FabTime Cycle Time Management Newsletter

Volume 7, No. 1 January 2006

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 AutoDispatch support, for sites that do not generate a Dispatch transaction when a BeginRun occurs, and new HideControls parameter for slide shows, making it possible to display only the slide show chart on fab monitors.

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Contributors: James Ignizio (Intel)

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Welcome

Welcome to Volume 7, Number 1 of the FabTime Cycle Time Management Newsletter, and Happy New Year! Early indicators suggest that 2006 is going to be a great year for the semiconductor industry, and a great year for FabTime, too. This year we have already started work with one new software customer, and received a purchase order from another. We hope that 2006 brings new business for all of you, too.

In this month's issue we have announcements about a new software development cost estimation tool from WWK, and a FabTime News and Updates website/blog that we are beta testing. We would love to have your feedback on that. Our software user tip of the month describes how to add a custom title to any FabTime chart. This month's subscriber discussion forum brings feedback from James Ignizio regarding last month's article on operational recommendations for fab cycle time improvement, as well as a new subscriber question about understanding the relationship between staffing levels and equipment utilization.

In our main article this month, we discuss the cycle time impact of running development wafers in a production fab. For many fabs, running development wafers in a production fab is a necessary part of doing business. However, the development wafers can have a negative impact on production lot cycle times. In this article, we discuss several reasons why development lots may contribute to higher production lot cycle times. We also trace each of these factors back to their effect on the three fundamental drivers of fab cycle time: utilization, variability, and number of tools per tool group. We hope that you will find it an interesting discussion.

Thanks for reading!—Jennifer

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Community News/Announcements

FabTime News and Updates Website

We are currently experimenting with a new FabTime News and Updates website. The goal of this site is to give us a way to communicate more frequently with our customers and newsletter subscribers. The website will feature links to industry articles relevant to fab cycle time, FabTime news, conference announcements, and occasional short articles about cycle time improvement and metrics. The site will use a blog format, which will allow you to subscribe to receive updates automatically, in either RSS feed or email format. Right now we have a beta version of the news and updates site (snapshot below) available at fabtime.typepad.com/. We welcome your feedback!

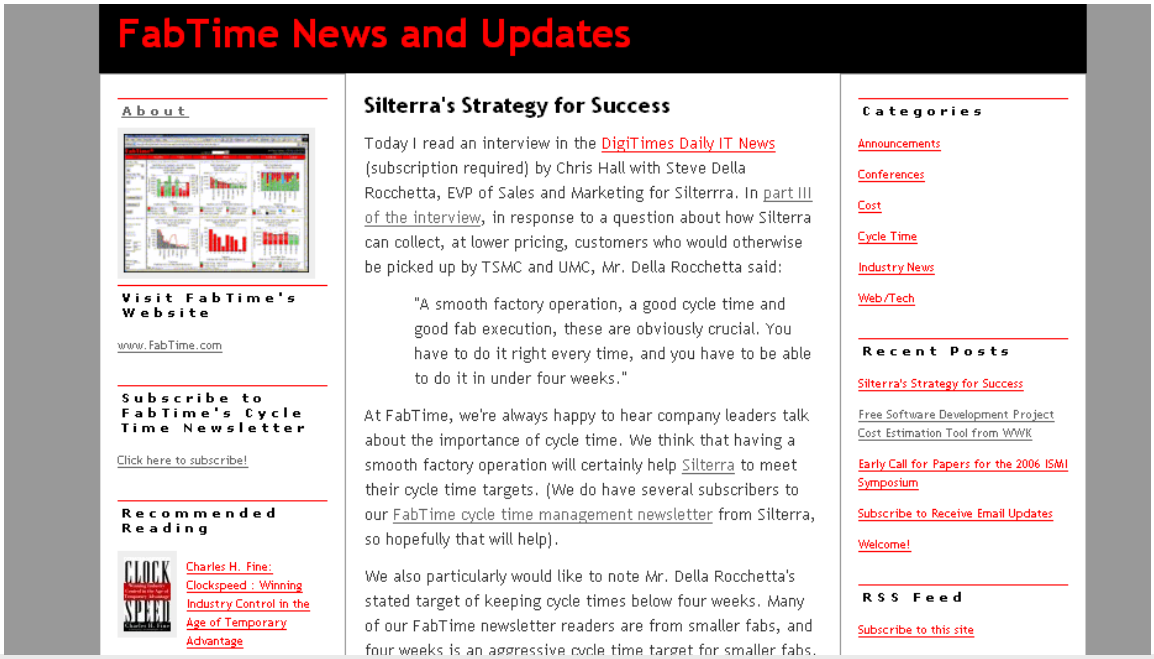
Free Software Development Project Cost Estimation Tool from WWK

January 16, 2006 (Pleasanton, CA) Wright Williams & Kelly, Inc. (WWK), a cost & productivity management software and consulting services company, announced today the availability of COOLSoft™ v2.0, its latest generation software development cost estimating tool. COOLSoft™ utilizes a hybrid approach of intermediate and detailed versions of the Constructive Cost Model (COCOMO). This allows for the reuse of existing code, development of new code, the purchase and integration of third party code, and hardware integration. The output is then displayed as man-months of programming effort, calendar schedule, support costs, and hardware costs.

"We have used COOLSoft™ for the past decade as an internal guide to our development projects", stated David Jimenez, WWK's President. "This latest release transforms our internal tools into a commercial grade application that any organization involved in software development or maintenance will see as a great benefit. Software development budgets and timelines are always met with skepticism by management and COOLSoft™ provides a quantitative approach to help reduce uncertainties."

COOLSoft™ download instructions are available on the WWK web site (www.wwk.com) by selecting the Products link and then the COOLSoft™ link.

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



FabTime User Tip of the Month

Add a Custom Title to any FabTime Chart

If you have home page charts that feature complex sets of filters, and/or home page charts that are similar to one another, you probably would like a way to more quickly tell which chart is which, without looking closely at the filter lists in the chart title. We have recently added this capability to FabTime 7, in response to a customer request. To add a custom title to a chart, follow these steps:

1. Go to the detailed chart view for the chart (rather than the home page). If the chart is already on your home page, simply click on the chart. If you are creating a new chart, create it from the Charts page.

2. Once your chart is configured the way that you would like it (with filters, etc.), scroll down to find the set of controls labeled "Format:" in the lower left corner of your screen. Near the bottom of this set of filters, you'll see a multi-line text box labeled "Title:".

3. Type your desired title into this text box. You can have long titles – a scrollbar will appear to the right of the text box once you start entering your fourth line of text.

4. When you finish typing your title, press the "Go" button below the "Format:" controls (below the "Refresh:" box). This is important – it's the only way FabTime will know about your title and include it on the chart. Your custom title will appear as the top row of the chart title. The other title rows, listing the default chart name and all of your filter settings, will appear below your title.

5. Click the "Add" button in the upper left corner of the screen to add the chart to your home page, or use the "Update" button is you are adding a title to a chart that was already on your home page.

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 6.10: Operational Recommendations for Wafer Fab Cycle Time Improvement

James Ignizio (Intel) wrote "The article in Volume 6 of FabTime titled "Operational Recommendations for Wafer Fab Cycle Time Improvement" presented an excellent summary of most of the procedural methods (i.e., as opposed to the brute force approach of buying tools, hiring more people) that may be employed to improve cycle time. The only matters I would recommend adding to the discussion are those regarding the allocation of maintenance personnel to tool sets and the employment of the M-ratio.

By means of optimized maintenance headcount allocation rather than traditional, heuristic means [i.e., see

Ignizio, J. 2004. "Optimal maintenance headcount allocation: an application of Chebyshev Goal Programming," *International Journal of Production Research*, 42(1), pp 201-210] it is possible to substantially reduce factory cycle time (e.g., from 5 to 20 percent in many cases). The same approach may be extended to the reduction in time spent waiting for spare parts. While most firms, in and outside the semiconductor industry, fail to appreciate the importance of technician and spares allocation optimization, I believe they are overlooking what can be a key factor in factory performance improvement.

When it comes to metrics and reporting, I'd strongly recommend the employment of the M-ratio. This ratio provides an excellent picture of factory tool health. A symptom of a poorly performing fab is a ratio of scheduled to unscheduled downtime that is less than 9. [At a ratio of 9, scheduled maintenance is 90 percent of maintenance downtime – a target that has been achieved and exceeded by factories aware of the importance of the M-ratio.] Any firm that is serious about reducing factory cycle time and improving factory performance in general should be monitoring their M-ratio – and taking actions necessary to increase it. I've been able to introduce the M-ratio metric (and such supporting tools as the Waddington Effect and Waddington Analysis) in a number of firms over the past 20 years and, in almost every case, just the awareness of the metric served to motivate efforts toward the reduction of cycle time via changes in maintenance protocols."

Equipment Utilization vs. Staffing Levels

An anonymous subscriber wrote: "I was wondering if you have some good resources for understanding the relationship between staffing levels and equipment utilization. Here is how I am thinking about it. With a given equipment and WIP level and a relatively low staffing level there seems to be a linear relationship between staffing and utilization. However, the closer the toolset approaches capacity the less of an impact staffing levels will have on utilization. At some point there is no more throughput that can be gained by adding more manpower. The point I am trying to make in our fab is that with certain bottleneck toolsets, if we want to squeeze out a few more percent utilization we need to baby sit those tools, which will require additional staffing at those toolsets."

FabTime Response: This is a topic that a number of people have looked into, primarily in conference papers. We've included the references below. We are unable to provide the full papers, but the first one is available for download.
We have an entire section on this in our two-day cycle time management class, and we include a small simulation example with animation that shows what happens when you have one operator trying to manage four tools at one time. If the operator is about 80% loaded and the machines are 85% loaded, and you always need the operator for load and unload, you can definitely see significant cycle time building up. The simulation helps to make this more clear to people. What you describe, in terms of babysitting the key tools to squeeze the last bit of utilization out of them, is certainly something that we recommend for cases where a fab is losing capacity on a bottleneck due to lack of operators. In our software, we report "standby-WIP waiting" time on the tools. This is time that the tool was up and had WIP ready to be processed, but sat idle due to the lack of an operator. This is an indicator of where additional staffing may be needed, particularly if it occurs at a tool that shows high per-visit cycle times. Here are some additional references:

- R. C. Kotcher, "How "Overstaffing" at Bottleneck Machines Can Unleash Extra Capacity," *Proceedings of the 2001 Winter Simulation Conference*, Washington, D.C., 1163-1169, 2001. (All 1997 to 2003 WSC

papers are available for free download from http://www.informs-cs.org/wscpapers.html).

- T. Croft, S. Sheamer, and T. Baker, "Wafer Fab Labor Modeling with Queueing Theory," *Proceedings of the 2002 International Symposium on Semiconductor Manufacturing (ISSM2002)*, Tokyo, Japan, 2002.

- P. Desruelle and H. J. Steudel, "A Queuing Network Model of A Single-Operator Manufacturing Workcell with Machine/Operator Interference," *Management Science*, Vol. 42, No. 4, 576-590, 1996.

- J. Foster, T. Nugent, and P. Marcoux, "Implementation of Best Known Methods," *IEEE 2000 Advanced Semiconductor Manufacturing Conference (ASMC 00)*, 181-186, 2000.

- H. Gold, "A Simple Queueing Model for the Estimation of Man Machine Interference in Semiconductor Wafer Fabrication," *Operations Research Proceedings 2001 (OR 2001)*, Duisburg, Germany, September 2001.

- J. Huang and Hsin-Cheng Wu, "Direct Labor Headcount Model Study for Semiconductor Fab Operation-Modulator Design Concept Approach," *Proceedings of the 2002 Semiconductor Manufacturing Technology Conference*, 98-101, 2002.

- Y.-F. Hung and I.-H. Chen, "Dynamic Operator Assignment Based on Shifting Machine Loading," *International Journal of Production Research*, Vol. 38, No. 14, 3403-3420, 2000.

- N. Kroehn, "The Impact of Staffing on Cycle Time Evaluated by Simulation," *IEEE 2004 Advanced Semiconductor Manufacturing Conference (ASMC '04)*, 379-382, 2004.

- R. Yu (TSMC), "Modeling the Transportation Manpower of Staffing

Running Development Lots in a Production Fab

As long-time newsletter readers know, FabTime has for several years been conducting an informal survey regarding the conditions in wafer fabs that contribute most to cycle time. One response that has been consistently in our top 10 list, and one that we have not previously discussed in this newsletter, is "running development lots in a production fab." While this situation is not present for all fabs, it seems to cause a great deal of pain where we do find it. In this article, we will discuss several reasons why running development lots in a production fab may contribute to higher cycle times. We will also tie each of these reasons back to the fundamental drivers of fab cycle time.

The 3 Fundamental Drivers of Fab Cycle Time: A Quick Recap

Back in Issue 6.05 we described the three fundamental drivers of fab cycle time. At the tool group level, cycle time is driven by the following:

1. Utilization = Productive Time / (Productive Time + Standby Time). As

standby time becomes small, and utilization approaches 100%, cycle time gets very large. It is necessary to have some standby time on each tool group, as a buffer for uncertainty and variability. When a tool group experiences capacity losses (due to downtime, setup, etc), they eat into this standby time, resulting in higher utilization, and hence higher cycle times. Anything that we can do in a fab to take unavailable time and move it to standby time reduces utilization, and is good for cycle time (and/or allows for increased production).

2. Variability in times between arrivals to a tool group, and in lot to lot process times. Variability simply refers to things not being the same, from lot to lot. Anything that increases variability in arrival times or process times will increase cycle times at the tool group level. For example, batch arrivals to an operation result in most of the newly arriving lots having to wait for a tool, and thus having higher cycle times. Contributors to process time variability include operators (not being available to load or unload), setups, downtime, rework, yield loss, and different recipes with different process times.

3. Number of qualified tools per tool group. Lots processed at one-of-a-kind, or single path, tools have higher per-visit cycle times than lots passing through tool groups that have two or more tools. Average cycle time per visit deceases as tool redundancy is added, even when the tool utilization per tool remains constant. For example, if we have two equal volume recipes going through a tool group with two identical tools, we will usually see much better cycle times if either recipe can be processed on either tool, rather than dedicating each tool to a specific recipe. This is because on one-of-a-kind tools, each lot is subject to any variability that occurs (including downtimes, setups, operator delays, etc).

When we look at other factors that affect fab cycle time, we can increase our understanding of why and how each factor influences cycle time by understanding its impact on the above three fundamental cycle time drivers. This is what we'll do below, with certain attributes of running development lots in a production fab.

Dedicating Tools to Running Development Wafers

When running development lots in a production fab, it may be necessary to dedicate particular tools to run only development wafers. This may be required for yield reasons, for example. This dedication can have a negative impact on cycle time because of its effect on utilization and on the number of qualified tools. Taking a tool away from a shared tool group, and dedicating that tool to running only development wafers leads to the following:

- Single path operations for the development wafers.
- Smaller tool groups for the tools running production wafers.
- Higher tool utilization for the tools running production wafers.

Also, even when tools are not dedicated full-time to running development lots, they may be subject to having large chunks of time set aside for engineering development experiments. This is a capacity loss for the tools, similar to a downtime event. As with downtime events (as discussed in previous newsletter issues), the longer the continuous time period that the tool is unavailable, the worse the impact on cycle time.

Process Time Variability from Running Development Wafers

Even when particular tools are not dedicated to the development wafers, running development lots through the production tools increases process time variability. This occurs because process times for the development wafers are not yet standardized. Also, development lots

frequently have smaller lot sizes, including single wafer lot sizes, and hence have different per-lot process times than the production wafers. Development lot process flows are also subject to experiments and tests, holds, and splits and merges, all of which contribute to process time and/or arrival time variability. Development lots typically have poor yields to start with, which further increases lot size variability. Finally, development wafers may be subject to more operator variability than other lots, because of non-standard processing requirements, the need to call in an engineer to approve the next step, and the increased likelihood of holds. All of this variability is present in pure development fabs, too, of course. But when the development wafers are introduced into a production fab, the development process variability will also impact the cycle times of the production lots.

Treating Development Lots as Hot Lots

Often development lots are treated as hot lots because they are important to a fab's ability to deliver new products, or because the results of particular experiments are needed right away. This prioritization increases variability in the fab, because the development lots move to the front of the line, instead of lots being processed in the order of arrival. The situation is more dramatic when development lots are prioritized as super-hot, or hand-carry lots. In this case, they are subject to all of the cycle time problems that stem from any type of hand-carry lot, including:

- Extra setups, and in some cases wasted setup time on tools where a setup is broken to accommodate a hand-carry lot. This results in a capacity loss, and hence increases tool utilization.
- Lost capacity due to tools held idle for upcoming hand-carry lots. Whenever a tool is held idea for an upcoming lot, this results in a capacity loss, which increases tool utilization.
- Lost capacity on batch tools, when run nearly empty to accommodate a development lot. This can occur even when the development lot is not treated as a hand-carry lot, but is treated as a strict front-of-the-line priority lot. Running a batch tool nearly empty, when there are other lots waiting to be processed, increases the cycle time of all of the waiting lots. For particularly heavily loaded batch tools, there may not be sufficient spare capacity to make up for the near-empty batch, leading to longer queue times for upcoming lots.

Sidebar: Exercise for FabTime Software Users

If you have FabTime's software, you can compare your production lot and development lot cycle times. To do this, follow these steps:

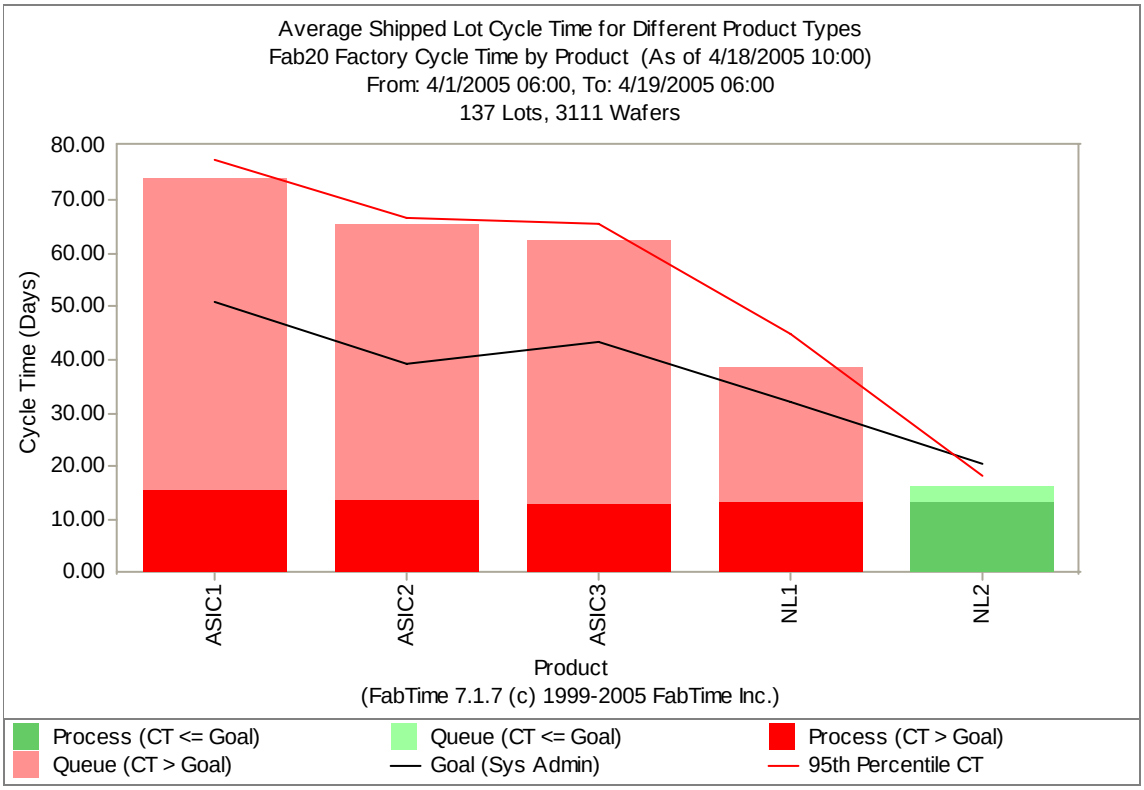
1. From the Chart list, show "Factory Cycle Time Charts", and press the "Go" button to generate the "Factory Cycle Time Pareto" chart.

2. Edit the "From" date to look back over some reasonable length of time, such as one month.

3. Scroll down to the "Slice" control near the bottom of the main set of filters, and slice by "Owner." Then press the "Go" button below the set of filters. FabTime should display average cycle time for all lots shipped during the time period, with a column for each owner class (e.g. mfg, eng, dev, etc.). If your fab uses the same owner codes for development and production lots, you may be able to slice by Product or Family to separate development lots from production lots. An example is shown at the top of the next page.

Conclusions

For many fabs, running development wafers in a production fab is a necessary part of doing business. However, the development wafers can have a negative impact on production lot cycle times. In this article, we have discussed several



reasons why development lots may contribute to higher production lot cycle times, in particular tool dedication and groupings, lot priorities, and development process variability. We have traced each of these factors back to their effect on the three fundamental drivers of fab cycle time: utilization, variability, and number of tools per tool group. We welcome your feedback!

Closing Questions for FabTime Subscribers

Can you think of other reasons why development lots contribute to higher cycle times? Are there things that your fab has done to mitigate this effect? If we receive sufficient feedback, we will do a follow-up article on ways to mitigate the cycle time effect of development lots in a production fab.

Further Reading

- Yu-Chih Chen, K. L. Young, and J. Y. Chou, "Key Factor for New Technology Transfer on the R&D Cycle-Time System," *Proceedings of the 2004 Semiconductor Manufacturing Technology Conference*, 182-185.
- S. H. Chung and H. W. Huang, "Cycle Time Estimation for Wafer Fab with Engineering Lots," *IIE Transactions*, Vol. 34, No. 2, 105-118, 2002.
- H. Koike, F. Matsuoka, S. Hohkibara, E. Fukuda, K. Tomioka, H. Miyajima, K. Muraoka, N. Hayasaka, and M. Kimura, "Quick-Turnaround-Time Improvement For Product Development And Transfer To Mass Production," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 11, No. 1, 54-62, 1998.
- M. Pullon and G. Kong, "Critical Factors in Successful Transfer of Semiconductor Products across Factories," *IEEE 2000 Advanced Semiconductor Manufacturing Conference (ASMC '00)*, 157-161, 2000.
- C. Terwiesch and R. E. Bohn, "Learning and Process Improvement during Production Ramp-Up," *International Journal of Production Economics*, Vol. 70, No. 1, 1-19, 2001.

Subscriber List

Total number of subscribers: 1953, from 434 companies and universities. 22 consultants.

Top 10 subscribing companies:

- Intel Corporation (108)
- Analog Devices (78)
- Infineon Technologies (64)
- STMicroelectronics (60)
- Atmel (59)
- Freescale Semiconductor (59)
- Micron Technology (54)
- Philips (47)
- Texas Instruments (46)
- TECH Semiconductor (43)

Top 5 subscribing universities:

- Virginia Tech (10)
- Arizona State University (8)
- Ben Gurion Univ. of the Negev (7)
- University of California – Berkeley (7)
- Georgia Tech (6)

New companies and universities this month:

- Comlase AB
- One Network Enterprises
- Seaware Technologies
- SYSTEMA GmbH
- Technology Resources Group
- University of Shanghai for Science and Technology
- Uppsala University (Sweden)
- Veeco Instruments

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.

To subscribe to the newsletter, send email to newsletter@FabTime.com, or use the form at www.FabTime.com/newsletter.htm. To unsubscribe, send email to newsletter@FabTime.com with "Unsubscribe" in the subject. FabTime will not, under any circumstances, give your email address or other contact information to anyone outside of FabTime without your permission.

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.

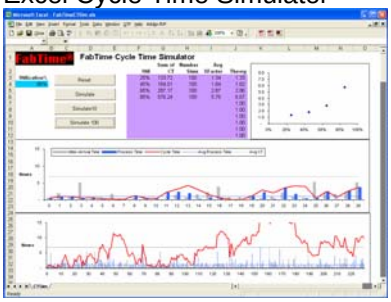
Skills Gained

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

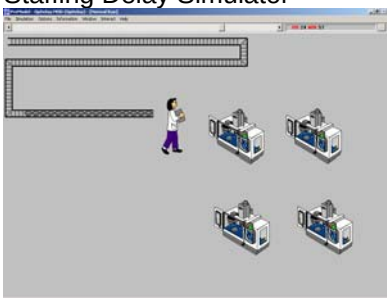
- Identify appropriate cycle time management styles.
- Teach others about utilization and cycle time relationships.
- Define and calculate relevant metrics for cycle time.
- Teach others about Little's law and variability.
- Quantify the impact of single-path tools and hot lots.
- Apply cycle time intuition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