FabTime Cycle Time Management Newsletter

Volume 14, No. 2 March 2013

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 the software this month include new instant-load home page tabs, and a new "Search FabTime" dynamic search control on charts page.

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Contributors: V. A. Ames (ISMI); Bob Kotcher (Simitar Consulting)

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Welcome

Welcome to Volume 14, Number 2 of the FabTime Cycle Time Management Newsletter! We hope that you are starting to experience spring, wherever you are. Here at FabTime we are excited to announce our first User Group meeting, to be held this fall at the Atmel site in Colorado Springs (details below). We also have other community announcements regarding the Fab Owners Association meeting schedule, and WWK's 7th annual semiconductor manufacturing technology survey. We have a new subscriber discussion question regarding percentages of hot lots and lots on hold, and responses to two past topics (Earned Plan Hours and OEE Loss Factors).

Because the subscriber discussion and announcements sections are rather lengthy this time around, we have opted for a brief main article. We revisit a topic first introduced way back in Issue 1.01: The Hawthorne Effect. The Hawthorne Effect refers to a tendency for worker performance to improve as a result of being monitored. Can you see the implication for reporting systems?

Thanks for reading – Jennifer

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Community News/Announcements

FabTime to Host First User Group Meeting at Atmel in Colorado Springs

In response to requests from several customers, FabTime will be holding its first software user group meeting this fall. The meeting will be held September 18th and 19th (1.5 days) at Atmel's campus in Colorado Springs. The meeting will provide our software customers with the opportunity to:

- Learn about how other fabs are using FabTime to improve their operations;
- Understand new software features;
- Review and comment upon FabTime's roadmap; and
- Network with FabTime staff and colleagues from other customer sites.

We are grateful to Dan Malinaric from Atmel for offering to host this meeting, and we hope that many of our customers will be able to attend. This meeting will only be open to FabTime software customers. Please mark your calendars. More details will follow via email.

Wright Williams & Kelly, Inc. Conducts 7th Annual Semiconductor Manufacturing Technology Survey

February 13, 2013 (Pleasanton, CA) - Wright Williams & Kelly, Inc. (WWK), the global leader in cost and productivity management software and consulting services, announced today the start of its 2013 survey on equipment and process timing in the semiconductor industry. The survey results will be consolidated and provided to all participants free of charge. Participation in the survey is the only way to receive a full set of results. The survey form can be downloaded from the WWK web site.

May Fab Owners Association Meeting

The May Fab Owners Association meeting will be hosted by Seagate Technology at their fab in Bloomington, MN on May 9th. The February meeting was held at the SEMI headquarters in San Jose on February 6th and 7th. This meeting was the FOA's first annual collaborative forum. Jennifer Robinson from FabTime presented with John Matthews from Anadigics on balancing WIP movement across the line via dispatching, among many other presentations by industry analysts and FOA members.

FabTime welcomes the opportunity to publish community announcements, including conference announcements and calls for papers. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

This section normally includes a "how to" tip about using FabTime, which is also sent directly to many of our customers via email. This month, we are not including a Tip of the Month, as we plan to send a more detailed version of our User Group meeting announcement to our Tips email list. If you are a FabTime software customer and are not on the Tips email list, you can subscribe here.

Subscriber Discussion Forum

Hot Lot and Hold Lot Percentages

An anonymous subscriber emailed looking to benchmark their percentages of hot lots and lots on hold. FabTime would be happy to collect this data anonymously and share it with you all, if anyone is interested in contributing. Send your responses to newsletter@fabtime.com. We will compile and report back in the next issue.

Issue 14.01: Earned Plan Hours

We received a response to the main article from the last newsletter issue from **Bob Kotcher at Simitar Consulting**. Bob said:

"At a fab many years ago, we were seeing fewer moves in Plating than planned. I set up a process-improvement team with the operators to investigate. We found that the biggest throughput loss was from operators not starting loads that they could not finish within their shifts. Since runs were about an hour long, this alone was causing about an 8% loss of throughput! But the reason for not starting runs was interesting. It was not driven by operators not getting credit (I don't even recall us tracking moves by operator at that time). It was driven by a kind of culture that had developed, in which starting something that you didn't finish was kind of rude—like making a mess that you didn't clean up. (It's amazing, the "soft" factors that you can find that affect performance when you get out on the front lines in a fab…) Still, this problem probably never would have occurred had something like the FabTime/Cypress Earned Plan Hours metric been in place.

A neat thing about results-based measurements like this is that they incentivize elimination of waste, no matter the cause. Thanks for the article."

Issue 12.05: OEE

V.A. Ames from the **International Sematech Manufacturing Initiative** sent us a very detailed response to the main article in Issue 12.05, about Using OEE to Enhance Factory Performance. In that article (written by Michael Krist, Frank Chance and Jennifer Robinson of FabTime), we wrote about a change in the method by which our software calculates OEE (Overall Equipment Effectiveness) Loss Metrics. We discussed the definition and calculation of OEE, introduced FabTime's current methodology for calculating OEE Loss Metrics, and reviewed how to properly use the information provided by OEE to continuously improve an organization's manufacturing capacity. In particular, we noted this:

"The SEMI Standard E79 specifically defines the E10 state relationship to Availability Efficiency and Operational Efficiency losses. However, this document does not explicitly define how to calculate productivity losses and improvement for Rate Efficiency losses and Assignable Quality losses."

We outlined the method that we are using to calculate those loss factors (developed after discussions with John Matthews from Anadigics), and the reasons behind it. V.A. Ames, who has been instrumental in the creation and maintenance of the E79 Standard, shares his response here:

"The SEMI Reliability, Availability, Maintainability, and Productivity (RAMP) task force has begun reviewing the latest SEMI Standard E79-1106 document on the Specification for Definition and Measurement of Equipment Productivity, or in simpler terms Overall Equipment

Efficiency (OEE), to ensure it aligns with the recent changes to SEMI E10 and is updated with any additional information we have learned over the past five to six years. As part of this effort, I reviewed FabTime's article on OEE in the Vol. 12, No. 5 Newsletter to clearly understand the calculations and determine if changes or additions should be made to the SEMI Standard document to provide the information to all SEMI members.

To begin with, I want to point out that the Quality Efficiency formula in Figure 1 of the newsletter is not in line with the SEMI E79 standard. The standard's formula is Theoretical Production Time for Effective Units (Good)/Theoretical Production Time for Actual Units (Starts). The FabTime method of calculating Quality loss (Total Moves – Scrap – Rework Moves) / Total Moves was the common method of calculating Quality before the standard was created, is the most widely used across industries, and is the original formula popularized by Nakajima.

The difference between the two is that when you use the original formula (units or moves) all scrap and rework impacts productivity equally. We used the time based formula to measure the difference in productivity impact that scrap and rework can cause. If you scrap or rework a product wafer that processes at 10wph, it has a greater impact on productivity than one that processes at 30wph. It is also the reason that the original definition of the acronym OEE was changed from Overall Equipment Effectiveness (time and units/moves) to Overall Effective Efficiency (time only) in the standard.

It is understandable why time and units/moves are commonly used because if you only run one product the result is the same with either calculation. Our industry is quite different though because of the magnitude of the different number of products and throughput rates that exist in our factories. Although the data is much easier to capture if moves are used, we decided that the most accurate method would be best for the standard and that the industry should try to attain it. The FabTime method of calculating OEE is an option that can be used. The result will only differ by a few percentage points or less, but it should be called Overall Equipment Effectiveness to differentiate it from the standard.

Also, the FabTime formula for reducing OEE to its smallest terms TheoreticalProductionTime% * Quality Efficiency (should be Effectiveness) can be used, but I feel that the Standard's Simple OEE formula of Theoretical Production Time of Effective Units/Total Time is a much better representation of the widely accepted definition of OEE, which is "The percentage of time it should have taken to complete the good units over the total time measured". I guess it is a matter of personal preference because both formulas give you the same answer.

The article mentions that "In general, OEE is not a useful metric for non-bottleneck equipment…" This is a true statement if the formula you use to calculate it includes all the increments of time being measured. You can, however, discount the amount of time that the equipment sat idle waiting on product in the Operational Efficiency calculation and you will identify all the efficiency losses as if it was a bottleneck tool (100% WIP). The formula for this is in the SEMI E79 Standard document. This can, and should, be done with any tool that could impact the bottleneck by not providing product and risking the chance that it could be idle. It doesn't provide value if you reduce the losses on your other non-bottleneck tools because you are only creating more idle time on them.

The most important factor and the primary reason you should be using OEE is to

identify and track the productivity losses that are occurring in your factory. The desire to have these losses add up to 100% has been around a long time. FabTime has developed a method to do that, so I will propose to the task force that the efficiency loss formulas be added to the standard. A key thing to remember is that no matter how you calculate OEE, it is only a metric. As long as you calculate it consistently, use it to identify potential areas of improvement opportunities, and track progress it really doesn't matter if it is 100% accurate or that the losses add up to 100%.

Our team at International Sematech Manufacturing Initiative (ISMI) works with our members on solutions to efficiency losses through sharing of best practices, benchmarking, and special projects. To better categorize these losses we have identified six areas where losses occur and generate equipment variation; 1) Unexpected downtime, 2) Scheduled downtime, 3) Input and output quality parameters, 4) Skills and quality of equipment support, 5) Spare parts and consumables availability, and 6) Equipment throughput rate.

We are working with members, associate members, and universities on projects like vacuum equipment downtime due to particle excursions, pump failures that cause CVD and LPCVD tool dustings, CMP Pad change and set-up reduction, Equipment Health Monitoring (EHM) using eDiagnostics and many more to better control equipment variation in the six categories above and optimize productivity. In my Equipment Variation Control Workshops we look across our industry, as well as outside our industry, to identify where gaps exist and lessons can be learned to define projects that provide solutions. If anyone is interested in learning how their company, whether it is a chip manufacturer, supplier, or university, can become a member and participate in these activities, they can contact me directly at v.a.ames@ismi.sematech.com."

FabTime Response:

We appreciate V.A. taking the time to review our previous newsletter article in detail, and we are pleased that he will propose our method of calculating the efficiency loss factors to the task force. Regarding our choice to use a moves-based calculation for quality loss, rather than a time-based calculation, the reason we still use the units definition is that doing so makes the quality loss available even to those sites that don't maintain perfect UPH (units per hour) data. For those sites, the only thing that they are missing is rate loss. Rate loss is still a significant component to miss, but if they don't have good UPH data, there's not much we can do to create it. As a software company that works with a wide range of customers, we have learned to make accommodations wherever possible to the data that people actually have available.

We do agree completely with V.A. that the most important reason to use OEE is to identify and track the productivity losses that are occurring within your factory.

If anyone would like a copy of Issue 12.05, to put V.A.'s comments in full context, please email newsletter@FabTime.com to request it.

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Simply send your contributions to Jennifer.Robinson@FabTime.com.

The Hawthorne Effect, Revisited

Introduction

We introduced the Hawthorne Effect thirteen years ago, way back in Issue 1.01. As there were only 33 subscribers then, it seems fairly safe to revisit it now.

The Hawthorne Effect is named after a series of studies conducted at the Western Electric Hawthorne plant in Chicago in the early 20th century. The initial aim of the studies was to understand the impact of lighting levels on worker productivity. As expected, the first studies found that as lighting levels increased, so did productivity. However, researchers did a parallel experiment in which lighting levels were decreased, and found that productivity went up as the light decreased, even when lighting was very low. After conducting a number of other related studies (such as looking at the timing of worker breaks), the researchers concluded that worker productivity increases as a result of the workers being studied. This phenomenon is believed to be due at least in part to the fact that work is a group activity, and employees strive for a sense of belonging [1].

Questions about Validity

Questions have been raised as to the statistical validity of the original Hawthorne experiments. There was a *New York Times* article to that effect entitled "Scientific Myths That Are Too Good to Die" [2]. The article says that "only five workers took part in the study... and two were replaced partway through for gross insubordination and low output." In 2011, Steven D. Levitt (author of *Freakonomics*) and John A. List published: "Was There Really a Hawthorne Effect at the Hawthorne Plant? An Analysis of the Original Illumination Experiments" [3]. According to their re-analysis of the original data, "Existing descriptions of supposedly remarkable data patterns prove to be entirely fictional."

Extensions to Other Areas

And yet... people continue to cite the Hawthorne Effect. There are approximately 233,000 matches on Google to the term, in areas like sociology, education, statistics, and psychology. It seems to come up particularly often in the medical field (in reference to research studies). We ran across this comment in the abstract of an article about patient care: "We utilize the Hawthorne effect, in which the very presence of a research team causes doctors to provide measurably superior quality care for any type of patient to show that patients respond to this increased quality and are more likely to be very satisfied." [4].

Similarly, the About.com Psychology section has a page on the Hawthorne Effect, defining it as "A term referring to the tendency of some people to work harder and perform better when they are participants in an experiment. Individuals may change their behavior due to the attention they are receiving from researchers rather than because of any manipulation of independent variables." [5]

These references put a slightly different spin on the same basic phenomenon. You can find more information via Wikipedia. See the link below [6].

Even when the Hawthorne Effect isn't specifically cited, one can find other articles that describe its effect. FabTime's Frank Chance noted a *Wall Street Journal* article from September 2012 called "How to Stop Hospitals from Killing Us". [7] Here are the bits that particularly caught our eye (though the whole article is well worth a read):

> "Every hospital should have an online informational "dashboard" that includes its rates for infection, readmission (what we call "bounce back"), surgical complications and

"never event" errors (mistakes that should never occur, like leaving a surgical sponge inside a patient). The dashboard should also list the hospital's annual volume for each type of surgery that it performs (including the percentage done in a minimally invasive way) and patient satisfaction scores...

Nothing makes hospitals shape up more quickly than this kind of public reporting. In 1989, the first year that New York's hospitals were required to report heart-surgery death rates, the death rate by hospital ranged from 1% to 18%—a huge gap. Consumers were finally armed with useful data. They could ask: "Why have a coronary artery bypass graft operation at a place where you have a 1-in-6 chance of dying compared with a hospital with a 1-in-100 chance of dying?"

Instantly, New York heart hospitals with high mortality rates scrambled to improve; death rates declined by 83% in six years."

In another case cited by the article, when doctors were told that their procedures were being videotaped: "The average length of the procedures increased by 50%, and the quality scores by 30%. The doctors performed better when they knew someone was checking their work."

This is the crux of the Hawthorne Effect, whether you call it that or not. People perform better when they know that someone is checking their work.

Implications for Reporting

Although it has been applied to many other fields, the Hawthorne Effect has at its root the performance of manufacturing workers. The Hawthorne Effect suggests that if you are looking to improve performance in a manufacturing facility, it may help to let workers know that you are paying attention to what they are doing. One way to do this is to have highly visible reports, with color that quickly shows whether things are good or bad. A sample dashboard that uses colors to quickly indicate problems, generated using FabTime's software (and demonstration data) is shown on the next page. Of course it's not enough to just have the reports - management has to demonstrate that they are using the reports to track how people are doing.

Any benefits from this type of Hawthorne Effect may be temporary, of course. A new performance tracking initiative could lead to a bump in worker productivity, a bump that levels back off again once people are accustomed to the new system. But it still makes sense to us that, if you want to launch a particular type of improvement, doing so with a highly visible performance tracking system, one that people see wherever they go, can only help. In order for people to be incentivized to work harder, they need to see (whether in person or in the form of visible reports), that someone is taking notice.

Conclusions

Regardless of the validity of the original data, the Hawthorne Effect remains a widely used term that refers to people improving their performance as a result of having attention paid to what they are doing. It seems to us that the reason the Hawthorne Effect remains well-known is that it makes sense to people. If you pay attention to what workers are doing, they will work harder than if they are toiling away in obscurity.

Closing Questions for Newsletter Subscribers

Have you ever observed the Hawthorne Effect in your factory? Have you ever deliberately tried to harness it?

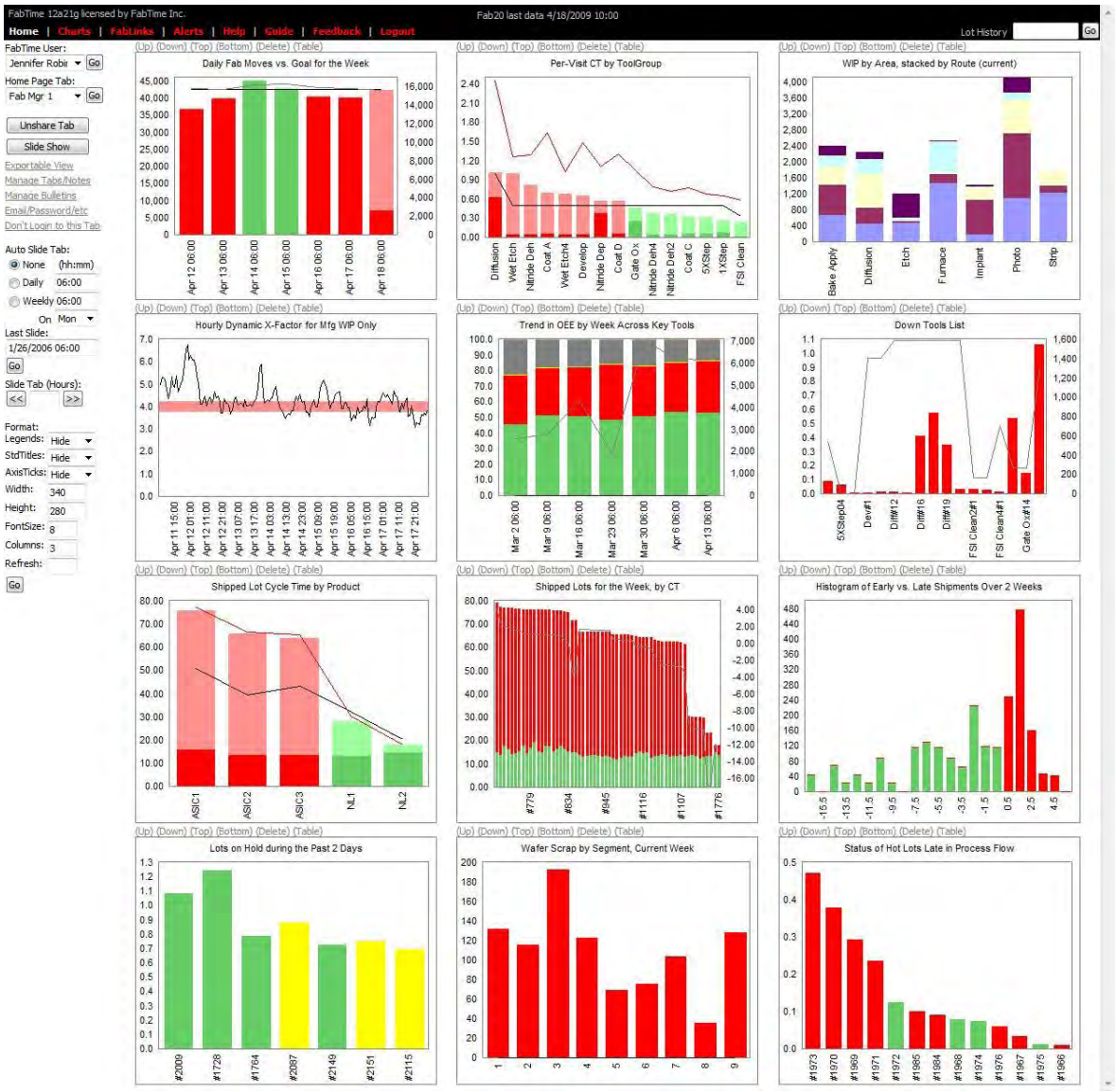

Figure 1. Sample Performance-Tracking Dashboard from FabTime's Software

References

[1] Hopp, W. and Spearman, M, *Factory Physics*, IRWIN, 1996

[2] Kolata, G. "Scientific Myths That Are Too Good to Die". *New York Times*. December 6, 1998.

[3] Levitt, Steven D. and John A. List. "Was There Really a Hawthorne Effect at the Hawthorne Plant? An Analysis of the Original Illumination Experiments", *American Economic Journal: Applied Economics*, 3(1): 224-38.

[4] Leonard KL. "Is Patient Satisfaction Sensitive to Changes in the Quality of Care? An Exploitation of the Hawthorne Effect". *J Health Econ* 27 (2): 444–59. March 2008.

[5] About.com. Hawthorne Effect.

[6] Wikipedia. Hawthorne Effect.

[7] Makary, Marty. "How to Stop Hospitals from Killing Us", *Wall Street Journal*, September 21, 2012.

Subscriber List

Total number of subscribers: 2763, from 441 companies and universities.

Top 20 subscribing companies:

- Intel Corporation (149)
- Maxim Integrated Products, Inc. (141)
- Micron Technology, Inc. (116)
- Texas Instruments (82)
- Carsem M Sdn Bhd (77)
- International Rectifier (70)
- GLOBALFOUNDRIES (68)
- Fairchild Semiconductor (67)
- X-FAB Inc. (66)
- ON Semiconductor (64)
- Western Digital Corporation (63)
- TECH Semiconductor Singapore (59)
- STMicroelectronics (56)
- Analog Devices (52)
- Freescale Semiconductor (50)
- IBM (50)
- Infineon Technologies (49)
- Skyworks Solutions, Inc. (47)
- Seagate Technology (39)
- Telefunken Semiconductors (37)

Top 4 subscribing universities:

- Ecole des Mines de Saint-Etienne (EMSE) (13)
- Arizona State University (8)
- Nanyang Technological University (8)
- Virginia Tech (7)

New companies and universities this month:

- Elettranova Engineering

Sampler Set of Other Subscribing Companies and Universities:

- font
- BOC Edwards (1)
- Dell Computer (2)
- Ernst & Young (1)
- Fab Owners Association (2)
- Finisar (1)
- Flextronics Invotronics (2)
- FSI International (1)
- Fujitsu (1)
- HCL Technologies (1)
- Infinera (4)
- Integrated Device Technology (11)
- Klune Industries (1)
- LG Display (1)
- Lite-On Semiconductor (1)
- Nova Measuring Instruments Ltd. (1)
- Rockwell Automation (1)
- Texas State University (1)
- Tower Jazz Semiconductor Ltd. (19)
- Uppsala University (1)
- Winbond (3)

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

$7500 plus travel expenses for delivery at your U.S. site for up to 20 participants, each additional participant $300. Discounts are available for multiple sessions.

Interested?

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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 and a half-day executive management version are also available upon request. The course is only available for delivery at sites within the United States, unless it is delivered in conjunction with software training for FabTime customers.

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.

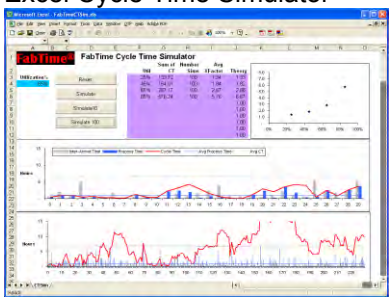
Skills Gained

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