next link in the supply chain, in the short term, the cost frame of reference makes their results look good, by recording these transfers as sales. However, unless the end consumer has bought**, no one in the supply chain has sold.** Inventory in the supply chain may be well beyond the level needed to satisfy end consumer demand. The fact that the inventory was recorded as "Sales" in the manufacturer's P&L is totally distorted. It is the *manufacturer* who must now provide incentives to consumers, reducing their own profits and the dealer's profits and cutting into sales of the next model year. In reality, the entire supply chain is actually worse off than before - the opposite of the way the current frame of reference, Cost Accounting, reports it!

Today, whether a company uses traditional Cost Accounting or its popular replacement, Activity-Based Costing (ABC), the distortions of allocated costs still apply. These distortions represent another failed attempt to deal with complexity by breaking down a system into smaller parts and trying to optimize within each part.

The distortions are so subjective that there is a popular joke in the accounting profession. When you ask an accountant, "How much does this cost?", the accountant answers, "How much would you like it to cost?" This chapter does not put blame on the accounting profession for distortions. Accountants look continually for better ways to help managers make more effective decisions. Rather, I am simply pointing out the distortions imbedded within current systems.

[3] By a distortion of cost accounting, when a company has more inventory at the end of a reporting period than they had at the beginning, the cost of goods sold (which includes the difference between starting and ending inventory) appears to decrease artificially.

Cost Accounting Distortion Example 2 – Judgment on Make/Buy Alternatives

Cost Accounting, as a way to manage complexity, can lead a company to wrongly believe that outsourcing will be "more cost effective". This has happened both in outsourcing some manufacturing and also outsourcing of services such as I.T. With cost allocations, a company looks at the "cost" per manufactured part, for example, as the actual cost of raw materials plus the *allocated* cost of labor and other overheads. The more you allocate, the better the outsourcing alternative looks. Often, cost allocations are made very subjectively, without really understanding the impact on the organization as a whole.

For example, when a manager decides to transfer the manufacturing of a part to an outside supplier, many of the allocated costs ***do not***, in reality, go away. If 10% of a worker's time is allocated to producing a part, and that part is subcontracted, does the worker lose 10% of their wages? *Not at all*. Does 10% of the depreciation on the machine producing the part disappear? No way! What about the heat, electricity and other operating expenses of the plant? While there may be some decrease, it usually is nowhere near what has been allocated to individual parts.

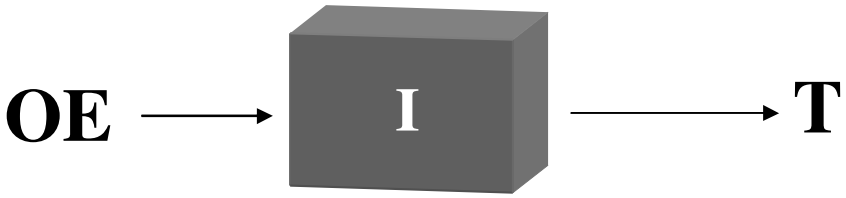
At the same time that some of the allocated costs are not realized as savings, the subcontractor is charging much more than the raw material cost to supply the part. Much of the "savings" are pure fiction! In effect, in many cases, the subcontracted part costs more and, at the same time, reduces flexibility and profit.

However, the effects can go much further than this immediate negative impact on profit. Consider what happened to some U.S. companies who decided to outsource their manufacturing to the Far East. The lead time for products and services went up, so inventories in the supply chain increased dramatically. In some companies, the lead time increase meant that they were

less responsive to consumer demand. The resulting shortages of some popular products meant that they eventually lost customer sales and at the same time, got stuck with huge inventories of less popular products. Leverage was diminished.

Similarly, Cost Accounting can distort judgment on investment in new equipment, judgment of profit centers and judgment on product line profitability[4]. A company will be quickly distracted from the company goals if they continually make bad decisions driven by poor management accounting support.

Metrics for the System as a Whole



In the new frame of reference, there are only three global parameters needed to measure the impact of any management decision at any level:

- **THROUGHPUT – T**
- **INVESTMENT – I**
- **OPERATING EXPENSE – OE**

THROUGHPUT (or **T** for short) is the rate at which the organization generates goal units. In for profit organizations, goal units are expressed in dollars. Throughput is calculated by taking the revenue received from customers in a given time period and subtracting amounts paid

[4] There is a detailed discussion of these distortions in the self-learning tool *TOC Insights into Finance and Measurements* by Eli and Rami Goldratt. See www.tocinternational.com

in raw materials and direct expenses to outside suppliers for each product or service sold. Every dollar of Throughput generated is money that is left in the company's bank account after paying raw material vendors. Since Throughput is a "rate", you can express it per hour, per week, etc. Note that Throughput is not recognized until money has been received from the customer.

In order to generate Throughput, a company makes **INVESTMENT** (**I** for short), both in terms of capital (buildings, equipment, computer systems, etc.) and in terms of inventory (raw materials, work in process, finished goods).

The money that the organization spends every month to turn Investment into Throughput is called **OPERATING EXPENSE** (or **OE** for short). This money includes salaries, depreciation expense, costs of supplies, heat, electricity, rent, etc.

From these three global parameters, two derivatives are:

- NET PROFIT = THROUGHPUT – OPERATING EXPENSES [NP = T – OE]
- RETURN ON INVESTMENT = NET PROFIT DIVIDED BY INVESTMENT [ROI = (T-OE)/I]

Driving Change in Behavior by T, I and OE

Using the new frame of reference, any manager, judging what actions to take, will use the impact on T, I and OE as their guide. If they are recommending a decision and have no idea what the impact will be on the company in terms of T, I and OE, then how dare they make such a recommendation?

There are now many documented examples that illustrate the simplicity, guidance and

power that this new frame provides[5]. In the example discussed above, a procurement manager made a decision to replace materials suppliers with cheaper vendors, using cost savings as his frame of reference. The savings were U.S. $1.3 million. In the new framework, this manager would be required to calculate the *net* impact of his decision on T, I and OE for the entire company, not just the OE savings for procurement.

How could a procurement manager possibly estimate, in advance, what the impact of a change in materials would be on production? Since this decision impacts both Operating Expense and Throughput, the Procurement and Operations managers would need to conduct tests with the new materials to assess the impact before the final decision is made. The real-life calculations for this example were:

IMPACT ON THROUGHPUT

- Cost of raw materials decreased by $1.3 million

Lost revenues due to material problems $82,800 per day, based on production tests:

- Revenues decreased by $29.8 million/year

IMPACT ON OPERATING EXPENSE

Waste increased by $4,000 per day, based on production tests:

- Operating Expense increased by $1.44 million/year

Carrying cost on $200,000 reduction in inventory saving, @ 10%:

- Operating expense reduced by $20,000 per year

IMPACT ON INVESTMENT

Switching vendors requires new testing equipment:

- Investment increased by $35,000 total

[5] E.g., See Statements on Management Accounting #4HH, Institute of Management Accountants, Montvale, NJ, 1999. Thomas Corbett, *Throughput Accounting*, North River Press, Great Barrington, MA, 1998. Victoria J. Mabin and Steven J. Balderstone, *The World of The Theory of Constraints*, St. Lucie Press, Boca Raton, FL, 2000

- Raw Materials Inventory can be reduced by $200,000

If the decision is executed as described in Chapter 3, the following summarizes the expected results (note that the delta symbol below means “change in”):

Δ T = +$1.3 million - $29.8 million = $-28.5 million

Δ OE = + $1.44 million - .02 million = +$1.42 million

Δ I = +$35,000 - $200,000 = -$165,000

In the example, even though investment in inventory was reduced by $165,000, the devastating impact on throughput and operating expense means that this would obviously be a bad decision if implemented as is. However, the Procurement manager had a great idea to begin with – to procure materials through different vendors, reducing lead time and reducing cost. The idea has some horrible negative consequences if executed without cooperation from operations.

When operating in silos, it is guaranteed that decisions will be executed without considering the negative consequences on the company as a whole. With holistic metrics, understanding the impact on T, I and OE globally across the company, the procurement manager will work to find suppliers that he can bring up to current standards. He will see part of his mission as minimizing the impact of any transition on production. He will NOT be measured on local improvements in isolation. As a result, he will not be satisfied until global improvement is achieved.

Metrics for a Supply Chain

Two key measurements are needed to cause each member of the supply chain and each

supporting department to operate in perfect alignment with each other.

1. ***Throughput $ Days (Late) –*** A supply chain must recognize that shortages of product increase the risk of losing both the current sale and future business. For some products, the end consumer will tolerate some shortages*, but not for too long*. To take this into account, this measurement *multiplies* the late throughput, valued at the point of end consumer sale, by the number of days that the throughput is late. If one line item on an order is missed, Throughput $ Days is calculated based on the value of the total order, recognizing the client's irritation that one item was missed. The objective is 0.
2. ***Inventory $ Days –*** People usually describe inventory either in terms of its dollar value or in terms of how many days of consumption it represents. This measurement considers both attributes by multiplying the value of the inventory within the supply chain (at raw material cost) by the number of days that the material is held within the supply chain at any level. The objective is to reduce, without negatively impacting Throughput $ Days (late).

Throughput $ Days (Late)

In many supply chains, the end product has a high price tag (hundreds or thousands of dollars), while many components of that product have minimal cost (dollars or even pennies). The entire supply chain benefits if the supplier of a $1 component reacts urgently when they are blocking a $25,000 sale.

To help each organization within a supply chain determine what is urgent to downstream links, they need a daily or weekly report showing Throughput $ Days (late) from their customers - the next link down in the supply chain. The Throughput $ Days are expressed using the pricing

of the end consumer. Such a report tells each organization the magnitude of a problem order to the entire supply chain and how to prioritize their actions.

For example, assume that Company A manufactures a $1 shear pin that is used in building a transmission by Company B. Company B ships their transmission to Company C, a major automotive manufacturer. If Company A is 1 day late with an order of 100 shear pins, they might ordinarily look at this order as unimportant, since it only represents $100 to them. However, each shear pin is holding up a $25,000 sale at the end consumer level, representing $20,000 Throughput to the entire Supply Chain. Company A receives a report showing $2,000,000 Throughput $ Days for the shear pins (100 * $20,000). Now, Company A understands the importance of this order and how to prioritize their efforts.

If the same order is late for a second day, the report would show $4,000,000 Throughput $ days (100 * $20,000 * 2). The amount will continue to increase until this order is satisfied.

Another example deals with quality problems. If company A, in the above example, ships the shear pins on time, but a quality problem shows up in the automotive manufacturer on the day the shipment is due, the transmissions are returned to Company B. Company B now has $2,000,000 Throughput $ days assigned to them – the order is now late. It is a hot potato for them. They examine the transmissions and determine the problem is with the shear pins. The Throughput $ days are now assigned to Company A, and will stay with them until the problem is resolved.

If the problem requires another 2 days to resolve, and company A ships the corrected shear pins to company B, the order, which is now 3 days late, has an assigned Throughput $ days of $6,000,000 (3 days * $2,000,000). It is an even hotter potato for Company B.

Similarly, if the problem resides with a materials or packaging supplier to Company A, the procurement department in Company A has the hot potato until the problem is resolved.

By combining both dollars and days in this measurement, the supply chain is more likely to retain customers by avoiding *long* stock-outs and *long* repair periods for quality problems. In order for Throughput $ days to be effective, the members of the supply chain must agree to use this measurement to drive priorities throughout the supply chain.

Inventory $ Days

Too much inventory in a supply chain hurts in several different ways:

- It increases the cost of obsolescence. When replacement products are released, the more inventory there is in the supply chain, the greater the cost of obsolescence.
- It delays the introduction of the new product into the market. Distributors and retailers will be reluctant to stock the new product until they get rid of their supply of old product
- It spoils sales for the new product. As soon as a retailer, for example, knows that one of their products will soon be obsolete, they put it on sale. Everyone who buys the sale product will not buy the new product.
- When retail shelves are stocked with too much inventory of individual items, they miss sales opportunities. Due to the constraint of the amount of shelf space available, they cannot have the variety of product on display, which means that they miss some consumer sales.
- The more inventory, the greater the carrying costs and the greater the other operating expenses (shipping, cost of rework, etc.)

The Inventory $ Days measurement is secondary to Throughput $ Days. Therefore, it is very important that reductions in supply chain inventory do not cause problems in missing orders. Some inventory is necessary in the supply chain as protection against Murphy – fluctuations and problems in transportation, manufacturing and end customer demand.

By making this a supply chain measurement, rather than an individual entity measurement, the behavior within the supply chain drives a holistic result. For example, the *correct* distribution of inventory within most supply chains is to hold the most inventory where the forecast is most accurate and the fluctuations are smallest. This implies that more inventory should be held at or close to the manufacturer, with smaller inventories at the distributor and smallest inventory at the source closest to the end customer.

Today, many organizations within a supply chain try to reduce their inventory investment by pushing the inventory on to the next link in the supply chain. They can then claim this as a "sale" on their books. However, this behavior hurts the performance of the supply chain in terms of both total inventory carried within the supply chain and stock-outs.

Therefore, as with the Throughput $ Days measurement, agreement is needed across all supply chain organizations to look at the overall inventory rather than an individual organization's inventory.

Project Management Metrics

I am a personal witness to the fact that the same problems that existed in projects over 30 years ago still exist today. The only difference is that today, the problems of finishing projects late, over budget and not within scope are far more common and significant. From the analysis

done by Goldratt in project management[6], the metric that drives behavior contrary to the goal is to measure people to finish their tasks according to an estimated time.

Goldratt claims that as soon as a person gives an estimate for a project task, it becomes a commitment. Since resources on projects are rated according to how reliable they are, it is natural for a resource to take the uncertainty of project work into account by inflating their estimate. In fact, there are many pressures to inflate estimates, including:

- Murphy exists in projects
- Project work, by definition, includes many tasks that were not done in exactly the same way before
- Management is likely to cut back on task time estimates to gain a more aggressive schedule
- Dependencies exist that can delay the start of your work, thereby delaying the finish (i.e., you are dependent on having other resources finish their work on time. The more dependencies exist within a project, the greater the chance of slippage).
- You cannot always be certain of which resources will be assigned to a project. Often, the "best" resources are already tied up on other projects. This means that many projects suffer from being forced to use less experienced resources.

There are three considerations for success in project management:

- Choosing the right project mix
- Ensuring the correct scope in each project
- Driving projects through to completion as quickly as possible

[6] See Eliyahu M. Goldratt, Critical Chain, North River Press, 1997

The first two items above are the subject of strategy, which is discussed extensively in two other books by the author[7]. For metrics, I will concentrate on the last issue – speeding up project delivery.

With most project task estimates having extra time imbedded in inflated estimates, how can we possibly explain why so many projects finish later than planned? An examination of human behavior on projects shows that this safety imbedded in task estimates is often misused.

In juggling work on different projects and operational responsibilities, the project team member must decide what to work on right now. People, knowing that they have safety in their estimate, often delay starting work on a given project task until much later than they had originally planned. Instead, they choose more urgent tasks. Goldratt terms this behavior "Student Syndrome". This refers to the behavior of students who have three weeks notice of an exam, but wait until the night before the exam to start studying. When a team member starts a task much later than originally planned, and Murphy does occur, the task finishes later than its estimate.

The effect of Student Syndrome is made worse by the dependencies between tasks on a project. While the team member delays the completion of *their* task, all following tasks, dependent on this task, are waiting. If some of the following tasks are also subject to Student Syndrome, the delay in getting a project completed will be substantial.

Another common behavior further delays vital project work. Project Managers are under tremendous pressure from executives to show progress NOW, so they push very hard on team members to cut task time estimates. As a result, when a team member puts up a tough fight and wins a concession on a task estimate, the team member and Project Manager both consider that estimate a due date.

[7] See Gerald Kendall, Viable Vision, J. Ross Publishing, 2004 and Advanced Project Portfolio Management, J. Ross Publishing, 2003

Team members know that if, by some miracle, they finish a task in less time and turn their task in *earlier* than the due date, next time they will be expected to finish tasks in record time. Therefore, in cases where the team member does finish the specified work early, they prefer to work up to the due date, adding unneeded bells and whistles and doing extra checking. This behavior is called Parkinson's Law, where work expands to fill the time available.

The devastating waste to the company occurs with the combination of Student Syndrome and Parkinson's Law. These behaviors drive up individual task time durations, resulting in longer projects. But while these negative effects are serious, in the multi-project environment, there is another sinister factor driving project durations through the roof.

The Multi-Project Environment

Most organizations today operate in a multi-project environment – an environment where different projects share one or more common resources. In fact, in real life, managers are not so polite in their description. They usually call it "fighting" over resources rather than "sharing".

Once again, local optima reign supreme. Functional heads initiate projects, *irrespective of the capacity of the organization to do the work*. They are doing this for an excellent reason – if they do not meet their goals by the next review period, they may no longer be employed or they may miss a significant measurement. ***Executives assume that the sooner the project is initiated, the sooner it will be completed***.

Each senior executive, who is accountable for results, sees project initiation as their right. By comparison, this is like giving each functional executive unlimited numbers of blank checks, and telling them to make whatever capital investments they feel are necessary.

The only difference with projects is that we are dealing with limited human capital, in addition to dollars. Every organization has many more opportunities to improve, using projects, than they have the resources with which to execute those projects. When too many projects are activated simultaneously, the result is bad multitasking – a huge waste of resource time.

Bad multitasking occurs when team members split their time between multiple tasks such that the combined duration of all projects is dramatically increased. There are two potential negative effects when a resource takes on multiple tasks at once and juggles, doing parts of each task every few days. One negative effect of bad multitasking is that the level of effort for each task increases. Due to effort to regain concentration each time the same task is restarted, a task with 3 weeks of effort can easily turn into 4 weeks or more.

The other negative effect is the extended duration of each task. When the effect of multitasking is combined with additional start up time, a task that could have been finished in 10 days of dedicated time is spread over 4 weeks or more. In new product development, this means that a company loses or defers many weeks of sales, and may miss a competitive window. For projects bringing internal benefits, it means those benefits were delayed or missed for several or many weeks.

Correct Metrics for Projects

It is not important if an individual task finishes on time. What is most important is that the project finishes on time, at the earliest possible time to drive benefits to the organization. Therefore, to discourage student syndrome and Parkinson's law behavior, implement these changes:

- Cut all task estimates in half. Thus, when a team member sees a very aggressive time estimate, they are unlikely to delay starting the task and they are unlikely to try to add bells and whistles to the task when finished
- Do not measure people on finishing their tasks on time, formally or informally. Make it clear to all team members that we no longer care if a task finishes on time or not. It is the project deadline that is most important
- Implement the relay runner work ethic. When a resource is assigned a task, they complete it as quickly as they can and they pass the baton on to the next resource as early as possible

To take care of the bad multitasking problem, the new metric is to stagger projects according to the capacity of one resource, the organization's strategic resource in the multi-project environment. This resource is the resource that is most heavily loaded, or the resource that is most badly multitasked. Another way of identifying the strategic resource is to look for the resource that most delays the entire collection of the organization's progress.

When projects are staggered according to this one resource, project success rates increase dramatically and flow much more quickly through the organization. Numerous real life case studies now show project durations being cut by half or more through the methodology, including the new metrics.

Summary

Every organization has two choices for metrics – complexity or simplicity. The frame of reference described in this chapter, based on a methodology called the Theory of Constraints, has

been implemented in many companies across the supply chain. This approach looks for the simplicity inherent in every complex system. It has been applied to marketing, production, engineering & project management, distribution and company strategy. In a study conducted by Mabin and Balderstone[8] of dozens of reported cases, the following mean improvements were noted:

- Lead time: 70%
- Due date performance: 44%
- Inventory reduction: 49%
- Revenue improvement: 83%
- Profitability improvement: 116%

Over 20 books have been published about the Theory of Constraints and many self-study materials are available. You are welcome to investigate further at www.tocinternational.com or by email to Gerryikendall@cs.com.

[8] International Journal of Operations and Production Management, Spring 2003