FabTime Cycle Time Management Newsletter

Volume 18, No. 4 August 2017

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 development right now include OEE Detail Trend and Pareto Charts, autocomplete functionality for the SQL Filter, and cumulative moves delta to goal display.

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Keywords: Delivery Performance; Equipment Downtime; Variability

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Welcome

Welcome to Volume 18, Number 4 of the FabTime Cycle Time Management Newsletter! We hope that you are all enjoying the summer. In this issue we have a community announcement about an upcoming conference that we think may be of interest to subscribers. We also have a subscriber response to the previous issue about managing late lots.

In both our user tip of the month and our main article we focus on metrics for tracking availability variability. Overall availability is an important driver of fab capacity, of course. But it is the variability of downtime, especially unscheduled downtime, that makes it difficult to manage on a day to day basis. In this article we discuss two metrics for quantifying availability variability, one more suited to day to day reporting and the other more of an in-depth analysis tool. As always, we welcome your feedback.

Thanks for reading – Jennifer

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Community News/Announcements

50th Winter Simulation Conference (including full track on Modeling and Analysis for Semiconductor Manufacturing)

On December 3-6, 2017, the 50th session of the Winter Simulation Conference will be held in Las Vegas, Nevada. From the conference website:

"The Winter Simulation Conference (WSC) is the premier international forum for disseminating recent advances in the field of system simulation. In addition to a technical program of unsurpassed scope and quality, WSC provides the central meeting place for simulation practitioners, researchers, and vendors working in all disciplines in industry, service, government, military and academic sectors.

From experimentation to theory; standards and advanced methodologies, modeling and simulation is continually pushing the envelope of the available technologies, as many sectors have growing needs to process, visualize, make readable, understand, and deploy complex models that use immense amounts of data. These players need to transform data into hypothesis building and critical decision-making, and to change their models in response to new hypotheses, usually involving multiple highly specialized experts working together in geographically distant areas."

What makes this conference of particular interest to subscribers of this newsletter is the Modeling and Analysis of Semiconductor Manufacturing (MASM) track. This was previously a standalone conference, but merged in with WinterSim a number of years ago. This year's keynote speaker for MASM is Stéphane Dauzère-Pérès from Ecole des Mines de Saint-Etienne, France, discussing Achievements and Lessons Learned from a Long-term Academic-Industrial Collaboration. Here is some additional information about the MASM track:

"The 2017 International Conference on Modeling and Analysis of Semiconductor Manufacturing (MASM) aims to again be a forum for the exchange of ideas and industrial innovations between researchers and practitioners from around the world involved in modeling and analysis of complex high-tech manufacturing systems...

The MASM 2017 conference will be fully contained within the Winter Simulation Conference 2017 (WSC 2017), the leading conference in discrete-event simulation. However, MASM 2017 covers a much wider range of techniques and approaches than simulation (e.g. optimization, scheduling, queueing theory, process control, data analysis). WSC 2017 features a comprehensive program ranging from introductory tutorials to state-of-the-art research and practice."

More information, including registration information, can be found here.

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

Subscriber Discussion Forum

Issue 18.03: Late Lots

Han Ehm from Infineon Technologies wrote: "Thanks for the last Newsletter. You mention the CTS (Cycle Time Spread) and you spend quite some effort to make it small so that you can predict the 95% percentile or even more to be not late. Is this the right approach?

There is quite some time from starting a lot until it is finished and customer demands do change over time. Thus one product might become more important than another one and it could be that some lots have been started which are just built for stocks and to fully utilize the fab. It is undoubted that semiconductor manufacturing requires a low x-factor to be efficient but does it also always need a low CTS – especially when the CTS is used to increase customer satisfaction without jeopardizing OEE and X-factor. What do you think?"

FabTime Response: Certainly we agree that a fab doesn't always need a low Cycle Time Spread, particularly in the case where the fab is making things to stock instead of making things to order. What we should have said upfront in the article was that IF you are making things to order and you have commitment dates to customers that are important to attain, then you will care about lots that are late, and perhaps be interested in this methodology.

We would agree that X-Factor and OEE are important to maintain over time in basically all cases. However, we also think that if you are having problems with lots that are later than planned, there is value in trying to understand why this occurred. Was it poor planning numbers? Changing conditions in the fab? Poor management of scheduled downtime on a key tool? Excessive holds? And so on. But of course this approach will be more relevant to some than to others.

Response from Hans Ehm: "Thanks for the feedback. Now we are aligned. Just to mention that many, if not all fabs, do make to stock and make to order in parallel and that this even can change during the time of production. I fully agree that caring about late lots is beneficial and your methodology is a good approach towards that. Thank you for the fast response."

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

FabTime User Tip of the Month

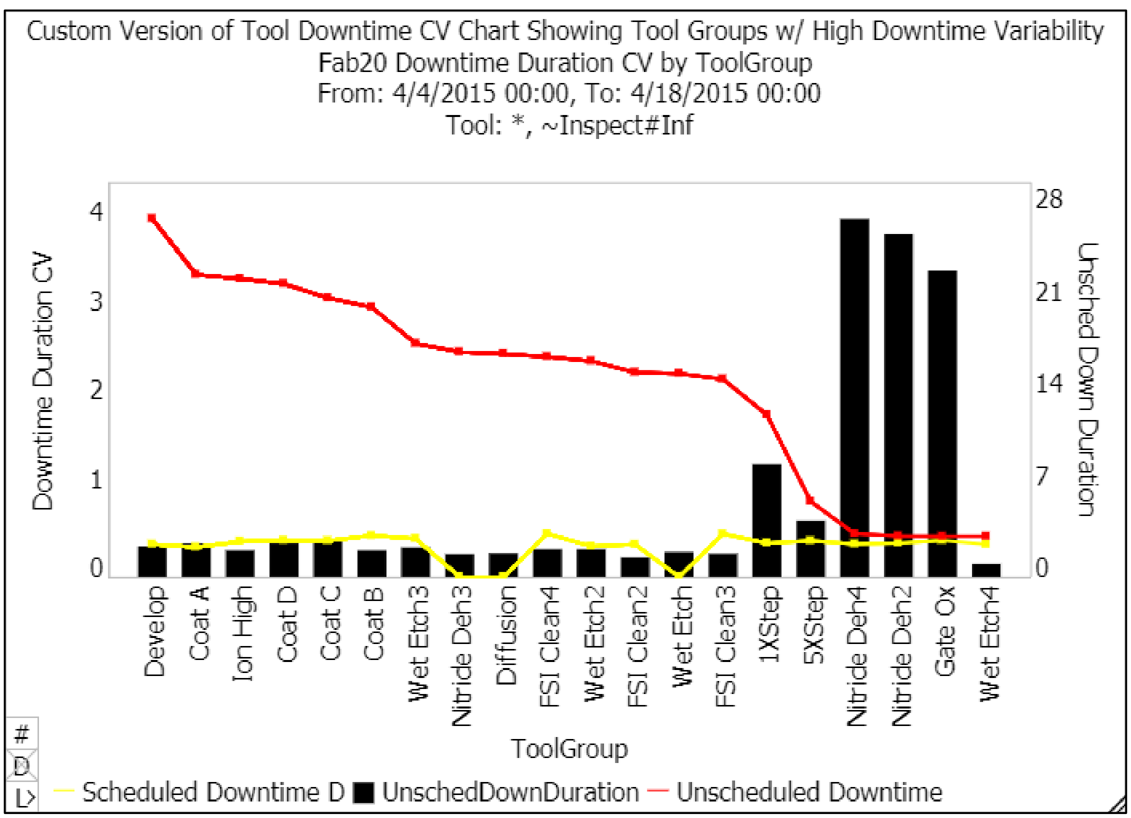
Identify Tool Groups with the Most Variable Unscheduled Downtimes

It is well known that the tools that are a particular problem for fab cycle time are the ones that go down for extended periods of unscheduled downtime. One way to get a sense for which tools have downtimes that are highly variable is to look at the Tool Downtime Duration CV Pareto chart. This chart displays the coefficient of variation (CV) of both scheduled and unscheduled downtime events that have been recorded for each tool, aggregated according to your selections on the chart. So, for example, one useful way to look at this chart is to generate it for all Tool Groups of interest (e.g. the ones in your area), as a pareto sliced by Tool Group, for a time window of at least two weeks (so that there is enough data for the chart to be meaningful). If you sort this chart in descending order by UnschedDownDurationCV it will bring the Tool Groups to the top that have the most variable unscheduled downtimes.

Under these settings, FabTime will take, for each Tool Group, the set of unscheduled downtimes reported in the MES over the time period for all tools in the group, and compute a CV for that dataset (and similarly for the scheduled downtime events). CV (standard deviation / average) is a measure of how dispersed values are from the average value. Where the CV is high, this means that you have a lot of variation in the recorded values; some short downtime events and some long ones. Where the CV is low, there is less variation in the downtime events. Usually the unscheduled downtimes will have a higher CV than the scheduled downtimes, because scheduled events are more predictable. However, if you have a bunch of short PMs, and then a few long ones, you'll also see that reflected in higher CVs.

The chart below shows an example that was generated using FabTime's demonstration server, with a bit of customization. Here we added line markings to the CV lines, and also added a separate data series to the right-hand y-axis. This secondary series is average Unscheduled Downtime Duration.

What we see here is that several tool groups have very high unscheduled downtime CVs (anything above 1 is considered high). There are also three tool groups that have relatively consistent unscheduled downtimes, but those downtimes are averaging nearly 24 hours. It's helpful in a case like this to also look at



the data table, and see the Unscheduled Downtime Count (the number of events included in the calculations). In the case of the two Nitride Deh Tool Groups, there are only 3 and 4 events, respectively, so this data could be an anomaly. The Gate Ox, however, is based on 43 separate downtime events. What this means is that this tool ALWAYS goes down for nearly a full day when it goes down. Useful information to have, we would say.

For those looking for a sense of which tools have downtime distributions that are likely to cause problems in the future, these Downtime Duration CV charts can be a useful tool. This is also a case where the additional information in the data table is particularly useful. We hope you find this tip useful! For more on measuring variability of availability, see the main newsletter article below.

If you have questions about this item, or any other FabTime software questions, just use the Feedback form inside FabTime's software. Subscribe to the separate Tip of the Month email list (with additional discussion for customers only). Thanks!

Measuring Variability of Availability

Introduction

A colleague asked us recently for advice on the use of fab performance metrics for availability variability. We had previously written about this topic back in Issue 4.02, but as this was more than thirteen years ago, we decided that an updated article would be useful.

All fabs, as far as we know, track availability of their equipment. The percentage of time that each tool is up and running and available for production is important in understanding the fab's capacity. What is not as universally understood is that the variation in tool availability is also a significant driver of fab performance. Availability variability can have a major impact on fab cycle time, as well as on short-term throughout rates.

If periods of unavailability were all short and predictable, manufacturing teams could easily plan around them. The problem comes when a tool is unavailable for some extended period of time, particularly if that down period is unexpected. Having metrics that quantify availability variability is useful in identifying the tools that are causing cycle time or throughput problems not necessarily because of their overall availability, but because of the way that variability is distributed over time.

The two primary metrics in use today for quantifying availability variability in fabs, to our knowledge, are A20/A80 and coefficient of variation of scheduled and unscheduled downtime. It is also possible to compute coefficient of variation (CV) of availability observations. We are working with FabTime's User Group on a metric involving CV of availability, and will report on that in a future issue. For this issue, A20/A80 and CV of downtime will be discussed in more detail.

A20/A80

We first learned about A20/A80 from a Future Fab International article by Peter Gaboury (reference below) about measuring equipment process time variability. The article mentioned a metric for availability called A80, "the value of availability where 80% of the time the equipment is up and ready for processing." The article also points out that the difference between A20 and A80 can be used to estimate the variability of availability.

Mr. Gaboury's article did not go into detail about calculating A20 and A80, but we wrote about our interpretation of this metric back in Issue 4.02 (2003), and eventually implemented that version of A20/A80 into FabTime's software. Although we have not seen much published work on this metric, our understanding is that it is in use in various wafer fabs around the world (some that use FabTime and some that do not).

A80 is the best availability reached within 80% of the periods in a set of periods (shifts, days, weeks, etc.). So, for example, if the availability is at least 75% for four out of five days, and then is some lower value on the fifth day, A80 for this set of days will be 75%. A20 is the best availability reached (or exceeded) in at least 20% of the periods in a set. In the previous example, if the highest availability value reached in the five days was 90%, A20 would be 90%. Because A20 looks at the 20% of the periods with the highest availability values, A20 will always be greater than or equal to A80 for the same set of periods. This may be counter-intuitive, and so we will use a more detailed numeric example to illustrate the calculation.

Suppose that we measure availability using FabTime's definition: Availability = Productive + Standby = 100% - Nonscheduled Time - Unscheduled Downtime - Scheduled Downtime - Engineering Time. (The slightly different OEE definition of Availability Efficiency could also be used here - the same general conclusions hold.) Availability can be calculated for any time period, but is often reported on a per-shift basis. Availability is defined for an individual tool, but can easily be rolled up to report availability for tool groups, or even areas.

For the purposes of our example, assume that we have measured the actual availability for a single tool for each of the past 10 shifts, and obtained the following values:

Shift	**Availability**
1	95%
2	75%
3	60%
4	65%
5	72%
6	81%
7	83%
8	91%
9	68%
10	78%

The average availability across the ten shifts is 77%. The easiest way to find A20 and A80 is to take the availability values and sort them in ascending order and look for the bottom 20% of the values and the top 20% of the values. The value just past the cutoff for the bottom 20% (the next higher value) is A80, and the value just past the cutoff for the top 20% is A20.

Shift	**Availability**
3	60%
4	65%

-------------------------------- 80% of the shifts have availability of at least 68%

9	68%
5	72%
2	75%
10	78%
6	81%
7	83%

-------------------------------- 20% of the shifts have availability of at least 91%

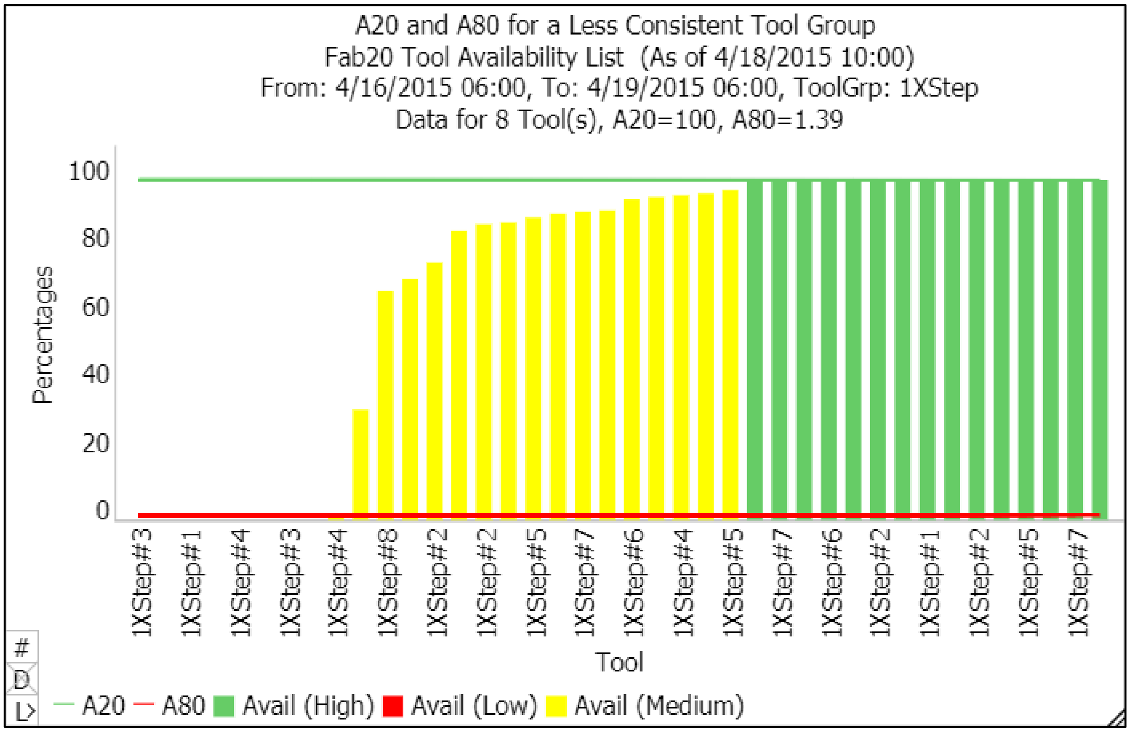
8	91%
1	95%

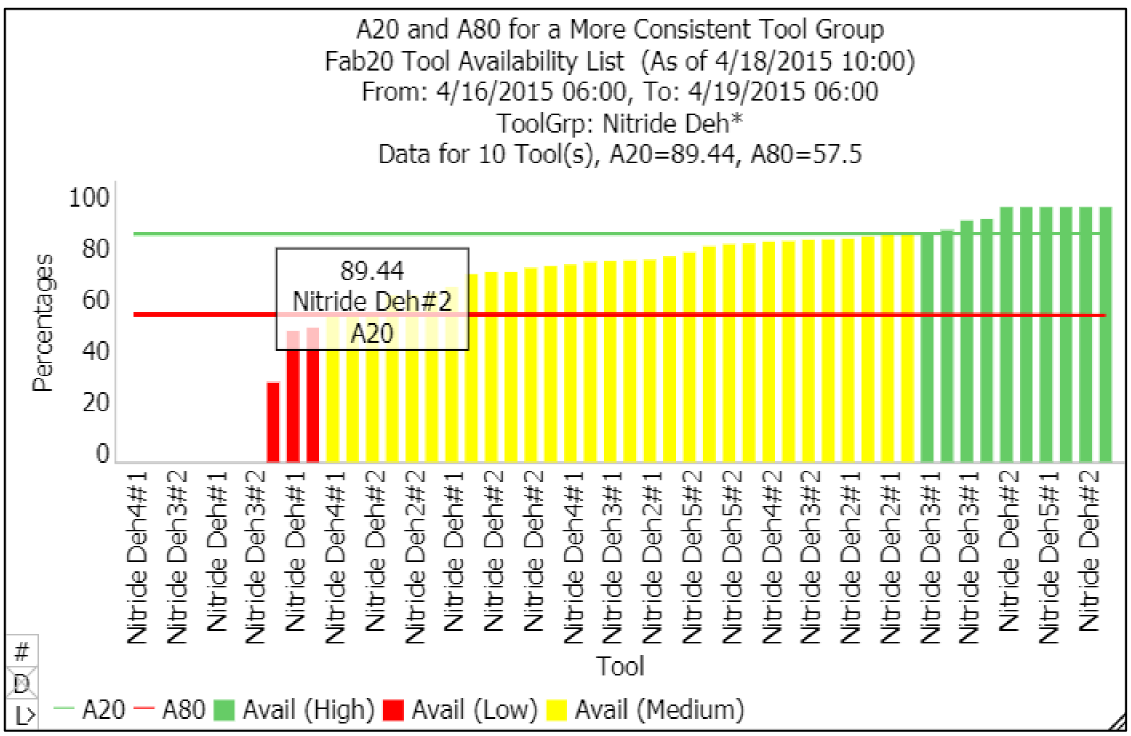
For A80 we look for the highest availability value that was reached (or exceeded) 80% of the time. From the sorted values, this is clearly 68%. For 8 of the 10 shifts, the availability was 68% or better. For A20 we look for the highest availability value that was reached (or exceeded) 20% the time.

From the sorted values, this is clearly 91%. For 2 of the 10 shifts, the availability was at least 91%.

The spread between the A20 and A80 values can be recorded and tracked to drive improvement. The smaller the spread between the A20 and A80 values, the more consistent the availability is from day to day and from tool to tool. Of course we can't look only at the spread - we also need to drive the average availability up. But for the same overall average availability, it is better for cycle time to have a tighter A20/A80 spread than otherwise.

For example, the two Tool Groups shown below both have similar average availability over a three day period (just below 70%). The top Tool Group (1XStep) has an A20





value of 100%. The A80 value, however, is nearly zero. The second Tool Group (Nitride Deh) has a lower A20 value of just below 90%. However the A80 value is much higher at 57.5%. The Nitride Deh tools are likely to be much more reliable to operate in practice (less likely to be down for an entire 12 hour shift).

CV of Downtime

Coefficient of Variation (CV) is a normalized measure of how widely dispersed values are from an average. CV is calculated as standard deviation / average for a set of values. CV is easy to calculate in Excel. Downtime CV is also a standard chart in FabTime, as discussed in the Tip section above.

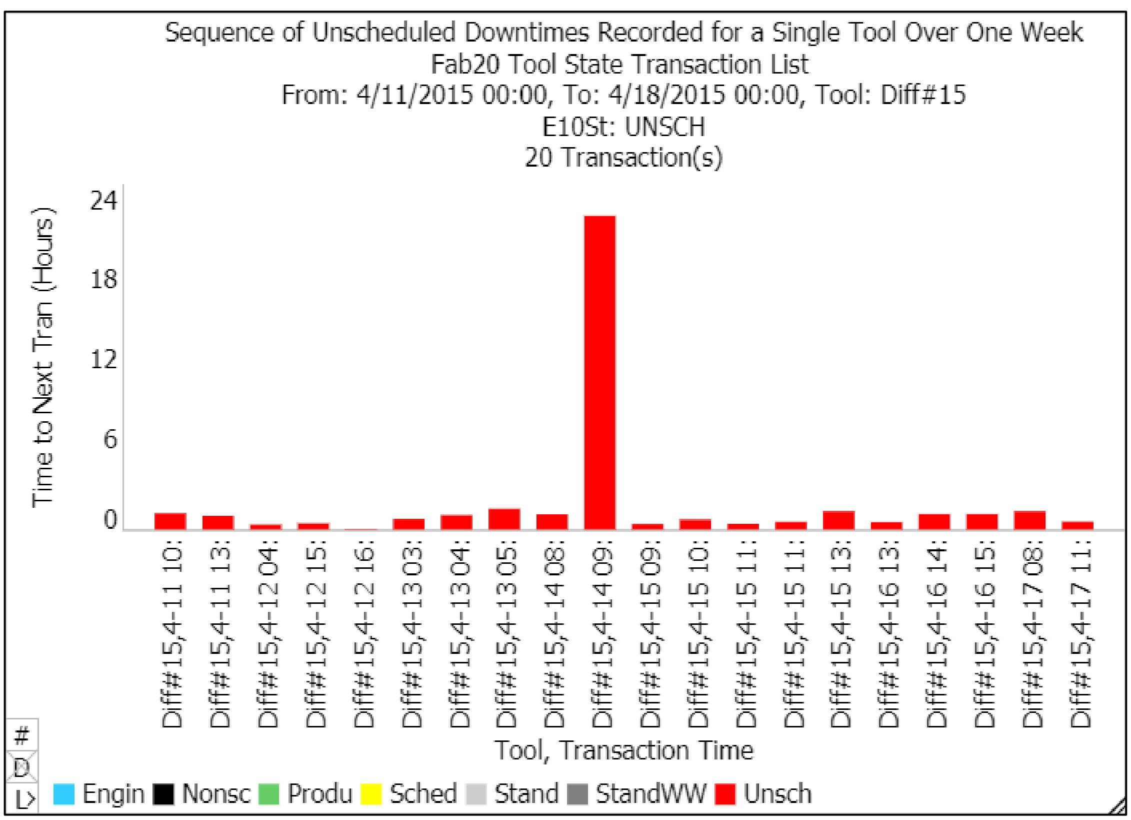
Here's an example of 20 unscheduled downtimes that occurred on a tool over a one-week period. This example is taken from FabTime's demo server. Times are in hours:

0.58, 1.35, 1.15, 1.15, 0.55, 1.35, 0.57, 0.42, 0.73, 0.40, 23.48, 1.13, 1.53, 1.07, 0.77, 0.05, 0.45, 0.35, 1.02, 1.22

The average of this set of numbers is 1.97 hours. The standard deviation (how widely the values are dispersed from the average) is 5.08 hours. This makes the CV 2.58. Anything above one is considered a high level of variability.

The figure below shows what these unscheduled downtimes look like visually. We can see that the one unscheduled downtime that lasted nearly 24 hours is the problem. If we re-do the CV calculations without that downtime event, the CV drops to 0.5, which is considered a moderate level of variability. It's still nearly 20 downtime events recorded over the week, but all of them are resolved in less than two hours, and thus are unlikely to have a major cycle time impact.

In practice, what we think makes sense is to look at a Pareto of scheduled and unscheduled downtime CVs by Tool Group over some reasonably long time period (perhaps two weeks). Tool Groups that display a high CV of unscheduled downtime are likely candidates for downtime improvement projects. Of course any Tool Group that has a high



average duration for unscheduled downtime events is also a candidate for improvement efforts. These Tool Groups, however, are more likely to already be known problems. Analysis of CVs may bring to light Tool Groups that are causing intermittent, but still significant, cycle time problems.

While the above example looks at the CV of unscheduled downtimes, analysis of the CV of scheduled downtimes can also generate useful information. Scheduled downtimes are by definition more predictable than unscheduled downtimes. However, long quarterly or annual PMs also drive up variability, which can be captured by CV analysis.

Our Recommendations and Conclusions

For ongoing monitoring of availability variability, we think that A20/A80 is the more useful of the two metrics discussed here. The idea is to drive for A80 (best availability reached in 80% of the shifts) to be high, and for the two lines to be close together. This means that availability is both good on average and consistent from day to day or shift to shift. We find some sort of Tool Availability List chart, as shown in Figures 2 and 3 above, to be the most visually informative. Comparing charts for two different tool groups makes it possible to see which one has more consistent bars. The A20 and A80 lines will be close together and there will be a minimum of short bars that mean the tool was unavailable for most of a day or shift. Looking at longer terms trends of the gap between A20 and A80 can be a good, quick gauge of the success of improvement efforts.

We think that it's also useful to look for Tool Groups where the CV of the repair time is especially high. This says that the fab may not be doing a good job of getting the tool repaired once it's reported down. Where one finds a high CV of repair time for a key Tool Group, the next thing is to dig into the tool sub-state information, and see if tools are spending extra time waiting for parts or technicians. This type of analysis tends be more of a troubleshooting analysis to look for specific improvement opportunities, while the A20/A80 is more of a day to day metric to measure performance to a target.

Metrics that focus on the variability of availability add an extra dimension to availability tracking. Certainly they do not replace a focus on the overall availability, or on OEE. Rather, availability metrics quantify the idea of keeping downtimes, whether scheduled or unscheduled, consistent from tool to tool within a Tool Group, and from shift to shift. This consistency makes the fab easier to manage, and certainly tends to help with cycle times.

Closing Questions for FabTime Subscribers

Do you measure A80 and A20 in your fab? Do you measure CV of equipment downtimes? Or do you use some other method for quantifying availability variability not discussed here?

Further Reading

- F. Chance and J. Robinson, "Quantifying Availability Variability," *FabTime Newsletter*, Vol. 4, No. 2, 2003. See this article for a more detailed explanation of A20/A80.

- F. Chance and J. Robinson, "FabTime User Tip of the Month - Use A20/A80 Charts to Measure Equipment Variability," *FabTime Newsletter*, Vol. 14, No. 1, 2013. See this FabTime Tip for more detail about using A20/A80 charts in FabTime's software.

- Peter Gaboury, "Equipment Process Time Variability: Cycle Time Impacts", *Future Fab International*, #11, p.163, 2001.

Acknowledgement

This article was inspired by email discussions with **Hani Ofeck** from TowerJazz Semiconductor LTD.

Subscriber List

Total number of subscribers: 2758

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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.

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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.

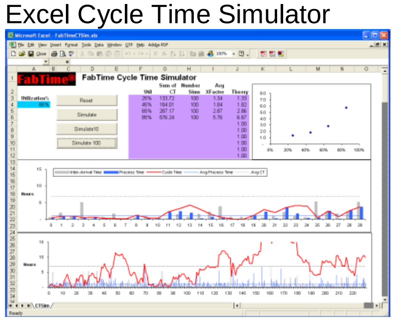
Skills Gained

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