FabTime Cycle Time Management Newsletter

Volume 6, No. 5 June 2005

Information

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

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in this version (7.5) include support for external references to FabTime charts and data tables – now live FabTime charts and data tables may be presented as part of any company intranet web site.

Editor: Jennifer Robinson

Contributors: Frans Brouwers (Philips Semiconductors); James Ignizio (Intel); and CM Chan (Chartered Semiconductor Manufacturing)

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Welcome

Welcome to Volume 6, Number 5 of the FabTime Cycle Time Management Newsletter! We hope that you're enjoying summer wherever you are. This month's FabTime user tip of the month is about setting up personal goals and displaying them on chart pages. We have subscriber discussion related to last month's article on lot dispatch for wafer fabs, as well as on the practical application of WIP turns and the cause of declining moves. We also have a conference announcement and call for papers for the 2006 Advanced Semiconductor Manufacturing Conference.

In our main article this month we have opted to go back to basics. The article discusses the three fundamental drivers of cycle time at the tool level: utilization, variability, and number of qualified tools per tool group. We introduce each of these factors, reviewing why and how they affect cycle time. Each discussion concludes with suggestions for mitigating the effect of the factor, and hence improving cycle times. While we have discussed each of these issues in previous newsletters, this article brings the topic together into one convenient format. We do have a one-hour presentation that is similar to the content in this article. If you would like someone from FabTime to visit your site to give this talk (perhaps to help you to kick-start a cycle time improvement project), please contact us.

Thanks for reading!—Jennifer

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Community News/Announcements

Conference Announcement: ASMC returns to Boston in 2006!

SEMI® and IEEE are now soliciting abstracts for the 17th Annual IEEE/SEMI Advanced Semiconductor Manufacturing Conference (ASMC 2006), which will be held on May 22–24, 2006 Boston, Massachusetts. Next year's conference will be co-chaired by Nirmal Govind, Intel and Jacek Tyminski, Nikon Precision. Featuring presentations and participants from the leading device manufacturers and their suppliers, as well as academia, ASMC provides practical manufacturing solutions direct from the fab. For the complete call for papers and guidelines, visit the ASMC homepage at http://www.semi.org/asmc. The deadline for abstracts is September 22, 2005.

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

Display Personal Goals on Chart Pages

Many FabTime charts display performance relative to a goal (e.g. moves charts, turns charts, per-visit cycle time charts, shipped lot cycle time charts). The default goal line that appears on the chart reflects the goal set by your site's management. Sometimes, however, you might want to set up a personal goal of your own.

To set up a personal goal, follow the "Set Personal Goals" link on the FabTime Charts page. If you do not see this link (just below the "Hide All Charts" link), you should contact your site's system administrator to request permission to set personal goals. The goal-setting interface always displays three blank rows, allowing you to specify up to three new goals at one time. To create a new goal in one of the blank rows, first use the "Result" drop-down to select the type of chart to which the goal will apply (moves, cycle time, etc.). Click the "Shared Goal" checkbox if you would like this goal to be visible to other FabTime users at your site. Enter the date at which the goal should start being displayed in the "Effective Date" column. Enter a numeric value for the goal in the "Goal" column, and enter the corresponding period length (in hours) for which this value applies in the "Period Len" column. For example, to enter a goal of 5000 wafer moves per day, enter 5000 as the goal, and 24 for the period length. (You could alternatively enter 2500 for the goal and 12 for the period length – these are equivalent). Once you have all of these columns filled in, press the "Save" button to the lower right of the goals table. FabTime will move your new goal to the top, and give you a new blank row for entering goals below (so that there are always three rows that you can use to enter new goals).

Before your goal will be relevant, you will probably need to add some filters to the goal definition. Remember that your goal will only be displayed if you are displaying the relevant chart AND have the same set of filters listed that are defined for the goal. Once you have saved a new goal, you'll see an "Edit" link in the "Filters" column. Click on "Edit" to reach the filter-specification page. Enter values for whatever filters you want to apply to this goal (e.g. only owner "Eng", only operations greater than 1000). The normal rules for filtering apply (wildcards, ranges, comma-separated lists, etc.). Once you are finished, click the "Save" button at the bottom of the page. Your goal is now in place.

Next, go to chart page for which you set up the new goal, and enter in any filters that you need to match those that you just specified. One last but critical step is to re-set the "Goal" drop-down on the chart, to tell FabTime to display your goal, instead of the default system administrator goal. You'll find this drop-down at the bottom of the main set of filters, right above the "Go" button. Find your name and select it, and then press the "Go" button. The chart should display your new goal line. If not, double-check that your filters exactly match those set up for the goal, and that your name is displayed in the "Goal" drop-down. (Your name will also be displayed in the legend on the chart).

If you have any questions about this feature (or any other software-related issues), just use the Feedback form in the software.

Subscriber Discussion Forum

Issue 6.04 – Lot Dispatch for Wafer Fabs

Frans Brouwers (Philips Semiconductors) submitted the following comments in response to last month's article about lot dispatching.

"1. Sequencing and scheduling is not the solution

I believe that sequencing and scheduling are working around the problem. Scheduling and sequencing can be rendered obsolete if you remove the bottlenecks, tool down situations, set up times, and differences in processes. So if you remove all sources of variability, then fab logistics becomes like a conveyer belt system with no lead time and limitless capacity. Luckily this dream never becomes a reality, and thus we still have a job to fulfill. But this thought should set the stage for your attention. It is more important to solve the problem than it is to optimize the working around it.

2. Scheduling should be done frequently.

This indeed is true. It requires a scheduling tool that is actually fast enough to make such calculations a few times in a short time (say 1/2 hour), and which is able to optimize towards preset conditions (all within this 1/2 hour). Note that an optimized schedule for the next shift requires a period to be calculated of at least a few days.

3. Relation between sequencing and scheduling

I believe that scheduling should provide an input for sequencing. An optimized schedule for the next few days should set boundary conditions and targets used in local real-time decision making. If done in such a way, frequent scheduling is not required. Once a day is sufficient. However the need for fast estimation of an optimized schedule remains.

4. "Sequencing is local decision making"

Yes, it is true; it is local decision making. But it should be local decision making like a football player does every second while playing in a team. The team has a strategy and an agreement on how to tackle the opponent. Thus, embedded in the rules of conduct of fab logistic strategy, and embedded in a set of targets and constraints, sequencing is the real-time execution of global decision making.

5. Selecting sequencing rules

In my experience it is good to have available a set of sequencing rules which can be combined into one rule. Just as you propose. We have done so for the last decade. It should be possible to change the importance of one rule above the other on daily basis. This is required since a tool might be bottleneck today, but was not yesterday and will not be tomorrow. Additionally, on a more long term basis, since capacity, actual load (mix) and customer requirements do change, it is logical to change the fab logistic strategy accordingly. So selecting sequencing rules is not a once in a life time decision. It is continuous adapting to new circumstances."

James Ignizio (Intel Corporation) submitted these comments: "I would have to respectfully disagree with your definition of SCHEDULING in the newsletter. A schedule determines which jobs will be processed on which tools AND THE PRECISE TIMES that these lots will be introduced. A SEQUENCE, on the other hand, is an ordered list (e.g., of lots) --- with no constraint on the time the items in the list are assigned (e.g., to a tool)."

FabTime Response: This is an excellent point. This was so inherent to us in thinking about a schedule, that we didn't state it explicitly in the discussion.

WIP Turns

An **anonymous subscriber** asked: "I have a couple of questions about the practical application of WIP Turns measurement. This is not a metric widely used within our company, but I would like to see if there is value in looking at it to determine areas for improvement. My first question is about the relationship between WIP Turns and other speed metrics such as steps/day or days/PR. Is there a good way to correlate these metrics? I have noticed that on days when we have high steps/day, we are not necessarily seeing high WIP Turns at our key equipment. The second question is about the relationship of WIP Turns measurement for different equipment. Our range of WIP Turns for different equipment is very large. Is there a way to normalize these measurements so that we can compare the impact of different equipment to our overall speed?"

FabTime Response: On days when you have high steps/day and low WIP turns, this is consistent with having a large amount of WIP in the fab. With lots of WIP, operators and others likely feel pressure to get WIP moved out. This means that it is easier to keep tools running. At the same time, this pile of WIP means that it's very hard to get a higher than normal turn rate, because turns = moves/WIP. The advantage of turns over a metric like steps per day is that turns does take into account your WIP. If you use only steps/day, you could be hitting the goal every day, but still have WIP piling up in the line if starts have been increased since the goal was set. Regarding a comparison of WIP turns for different equipment types, we have seen this same behavior but don't have a great answer as to how to normalize the metric. We're opening this question up to other subscribers, to see if anyone else has anything to add. Send your responses to Jennifer.Robinson@FabTime.com.

Issues 6.04: Identifying the Cause of Declining Moves

CM Chan (Chartered Semiconductor Manufacturing) submitted the following comments in response to last month's subscriber discussion question about the cause of declining moves in a wafer fab. "In dealing with a declining moves situation, we tend to conclude that the performance of the fab is deteriorating; and start to take measures to push up the overall moves. However, the true cause of the decline must be carefully examined first.

Even at a steady rate of starts, one must look into whether there is any change in the mix of the starts. For a simple scenario of two main parts, A (with total 200 process steps) and B (with total 300 process steps), a swing in the proportion of each part will cause the fab's total weighted steps to change:

	Wafer Starts Per Day	
Part	**Before**	***New***
A (200 Steps)	250w	*350w*
B (300 Steps)	250w	*150w*
Total Starts	500w	*500w*
Weighted Steps	250	*230*
Moves Required	125K	*115K*

In this simple example, the absolute wafer starts quantity has not changed (500w per day) but due to a swing in mix toward the less complex part, the overall weighted steps in the fab will decrease and result in a corresponding drop in total fab moves requirement. In this case, a decline in fab moves is natural.

In a cycle-time driven fab, the main performance indicator should not be overall moves. Instead, the Fab Turns Ratio (Overall Moves divided by the WIP) should be used. The Fab Turns Ratio is a leading indicator of whether the WIP is moving at the target cycle-time. From a cycle-time perspective, a declining moves trend is not as alarming as a decreasing Fab Turns Ratio trend. Sometimes we tend to get worried about a declining moves trend and start to react by injecting more wafers into the line, putting in more resources, etc. This may bring the moves up momentarily but will inevitably bring about more damage to overall cycle-time and cost control.

If in a scenario where starts have been consistent (both quantity and mix), then a more in-depth analysis is required. Beside the traditional method of looking at individual production areas, we can also divide the entire process flow into "sub-regions" (For example, Region 1 from Laser-mark to the Gate Poly step; Region 2 from Post-Gate to Contact layer, etc.) The trend charts (WIP, Moves and Turns Ratio) for these "regions" will generally tell where the problematic areas could be. Usually the problematic tool sets are those non-bottleneck tools that generate mass moves daily. They are like the heart beat of the fab; moving WIP quickly to other areas that in return generate multiple moves downstream. Typically when there is a drop in performance level of these tools, the impact to overall fab moves will be magnified.

The Three Fundamental Drivers of Fab Cycle

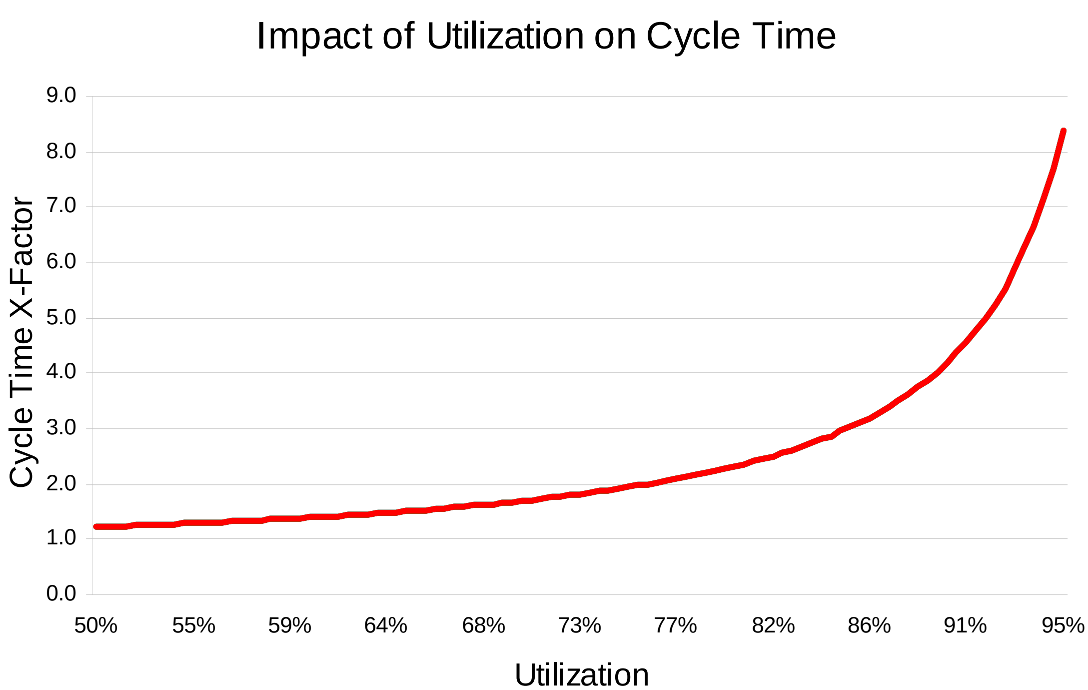
In this article we discuss three fundamental drivers of cycle time: tool utilization, variability, and number of qualified tools per tool group. At the tool level, these are the primary factors that affect cycle time. Other secondary factors such as downtime and setups affect cycle time through their impact on these three primary factors. Below, we will introduce each of the three factors, and suggest ways to influence them for cycle time improvement.

Utilization

Utilization has a direct and non-linear impact on cycle times through a tool. Here we define utilization for a tool (as in previous newsletters) as Productive Time / (Productive Time + Standby Time). Productive time is time that the tool is busy processing wafers. Standby time is time that the tool is available, and hence could be processing wafers, but is not. Utilization under this definition is what drives cycle time. In the presence of any variability at all, when standby time gets small relative to productive time, cycle time increases. As standby time approaches zero, cycle time gets very large. Intuitively, what happens is that we need the standby time to recover from variability. When there isn't much standby time, it takes longer to recover from variability, and cycle times suffer.

For a real-world example, think of driving along on the highway. When there's not much traffic (utilization is low), you can drive along pretty much unimpeded by other drivers. The more cars there are, however, the more chance there is that someone else will slow you down. If we all drove at exactly the same speed this wouldn't be so much of an issue. But of course we don't. A gap can form in front of a slower driver, adding a tiny bit of cycle time to the commute time of each and every other driver following behind.

So we see that as tool utilization increases, cycle times increase. When we graph this behavior (cycle time vs. utilization), we get what's called an operating curve. An example is shown in the picture below. In most cases this operating curve is shaped according to this formula:



- Cycle Time X-Factor ~= 1 / (1 - Utilization)

Here x-factor is actual cycle time divided by theoretical cycle time. As standby time approaches zero, utilization approaches 100%, and the denominator of the above equation approaches zero. Then we have one divided by zero, which approaches infinity. What we see in practice is that as utilizations get above about 85%, cycle times start to become large. And because the operating curve is non-linear, even small increases in utilization lead to big cycle time increases at this point. This, we believe, is why so many fabs plan capacity such that most tools are loaded to no more than 85%.

For tool groups with only one tool, a moderate amount of variability (exponential process times and times between arrivals), and independent arrival and process times (e.g. the tool does not get faster just because it is busier), the above equation is fairly accurate. It can be used to get a sense for what the cycle time will be for one-of-a-kind tools under different utilization values. For example, if such a one-of-a-kind tool is 75% utilized, then (under moderate variability) the cycle time x-factor is likely to be 1 / (1 - 0.75) = 1 / 0.25 = 4 times theoretical.

Utilization is often viewed as relatively fixed on a day to day basis. Fabs are under constant pressure to increase utilization, to make the most of the high capital cost of the equipment. Therefore, saying that you should reduce tool utilization in order to reduce cycle time does not immediately sound practical. However, remember the definition of utilization that we're using. Productive Time / (Productive Time + Standby Time). The denominator here is also sometimes called Manufacturing Time. It's what you have left after you take out any downtime, engineering time, and non-scheduled time. Therefore, anything that we can do to reduce downtime, engineering time, and non-scheduled time will, if starts are not increased, directly increase standby time. This will reduce utilization, and hence improve cycle time.

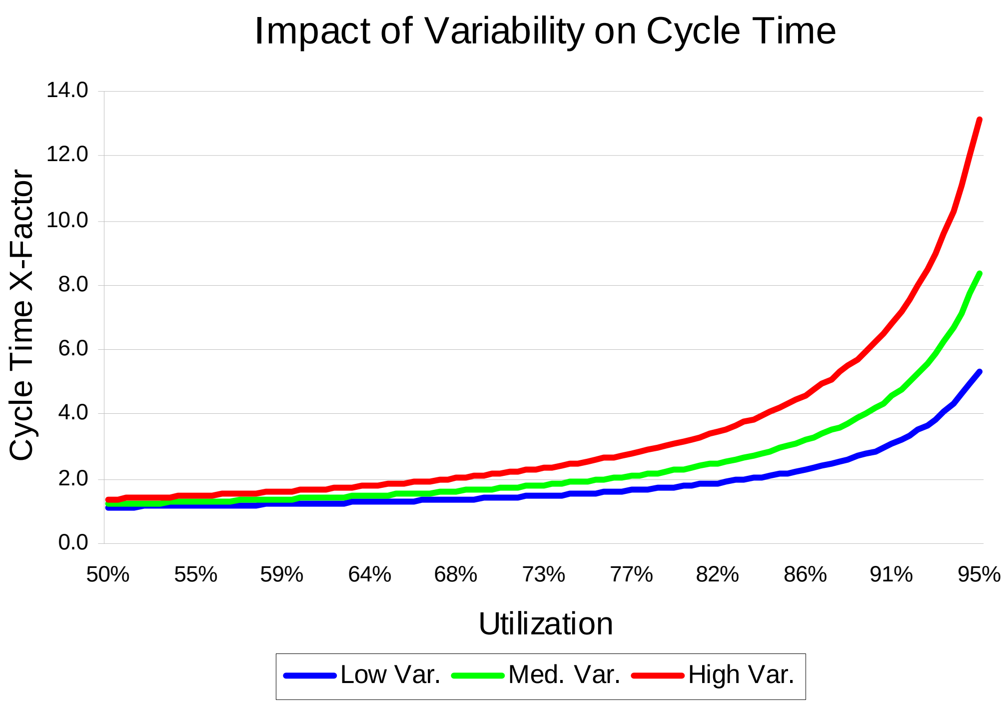
One further note is necessary regarding standby time. What drives down cycle time is having standby time as catch-up time on the tool. This means that everywhere that we've discussed standby time in the above, we should really be more specific, and refer to standby time during which no WIP is waiting for the tool. This is true standby time. The tool is available, but is not running because there is no WIP waiting to be processed. Having a buffer of such true standby time is helpful for cycle time improvement, because it allows room to recover from variability. If, however, we have time reported as standby time on the tool, during which WIP was qualified and waiting for the tool, this time should really be treated as a loss for the tool. Usually it occurs because there is no operator available to load the tool. Reducing time spent in this state and replacing it with true standby time will improve cycle times.

Variability

Variability also affects cycle times adversely. Variability takes the operating curve of cycle time vs. utilization and moves it upward and to the left. (An example is shown on the next page). This means that for the same utilization, lots passing through higher variability tools will have higher average cycle times. There are many sources of variability in a fab, both in process times and in times between arrivals to tools. Contributors to process time variability include:

- Different recipes on the same machine, with different process times.
- Setups
- Equipment failures and maintenance events
- Rework lots
- Yield loss (scrap)
- Operators

Contributors to variability in arrivals to tools include:



- All of the above (because departures from one step become arrivals to the next step)
- Transfer batching and automated material handling
- Batch processing (running multiple lots in a machine at one time)

Earlier we said that for a one-of-a-kind tool, the operating curve is shaped like: X-Factor ~= 1 / (1 - Utilization). This was actually a simplification of a more general formula:

- X-Factor ~= 1 + [Utilization/(1-Utilization)] * [Variability Factor]

When the variability factor equals one, this reduces to the previous equation (1 / (1 - Utilization)). When the variability factor equals zero, the entire second term drops off, and we get X-Factor ~= 1. That is, we only have cycle time equal to theoretical cycle time when there is no variability. Any variability leads to increased cycle time, particularly when utilization is relatively high. The more variability, the higher the cycle time.

The variability factor is a sum of arrival variability and process time variability. More specifically, the variability factor = $(CV_a^2 + CV_p^2)/2$, where CV_a is coefficient of variation of interarrival times, and CV_p is coefficient of variation of process times. Coefficient of variation is a statistical measure of how widely dispersed values are, and is equal to standard deviation divided by average. We observe high coefficients of variation when values are widely spread out. For example, arrivals to a tool immediately downstream from a large batch tool might have a high coefficient of variation, because the sequence of times between arrivals looks like this: 0, 0, 0, 0, 0, 0, 0, 0, 12 hours. Here the zeros represent a batch arriving, with essentially no time between arrivals from lot to lot.

In summary, variability in either arrival times or process times increases cycle time. The good news is that anything that you can do to reduce variability will tend to improve cycle times. Some concrete suggestions (which have been discussed in more detail in other newsletter issues) include:

- Reduce transfer batch sizes.
- Eliminate minimum batch size

constraints on batch tools that are not heavily loaded.

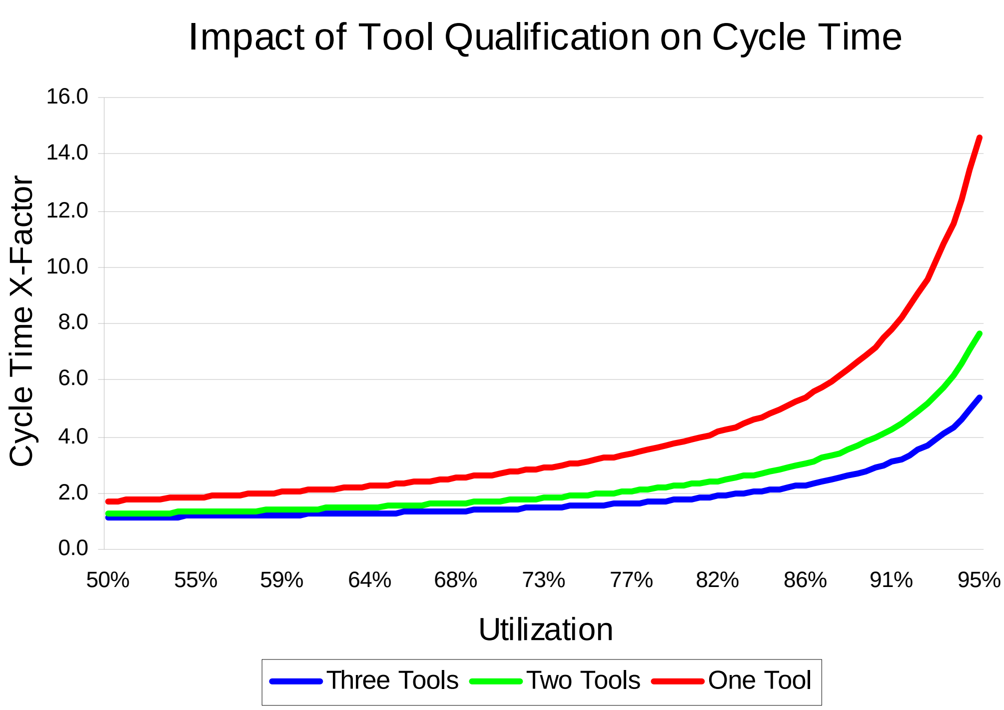
- Break up maintenance events, to avoid having tools unavailable for long, continuous stretches of time.
- Focus downtime improvement programs on reducing the duration of repair times.
- Spread out lot releases into the fab, instead of releasing lots in large groups.

Number of Qualified Tools per Tool Group

The third fundamental driver of cycle time at the tool level is tool qualification, or the number of tools available to process a lot at a particular recipe or operation. A recipe with only one qualified tool (often called a single-path tool, or a one-of-a-kind tool) will have higher average cycle times than a recipe with two qualified tools, even if the two tools each have the same utilization as the single tool. A recipe with two qualified tools will have higher cycle times than a recipe with three qualified tools (again, assuming the same utilization on all of the tools), and so on, although the effect is most dramatic when going from one tool to two tools. We have observed that per-visit cycle times are often reduced by about 50% when going from single path to dual path.

For example, suppose that you have two different, equal volume, recipes, which can be run on each of two tools. In the first case, you dedicate each recipe to one of the tools, so that you have two single-path tools. In the second case, you share both recipes across the two tools. The utilization of the tools is the same in both cases. However, the average cycle times through the tools will be approximately twice as high in the first (dedicated) case than in the second (non-dedicated) case. This is because in the dedicated case the single-path tool has less of a buffer against variability. This is often true even if some additional setup/qualification time is needed for the non-dedicated case.

An example is shown above. Cycle time decreases significantly when going from one tool per recipe to two tools per recipe. Cycle time decreases again when going from two tools per recipe to three, but does not decrease by as much.



To think about this intuitively, consider again the example of driving. If you are on a single lane road, and you end up behind a large, slow-moving truck, your cycle time is increased. On a two-lane road you have another lane that you can use to go around the truck. Similarly in the fab, if a single-path tool goes down, or has to process a lot with an exceptionally long process time, everything else has to wait.

What this means is that small fabs with many one-of-a-kind tools will tend to have higher cycle times than large fabs with many similar tools. (This assumes, of course, that the large fab has qualified most of the recipes in the fab to run on multiple tools.) Often this cycle time contribution from one-of-a-kind tools is an inevitable consequence of being a smaller fab. There are, however, sometimes things that can be done to mitigate the problem. Many fabs plan their capacity such that one-of-a-kind tools have a lower planned utilization than other tools (75-80% instead of 85-90%). Focusing variability reduction programs on one-of-a-kind tools can also help, since these tools are the ones most adversely affected by variability.

Another factor to consider is that dedication and qualification policies in many fabs lead to single-path tools, even when other similar tools are available. Sometimes this dedication is necessary, for reasons relating to yield improvement and process restrictions. However, we would urge you to ask your process engineers to re-evaluate tool restrictions from time to time. Sometimes a restriction that is initially put into place can be later relaxed. And the cycle time benefit can be significant. What we have also seen sometimes is what we can "soft constraints." These occur when operators prefer a certain tool to another, even though both are technically qualified to be used. Searching these out and eliminating them can be a source of cycle time improvement.

Conclusions

In this article, we have reviewed the three fundamental drivers of cycle time: utilization, variability, and number of qualified tools per tool group. Cycle time increases as utilization (Productive Time / (Productive Time + Standby Time)) increases. Anything that can be done to convert non-value-added time such as downtime to standby time (and hence to productive time whenever lots are available for processing) will tend to improve cycle time. Cycle time also increases with variability in process times and in times between arrivals. Variability reduction, then, is a relatively inexpensive way to improve cycle time. Finally, the more tools that are qualified to process each recipe in the fab, the lower the cycle time will be. True one-of-a-kind tools should be planned at lower capacity loading values to improve cycle time, while process restrictions that lead to single-path tools should be examined, and removed where practical. We believe that focusing on these three factors (which interact significantly) will provide an excellent start to any cycle time improvement program.

Closing Questions for FabTime Subscribers

Do you focus on utilization, variability, and tool qualification in your cycle time improvement projects? Do you feel that your colleagues understand the impact of utilization, variability, and qualification on fab cycle time?

Further Reading

- W. Hopp and M. Spearman, *Factory Physics*, McGraw-Hill/Irwin, 2000. See a review at www.fabtime.com/physics.shtml.
- J. H. Jacobs, L. F. P. Etman, E. J. J. van Campen, J. E. Rooda, "Characterization of Operational Time Variability using Effective Process Times," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 16, No. 3, 511-520, 2003.

■ S.-S. Ko, R. Serfozo, A. Sivakumar, "Reducing Cycle Times in Manufacturing and Supply Chains by Input and Service Rate Smoothing," *IIE Transactions*, Vol. 36, No. 2, 145-153, 2004.

■ J. Robinson and F. Chance, "Cycle Time Constrained Capacity," *FabTime Newsletter*, Volume 5, Number 6, 2004.

■ J. Robinson and F. Chance, "How Much Does Tool Dedication Inflate Cycle Time?" *FabTime Newsletter*, Volume 3, Number 3, 2002.

■ J. Robinson and F. Chance, "Quantifying Wafer Fab Variability," *FabTime Newsletter*, Volume 4, Number 1, 2003.

■ A. Schoemig, "On The Corrupting Influence Of Variability In Semiconductor Manufacturing," *Proceedings of the 1999 Winter Simulation Conference*, 1999. (All 1997 to 2003 WSC papers are available for free download from www.informs-cs.org/wscpapers.html).

Subscriber List

Total number of subscribers: 1878, from 421 companies and universities. 25 consultants.

Top 10 subscribing companies:
- Intel Corporation (97)
- Analog Devices (78)
- Atmel Corporation (62)
- Infineon Technologies (57)
- Freescale Semiconductor (55)
- STMicroelectronics (54)
- Micron Technology (47)
- Philips (47)
- Texas Instruments (41)
- TECH Semiconductor Singapore (38)

Top 4 subscribing universities:
- Virginia Tech (10)
- Arizona State University (8)
- University of California – Berkeley (7)
- Nanyang Technological University (6)

New companies and universities this month:
- ESME-Sudria Ecole D'Ingénieurs Généralistes
- National Chiao Tung University
- Selastar Corporation
- Toppan Photomasks
- University of Hong Kong
- Vanguard International Semiconductor Corporation

Note: Inclusion in the subscriber profile for this newsletter indicates an interest, on the part of individual subscribers, in cycle time management. It does not imply any endorsement of FabTime or its products by any individual or his or her company.

There is no charge to subscribe and receive the current issue of the newsletter each month. Past issues of the newsletter are currently only available to customers of FabTime's web-based digital dashboard software or cycle time management course.

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FabTime® Cycle Time Management Training

"It was helpful to see best-in-class methods for wafer fab cycle time management. Discussing these matters in-depth with you was quite valuable, as we could ask questions specific to our fab and processes."

Shinya Morishita
Manager, Wafer Engineering
TDK Corporation

Course Code: FT105

This course provides production personnel with the tools needed to manage cycle times. It covers:

- Cycle time relationships
- Metrics and goals
- Cycle time intuition

Price

$4950 plus travel expenses. On-site delivery for up to 15 participants, each additional participant $195. Discounts available for multiple sessions.

Interested?

Contact FabTime for a quote.

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Do you make the best possible decisions?

- Do your supervisors possess good cycle time intuition?
- Are you using metrics that identify cycle time problems early?
- Can you make operational changes to improve cycle time?

FabTime's Cycle Time Management Training is a one-day course designed to provide production personnel with an in-depth understanding of the issues that cause cycle time problems in a fab, and to suggest approaches for improving cycle times. A two-day version is also available upon request.

Prerequisites

Basic Excel skills for samples and exercises.

Who Can Benefit

This course is designed for production personnel such as production managers, module managers, shift supervisors, hot lot coordinators, and production control.

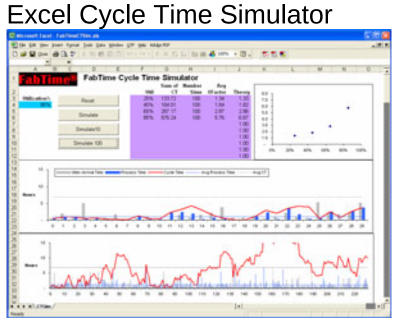
Skills Gained

Upon completion of this course, you will be able to:

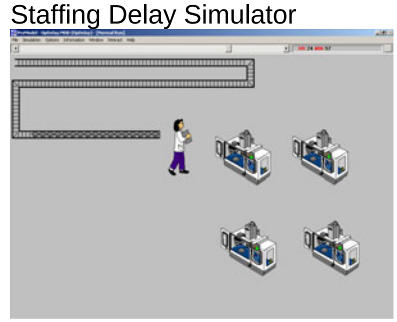
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition to operational decisions.

Sample Course Tools

Excel Cycle Time Simulator



Staffing Delay Simulator



Additional Half-Day Modules

- Executive Management Session.
- Site-Specific Metrics Review.
- Capacity Planning Review and Benchmark.