FabTime Cycle Time Management Newsletter

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Information

Mission: To discuss issues relating to proactive wafer fab cycle time management.

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Welcome

Welcome to Issue #4 of FabTime's cycle time management newsletter. The newsletter is a free monthly publication, distributed by email to people interested in wafer fab cycle time. To subscribe, just send an email to Jennifer.Robinson@FabTime.com. We're now up to 145 subscribers, representing 56 organizations and several independent consultants. I encourage you to pass along this newsletter to anyone within your company who you think might be interested. This month's issue features a great write-up from Frank Chance. The subject is the Theory of Constraints. Even if you're familiar with TOC, I think you'll find some new information, and food for thought. Thanks for reading!

A Short Introduction to the Theory of Constraints

Eliyahu Goldratt

The Theory of Constraints is now in its fourth decade of development. Eliyahu Goldratt, the central figure in this development, first came to the area in the mid 1970's. At the time, a friend was having difficulty scheduling work at a factory that built chicken coops. Goldratt, a physicist by training, developed a new scheduling system for this factory that helped the factory to dramatically increase throughput without increasing operating expenses. The ideas behind this scheduling system were incorporated into a commercial piece of software, OPT, that was released in 1978.

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OPT's success, however, was limited, and this led Goldratt to further consider the problem of job-shop manufacturing. What he found was that placing a scheduling system on top of a chaotic operating environment rarely made things better, and often made things worse. Workers on the floor develop workarounds, such as expediting (hot lots), to deal with the chaos. When these workarounds are suppressed in favor of a scheduling discipline, the underlying chaos doesn't disappear, it still causes problems, which are often blamed on the new scheduling system. In order to install any scheduling system, Goldratt discovered that it may be necessary to first solve much deeper basic problems. It is this insight that led Goldratt to the concepts found in "The Goal", first published in 1984.

The Goal

Most people are introduced to the theory of constraints via "The Goal", often at the urging of a friend or colleague who has previously read it. The book is a fast-moving novel that considers the plight of Alex Rogo, a plant manager whose factory is in deep trouble. Orders are late, customers are unhappy, and the entire division has only a few months to improve or it will be sold off by the parent company.

"Placing a scheduling system on top of a chaotic operating environment ... often made things worse."

In the midst of this crisis, Alex tracks down an old professor, a very Goldratt-like figure named Jonah, for his advice. Jonah, in a Socratic fashion, helps Alex to discover that while the plant may be doing well according to traditional cost-accounting measures such as tool efficiencies and product cost, it is actually doing poorly when it comes to the real goal of making money. Thus, these cost-accounting measures are falsely leading his factory away from the goal. The first step is to develop a set of performance measures that, if improved, will result in the factory approaching its goal. These are:

1) Throughput - the rate at which the factory generates money through actual customer sales;
2) Inventory - money the factory has invested in things which it intends to sell; and
3) Operating Expenses - money the factory spends in order to turn Inventory into Throughput.

The second step in Alex's challenge is to understand what he should change in his factory in order to increase throughput, to decrease inventory, and to decrease operating expenses. Very quickly Alex comes to the conclusion that his main opportunities lie in increasing throughput. Inventory and operating expenses could be improved with some effort, but unless throughput improves dramatically, the plant will be sold and possibly shut down. The question becomes, then, how to improve throughput. Since the factory has customer orders that it is unable to fulfill, throughput could be improved if the factory could produce these orders more quickly. Which leads to a search for production bottlenecks, or constraints.

Find the Herbie and Drum-Buffer-Rope

It is this process of searching for and improving the production bottleneck that most people consider to be the heart of the theory of constraints. The book contains several examples, including a simple method for finding the constraint - look for the tool with a big pile of inventory waiting in front of it. Alex makes this observation after leading his son's Boy Scout troop on a hike. This hike is probably the most famous example in the book, for it leads to

the expression "Find the Herbie". On the hike, Alex watches the troop gradually spread out in a line as the day progresses. He compares the boys to machines in his factory, where each boy's job is to "walk trail", and only when the last boy has walked a section of trail does it become throughput. The distance between the first boy and the last boy is the total "inventory" of the system, and the distance between boys is similar to the inventory in front of a machine.

Alex discovers that as the boys spread out, they naturally order themselves so that the fastest is in front, and the slowest (a boy named "Herbie") is last. To keep the troop together, he reverses the line so that Herbie is in front, with each boy behind him gradually faster. This makes it obvious that the troop's throughput is limited by the slowest boy (thus the expression, to "Find the Herbie" in reference to finding a system's bottleneck). Next Alex lightens Herbie's pack so that Herbie, and thus the entire troop, can hike faster.

Back in his factory, Alex uses this trick to find his factory's current bottleneck, but quickly discovers that the bottleneck is right in the middle of his process. He cannot move this tool to the beginning of the production process, where it would naturally limit the flow of work released into production (as moving Herbie to the front of the line did on the hike). Instead, he ties the flow of new work into the factory to the bottleneck, so that work does not arrive faster than the bottleneck can process it.

Using the hike analogy again, this would mean that Herbie is in the middle of troop, and there is a rope tied between the first hiker and Herbie, so that the first hiker can go no faster than Herbie. The boys in front of Herbie naturally bunch up behind the lead hiker, leaving a buffer of unwalked trail in front of Herbie. This is the basic idea of the "Drum-Buffer-Rope" scheduling system. Herbie is the Drum, i.e. he sets the pace for the entire troop, the buffer of unwalked trail in front of Herbie ensures that he never waits for the boy in front of him to move, and the Rope ensures that the system only accepts work (unwalked trail) at rate that Herbie can handle.

Policy Constraints

Over time, Alex and his team become quite proficient at identifying and breaking production bottlenecks. As throughput rises, however, they eventually reach a point where customer demand becomes the limiting factor. Here, Alex must work with the company's salesman to find more customer orders. Part of this process involves changing assumptions about how quickly the factory can deliver, and what pricing methods will be profitable.

It is this process that leads to the conclusion that constraints are not always physical tools in the factory. Once the factory has improved to the point where it is able to meet demand, constraints often shift to policy decisions. And these policy constraints can be just as hard to break as physical constraints in the factory.

Ongoing Improvement

In the latter part of "The Goal", Alex and his team begin to develop a systematic method for identifying and attacking system constraints. They hammer out the basic steps in this process:

1) Identify the system's constraint(s)
2) Decide how to exploit the system's constraint(s).
3) Subordinate everything else to the above decision.
4) Elevate the system's constraint(s).
5) If in the previous step a constraint has been broken, go back to step 1, but do not allow inertia to cause a constraint.

These five steps form the classic definition for the theory of constraints methodology. Notice how they are a generalization of the steps Alex took to fix his production bottlenecks. Since the publication of "The Goal," the Goldratt Institute has taken this generalization one step further with "The Thinking Processes". The thinking processes are a generalization of the theory of constraints, with the aim of helping people to confront and solve complex problems.

Implications for Wafer Fabs

Certain elements of the theory of constraints apply easily to wafer fabs. For example, the 5-step process for identifying and attacking system constraints is certainly valid, as is the concept of a bottleneck tool or tool group that constraints throughput. Most capacity planners are comfortable using spreadsheets or other software tools to predict the location of the bottleneck, and using this information to calculate a maximum throughput number for the fab.

The extreme expense of wafer fab capital equipment, however, makes it more difficult to justify the unbalanced factory recommended in "The Goal." (see Jonah's comment that "the closer you come to a balanced plant, the closer you are to bankruptcy"). So capacity planners tend to hedge and buy spare capacity only where it is relatively inexpensive (inspection equipment, for example). The net result is a bottleneck that in practice floats among several highly loaded groups of equipment. A floating bottleneck makes is practically impossible to implement drum-buffer-rope scheduling, since the location of the drum keeps shifting. We have seen fabs explicitly purchase additional non-bottleneck capacity in order to reduce cycle times, but not frequently.

"The closer you are to a balanced plant, the closer you are to bankruptcy."

And finally, the reentrant nature of wafer fab flow also is quite different than the job-shop factory described in "The Goal." This difference compounds the difficulty of locating the bottleneck, and managing it with any sort of drum-buffer-rope scheduling policy.

Nevertheless, "The Goal" has been widely read among fab personnel, and has contributed to a broad understanding of bottlenecks and constraint management.

Next Time

The theory of constraints and just-in-time (lean manufacturing) both seek to address the problem of chaotic manufacturing operations. At times they appear to offer directly conflicting advice. How are these methodologies alike and how are they different? In our next issue we will explore this question in depth. (If you have other questions that you would like to see us explore in future issues, send email to Jennifer.Robinson@FabTime.com.)

More Resources

If you haven't already read it, pick up a copy of "The Goal", 1992 (2nd edition), Goldratt and Cox.

Much is said in "The Goal" about the difficulty of running a manufacturing plant according to the principles of cost accounting. For a followup study that addresses this issue and reports on the real-life experiences of several factories that implemented the theory-of-constraints methodology, see "The Theory of Constraints and its Implications for Management Accounting", 1995, Noreen et al.

For an introduction to the thinking processes, see "It's Not Luck", 1994, Goldratt.

Community News

SEMICON West

Frank and I attended Semicon West this year. It was a fun place to be, because the industry is doing so well, and people were generally upbeat. The booths were very flashy. We do think, however, that the conference organizers should provide for more places to sit and meet with people.

Job Change - Daniel Miroglio

Daniel MIROGLIO is leaving IBM after 26 years in semiconductor manufacturing logistics to go to work at Synquest, a provider of advanced scheduling systems which is in the process of going public. His new responsibility will be to coach the WW marketing and presales operations of the Virtual Production Engine targeted at Semiconductor Front end and Back end fabs. The tool includes a discrete event simulator, a capacity engine, and an MES interface. You can contact Daniel at dmiroglio@synquest.com, or at +33 1 41 05 99 13 for more information.

Location Change - Jennifer Robinson

I am happy to report that I recently moved from Houston, Texas to Menlo Park, California. My email address is the same. My new direct phone number is 650-233-9193. My business mailing address is: FabTime, 2055 Gateway Place, Suite 400, San Jose, CA 95110. So far I am REALLY enjoying the weather in the Bay Area, though I'm less happy about the housing prices. It's also very nice to be closer to the action in the semiconductor industry. I already know more people here than I did after two years in Houston. If any of you are living in the Bay Area, and would like to get together for lunch sometime, please give me a call.

FabTime welcomes the opportunity to publish announcements for individuals or companies. Simply send them to Jennifer.Robinson@FabTime.com.

Recommendations

■ July's FabTime book review was World Class Manufacturing Casebook: Implementing JIT and TQC by Richard Schonberger (http://www.fabtime.com/worldclass.htm). August's FabTime book review (mentioned above) will be "The Theory of Constraints and its Implications for Management Accounting", 1995, Noreen et al. Both of these will contribute to the topic of next month's newsletter. We also recently discovered a new edition of Factory Physics, by Hopp and Spearman, a previous FabTime book recommendation (http://www.fabtime.com/physics.htm). You can buy it at Amazon.

■ Last month we mentioned the semiconductor modeling bibliography that John Fowler maintains at Arizona State (http://www.eas.asu.edu/~masmlab). I maintain a related bibliography on capacity modeling for wafer fabs at http://www.jkrconsult.com/capbib.htm). Both bibliographies originated from the SEMATECH Measurement and Improvement of Manufacturing Capacity Project (MIMAC), but they have been maintained independently since 1995, and each now contains many unique references. I have abstracts for many of the articles in my bibliography, and you can email me if you would like me to send you any of them.

■ The N-Able Group website (http://www.n-ablegroup.com/) has a great collection of industry databases, with links where appropriate. Topics include Semiconductor companies, Associations & Organizations, Foundries, Subcontract Assembly & Test, Distributors, Materials Vendors, Design Services, IP Resources, Semiconductor Reference Sites & Newsgroups, and Software Vendors.

■ If you're interested in cycle time management, you might be interested in

attending SISA's Value Chain Optimization conference, to be held September 12th, at the Westin Hotel in Santa Clara. You can register at http://www.sisa.org/registration-forms/vco/vco-form.cfm. The website says that "This conference will build upon the concepts of cycle time manufacturing and lean manufacturing. The conference will focus on successful implementation of cycle time manufacturing concepts by past conference attendees." SISA is the Semiconductor Industry Supplier's Association, formerly SEMI/SEMATECH. SISA and SEMATECH members can attend at no charge - other non-member attendees must list a sponsoring organization.

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