# FabTime Cycle Time Management Newsletter

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## Information

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

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**Editor:** Jennifer Robinson

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## Welcome

Welcome to Volume 4, Number 2 of the FabTime Cycle Time Management Newsletter. This month we are happy to announce the availability of past issues of the newsletter from our new zShop at Amazon.com. We also have two announcements from Court Skinner related to Semicon West. This month's subscriber discussion forum includes a response to last month's article about process time variability, a question about the cost of having the entire fab down for a period of time, a question about a "train scheduling" batch loading policy, and some comments on wafer moves per operator.

This month's main article is about quantifying the variability of availability in a fab. Last month we discussed calculating coefficient of variation for interarrival times and process times. We could calculate the coefficient of variation of availability. However CV is a dimensionless metric that may not carry intuitive meaning for people. Instead, we discuss the metrics A80 and A20, recently described by Peter Gaboury in a Future Fab International article. A80 is the best availability reached within 80% of the periods in a set of periods (shifts, days, weeks, etc.), while A20 is the best availability reached (or exceeded) in at least 20% of the periods in a set. By tracking the spread between A20 and A80, and trying to reduce it, we can reduce the variability of availability, and hence improve cycle time. And by dealing with percentiles, we can use metrics that carry more meaning for people on an ongoing basis than CV values.

Thanks for reading!—Jennifer

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# Community News/Announcements

### Past Issues of FabTime Newsletter Available from Amazon

FabTime is pleased to announce that due to high demand, past issues of this newsletter are now available for purchase from Amazon. Issues are available in PDF format for $9.95 each, and are delivered electronically. You can find the complete listing at http://www.amazon.com/shops/FabTime. The issues will no longer be available directly from FabTime.

### Semicon West Technology Symposium

Court Skinner brought to our attention this call for papers: "Original papers are requested from innovators around the world for the SEMICON® West 2003: SEMI Technology Symposium (STS): Innovations in Semiconductor Manufacturing. This symposium will feature significant technical advances of interest to both materials and equipment users and suppliers. Technical Sessions will feature papers that address practical solutions to real problems. Included will be discussions on new developments and interactions with experts in your field. Collaboration between users and suppliers is encouraged. Abstracts are welcome from all that are directly or indirectly involved with the semiconductor industry including IC manufacturers, academic and government research institutes, equipment makers and materials suppliers." More details are available at http://www.semi.org/web/wcontent.nsf/url/cfpwestf03.

Court added: "Also I'm looking for nominations for the SEMI North American Technology Awards for 2003. It occurred to me today that a lot of the SEMI members sell their accomplishment short. We need to identify those small innovations with the big impact that are real. Here's a link to the nomination form. http://www.semi.org/semiaward." For more information about either of these SEMI activities, you can contact Court at L.Skinner@ieee.org.

FabTime welcomes the opportunity to publish community news and announcements. Simply send them to Jennifer.-Robinson@FabTime.com.

# Subscriber Discussion Forum

### Quantifying Wafer Fab Variability (Issue 4.01)

An anonymous subscriber submitted the following thoughts in response to Issue 4.01: "The discussion about CV is reminiscent of work I was involved in back in 1991/92. The version of the equation we used at the time was:

$$CT_a = CT_{th} \text{ x } K \text{ x } \{[ (rho / (1-rho)) \text{ x } ((Ca^2 + Cb^2)/2) ]^{(1/sqrt(N))}\}$$

similar to yours, but K = a batching constant (furnace vs. single wafer examples) and N = number of parallel processing "like" tools.

In your discussion here I think you have placed too much emphasis on the processing time of the tool, specifically because of all the other impacts you mention (qual time, operator availability, downtime, etc.) are in sum non-trivial vs. the processing time variation. The TOTAL time spent at the tool is the processing time plus the queue time. This is important, as this is what ultimately impacts the release for the next tool (making it part of the arrival distribution of the downstream tool). From studying a fairly high volume, fully loaded fab (26-28K per month) it was our finding that the dominant factor in the CV term for "high loaded" (rho > 70%) is the variability of the TOTAL processing time. Inside of this, the dominant factor was tool performance:

**Case A:** "good" tool performance, MTBF > 100 hours, MTTRecover dominates CV

**Case B:** "bad" tool performance, MTBF < 25 hours, MTBF dominates CV

Of course there was some movement around these cases for different types of tools (mainly based on batching). It was our conclusion that nearing full loading, the most important measurable parameter to control at the bottlenecks was the standard deviation of the MTTRecover (Recover meaning any event that stops the processing of production material when material is available: qual, test, PM, down, no op, etc.). "Managing" the variability of the MTTRecover at bottleneck tools has been the single most effective tool I have found for managing, predicting, and reducing cycle times in a fully loaded fab in my 18 years in the industry."

### FabTime Response:

This is a very interesting point. I agree that more than the pure process time is important. I think that the time that the lot spends waiting at the front of the queue for a tool that should be ready (but is down or doing setup or whatever) should be considered as part of its effective process time - I just think that it's hard to calculate that (because of issues over which lot is at the front of the queue, what happens if another lot comes before the tool becomes available, etc.).

My take on this was that it's much easier to calculate the CV of the pure process times, and that might be a place for people to start. What you're doing is taking another approach to simplify the problem, and using the total time that the lot is at the tool, and calculating the CV of this queue time plus process time.

I still think that the true Effective Process Time (adding in the time that the lot could have been processed, except that the tool is unavailable due to some problem with the tool, but not adding in queue time just because the tool is busy) would be the most accurate thing to use in computing CV of process times, if it were easy to calculate it. But I can well imagine that using the CV of the total time at the tool would be more accurate than simply using the actual process times (move out minus move in). I think that this point is well worth sharing with our other newsletter subscribers, and could be very helpful as they try to implement this type of methodology.

## Cost of Entire Fab Downtime

Madhav Kidambi (Infineon Technologies) asked "If due to some issues the whole fab is down for a period of time, then how can we quantify the impact of this down time in terms of cost or other metrics?" Readers??

## Train Schedule Batch Policy

Jimmy Giles from STMicroelectronics wrote: "I was reading over some of the FabTime issues regarding batch policies, and I wondered if you had run across any information on the Train Timetable or Train Schedule Batch Policy. It is based on the premise that at some point and time, those lots that are building cycle time waiting for the MBS to be achieved should go ahead and process (even without the MBS being achieved). Like a train schedule, at a certain time the train is going to pull out of the station whether it's full or not.

This type of batch policy is basically a policy that supersedes your MBS Rules for the sake of saving lots that are waiting at a batch tool from building unacceptably high lot-based cycle time, and also, making sure we hit the lot's delivery commit date."

**FabTime Response:**
I have heard people informally say that they do batching like trains, meaning that they set a time that the batch will be started, and people try to get lots to the batch tool by that time. However, I've never seen anything published on this. There's actually very little that's published at all on batching rules as implemented in fabs. What I can do is ask this as a question in our newsletter, if you're interested, and see if anyone has any papers on the subject. So, readers, if you know of any papers on this, or even batching dispatch policies as implemented in real fabs, please let us know. Thanks!

### Wafer Moves Per Operator

Najeeb Syed of Agere Systems wrote: "I had a question on one of the topics covered in the last newsletter "Wafer Moves Per Operator". Fab loadings will indeed impact the # of mask aligns, but wouldn't level of automation and type of product running be a bigger impact. For example if in a fab with automated delivery system and more linked tools with automated recipe downloads etc., the operator role will be limited to loading and unloading the lots from the tool. Hence the staffing levels would be low.

Also the comparison can only work between fabs running similar/standard technologies. Products with varying amount of processing per mask level would have a big impact on # of mask aligns per operator, since more operators would be required for technologies with higher amount of processing per mask level. I'll appreciate any feedback."

**FabTime Response:**
I think that level of automation will have a significant impact on the number of operators. I think that the point made last month was that for a given fab (assuming a given level of automation and type of production), the number of operators will vary according to the loading of the fab.

In general, I think that you are completely correct that the comparison of number of operators will only work for very similar fabs. I think that our survey of numbers of operators provides an interesting snapshot of data. But I think that to do a real benchmarking concerning number of operators would require a much more detailed approach, taking into account all of the information that you mentioned. My impression is that many companies are struggling with issues around planning operators right now.

# Quantifying Availability Variability

## Introduction

One of the biggest drivers of cycle time in a wafer fab is equipment downtime (including scheduled downtime, unscheduled downtime, and non-scheduled time). Downtime increases cycle times by reducing available capacity and by increasing variability. The capacity side is fairly straightforward. For a given toolset and product mix, time lost due to downtime reduces equipment standby time, and drives tools upwards on the operating curve of cycle time vs. utilization (where utilization is defined as productive time / manufacturing time, or productive time / (productive + standby time)). In the limit, where equipment downtime pushes standby time towards zero, cycle times can grow very large.

Equipment downtime also dramatically increases variability in a wafer fab, especially when single path tools go down for long periods of time. In this case, WIP piles up, and WIP bubbles can linger in the fab long after the availability problem is corrected.

It is fairly easy to show, using the FabTime Characteristic Curve Generator (first described in Issue 2.7, available as a free download from www.fabtime.com/charcurve.shtml), that longer failures or PMs are more detrimental to cycle time than shorter down events (at the same overall percent of time spent down). That is, it is better from a cycle time perspective for a tool to be down once per day, for 2.4 hours (10% down) than once per week, for 16.8 hours (also 10% down). A long 16.8 hour downtime, especially on a single path tool, gives plenty of time for a WIP bubble to build. To try this, download the Characteristic Curve Generator, and enter 12 (one downtime event per shift), 24 (one downtime event per day) and 168 (one downtime event per week) in the row for MTBF (keeping the percent down the same for all three scenarios).

The point of the above example is not to discuss maintenance schedules in detail, but merely to make the point that when looking at cycle time improvement, simply driving to reduce the overall percentage of downtime is not enough. We need to reduce the variability of the downtime, to avoid longer time periods when tools are not available. What fabs need, then, on an ongoing basis, is a way to measure the variability of equipment availability. This article describes one such metric.

## A80/A20 Background

We came across a recent 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 (he was focused on the calculation of process time variability estimates), and we did not find any publicly available documents describing this metric. However, we thought that it could be useful in measuring the variability of availability. Therefore, we have decided to use this issue of FabTime's newsletter to describe a possible method for calculating A20 and A80 and using them to track availability variability. This calculation method is based on our interpretation of A20 and A80, as described in the Future Fab paper.

## Calculating A80 and A20

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 the OEE definition of Availability Efficiency = Equipment Uptime / Total Time, where Equipment Uptime is 100% - Nonscheduled Time - Unscheduled Downtime - Scheduled Downtime. Availability can be calculated for any time period, but is often reported on a per-shift basis. Availability Efficiency 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 above the cutoff for the bottom 20% (the next higher value) is A80, and the value just above 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%.

## Using the A20/A80 Spread to Drive Improvement

The spread between the A20 and A80 values in the above example is 91% - 68% = 23%. To reduce the variability in our availability numbers, we would like to see a smaller spread between the A20 and A80 values. Suppose that we had exactly the same availability in each of the 10 shifts - 77% (the previous average). Then we would have A20 = A80 = 77%, and the spread between them would be zero. From a cycle time perspective, having the same availability during each of 10 shifts would be better than having the availability fluctuate so widely.

Alternatively, suppose that we had been able, in the previous example, to schedule some PM events differently, so that we could reduce the availability during the two highest shifts (1 and 8) by 15% each, and could improve the availability during the two lowest shifts (3 and 4) by that same 15%. The average availability across the 10 shifts would be the same (77%), but the A20 and A80 values would be quite different, as shown below.

**Shift** **Availability**
9 68%
5 72%
(---- 80% of the shifts have availability of at least 75%)
2 75%
3 75%
8 76%
10 78%
1 80%
4 80%
(---- 20% of the shifts have availability of at least 81%)
6 81%
7 83%

Now we have A20 = 81% and A80 = 75%, and the spread between them has decreased from 23% to 6%. While A20 has degraded, both A80 and the spread have improved from the previous example, by more smoothly distributing the downtime across the 10 shifts. Naturally, it would be dangerous to look only at the A20/A80 spread, since we would have had a lower spread if we had had an availability of 60% (the worst value) for all 10 shifts. Then we would have had A20 = A80 = 60%, with a spread of zero, but a significantly worse overall average availability.

## Summary

The difference between A20 and A80 is a measure of how variable the availability is between periods (shifts, days, weeks, etc. - the calculations would be performed the same way). At the same overall average availability, a set of periods with a smaller spread between A20 and A80 will likely have better cycle times than one with a larger A20/A80 spread. Once you have availability values, the calculations for A20 and A80, at least as we have defined them in this article, are very straightforward. They simply require sorting the values, and finding the cutoff points for the top and bottom 20% of the values. A80 is the highest availability value that was reached 80% of the time (or the next value that you reach after you chop off the worst 20% of the observations). A20 is the highest availability value that was reached 20% of the time (generally a higher value than A80, since we only look for the best 20% of the values).

## Recommendations

If you do not currently measure A20 and A80, we recommend that you take some historical data (in whatever time periods you have handy) and measure A20 and A80, and the spread between them, for your bottleneck tools or tool groups. If you also have historical data for average operation cycle times by tool (or tool group), you may be able to make comparisons, to look for correlation between low availability variability and low cycle times (or vice versa).

## Closing Questions for FabTime Subscribers

Do you measure A80 and A20 in your fab?

If so, do you measure them using the method that we described here, or do you use some other definition/method of calculation?

### Further Reading

- P. Gaboury, "Equipment Process Time Variability: Cycle Time Impacts," *Future Fab International*, Issue 11. Available from www.mksinst.com/pdf/IPCeptv.pdf.

## FabTime Recommendations

### The Visual Display of Quantitative Information - Edward Tufte

This is a classic book about the display of quantitative information. We recently read it for the first time, and found it filled with those "Aha!" moments, where something seems obvious as soon as you read about it. You can find this book on Amazon, where it continues to receive excellent reviews.

### Root Cause Analysis - Second Edition

We previous reviewed the book "Root Cause Analysis" by Robert J. Latino and Kenneth C. Latino, and wanted to bring to your attention a new release of this book. You can find a link to purchase this new edition from Amazon, along with our original review, at www.fabtime.com/rootcause.shtml.

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Voltas Limited (1)
Vuteq Corporation (1)
Wacker Siltronic (2)
WaferTech (16)
Win Semiconductor (1)
Wright Williams & Kelly (4)
Xerox Brazil (1)
X-FAB Texas, Inc. (3)
Yonsei University (1)
Zetek PLC (1)
ZMC International Pte Ltd (2)
Unlisted Companies (16)

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