FabTime Newsletter

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Information

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. FabTime's mission is to help the people who run fabs improve performance by 1) letting them configure their own charts, so that they don't need assistance from IT for each new data request; and 2) including them in a community of people around the world working to improve fab operations.

Editor: Jennifer Robinson

Contributors: Avi Turgeman (Tower Semiconductor)

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Welcome

Welcome to Volume 22, Number 1 of the FabTime Cycle Time Management Newsletter. This is the first issue of 2021. Our apologies for the delay in getting this issue released. We do think you will find it worth the wait. In this issue we have an announcement about our new FabTime user interface, a call for papers for the TSIA Joint Symposium, a quick announcement about delivery of sessions of our cycle time management course, and a couple of news links from Jennifer's LinkedIn.

One of the main topics of our course, downtime, particularly scheduled downtime, is the primary theme of this month's issue. Our software tip of the month is about using our new Green-to-Green charts (G2G) to identify cases where you might be grouping PMs. In our main article, we discuss why grouping PMs isn't a good idea for cycle time, and why G2G is a useful metric for monitoring downtime instances. We also have subscriber discussion about dedicating weekends to maintenance events, analyzing failures for time-of-day patterns, and comparing OEE across fabs.

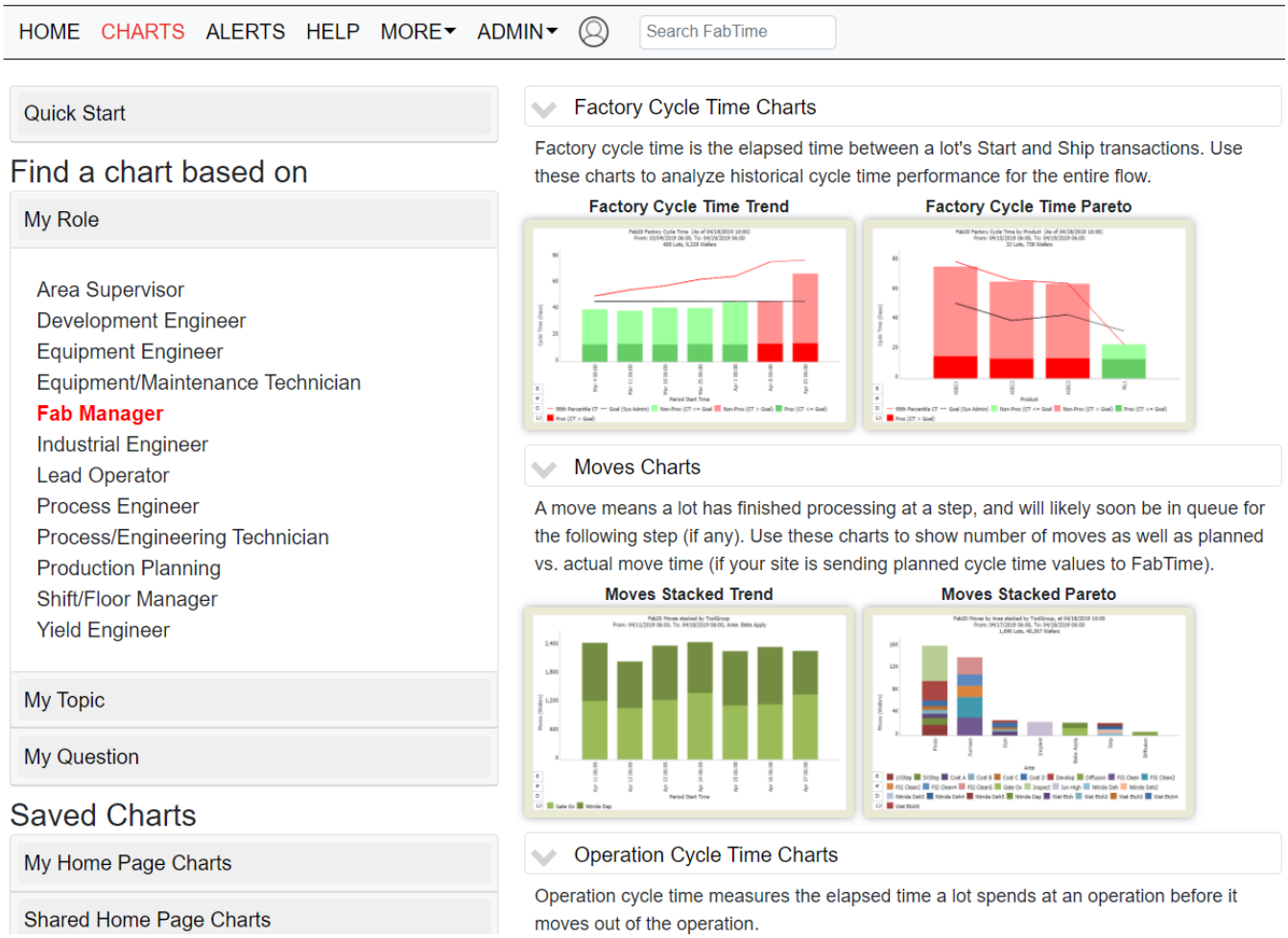
Thanks for your patience in waiting for this issue, and thanks for reading! – Jennifer, Frank, Lara, and the FabTime Team

Community News/Announcements

New User-Friendly FabTime Interface

FabTime is pleased to announce the imminent release of Patch 114, which includes a fully refreshed user interface. Our development team worked closely with our User Group to make FabTime easier to use, especially for new users. Their collective goal was to "make FabTime a joy to use."

The centerpiece of the new UI is a brand-new Charts page that lets users find charts based on their role (e.g., Fab Manager, Industrial Engineer, etc.), their question (e.g., "Which tools have been down > 6 hours?"), their topic of interest (cycle time, holds, etc.), or a recommended set of useful charts. These categories and questions will be pre-populated by FabTime (again, with thanks to our User Group), but can be customized by site. The Charts page includes pop-up sample charts and site-customizable descriptions (e.g., "In our fab, cycle time is recorded from operation 1001 to operation 9050."). Links are also available to user-specific and shared home page tabs, of course, and to the full list of 150+ FabTime charts.



Other highlights of the new version include:

- Smart search: Quickly find charts, help articles, home page tabs, and newsletters, or jump directly to performance charts for a lot or tool.
- Wafer-level tracking: Store and analyze wafer-level transactions in FabTime.
- Improved Look and Feel: New icons, tool tips, drill-down styling, and responsive layout for mobile devices make FabTime easier to navigate.

For a demo of the new user interface, contact Jennifer.Robinson@FabTime.com.

FabTime is grateful to our User Group for sharing their time and experience to help us get these changes right. Special thanks to Justice Stiles from Infineon Technologies, Jason Burk from Microchip, Hani Ofeck from Tower Semiconductor and David Kayton from ON Semiconductor. Thanks also to Art Anderson and his team at Renesas for testing the new UI. We are also grateful to our development team: Frank Chance, Lara, Nichols, Jean-Paul Tu, and Bailey Vandehei, and to all our customers for their patience while the team worked on this upgrade.

Call for Papers: TSIA Joint Symposium 2021of e-Manufacturing & Design Collaboration and ISSM

TSIA/SEMI/GSA, in collaboration with ISSM, endeavor to bring together all the experts and researchers from different fields to share their latest developments, break-through advancements, practical experiences and innovative ideas. Our focus has always been on cross-collaborations, operational strategies, technological innovations, and business partnerships. Topics of sustainable developments are of principal interest.

This Call for Papers is directed towards all industries but the communities of semiconductor, PV and SSL/LED (light-emitting diodes), flat-panel displays (FPD), packaging and testing are highly encouraged. Topics include the following (list abridged by FabTime to retain topics most likely to be of interest to the newsletter audience):

- Benefits and Justification (ROI, CoO, OEE ...)
- Data Collection/Quality/Storage/Management
- e-Diagnostics, e-Manufacturing, and EEC
- Fab Management/Scheduling/Dispatching
- Factory Integration/Operations
- Factory Physics & Queueing Operations
- Final/Lean/Green/Smart/Intelligent Manufacturing
- Industry 4.0/Internet of Things/Machine Learning
- Manufacturing Control and Execution Systems
- Manufacturing Strategy and Operation Management
- Predictive/Preventive Maintenance
- Yield Enhancement and WIP Management

Conference Date: September 10, 2021
Location: Due to the current global lockdown situation, the Joint Symposium 2021 is scheduled as an online virtual event. It shall revert to a physical assembly if the global situation returns to normal by August 2021. The physical event would at the Ambassador Hotel in Hsinchu.
Paper Submission Due Date: June 1, 2021
For more information, see https://www.tsia.org.tw/eMDC2021/

FabTime's Online Cycle Time Management Course

Since the last issue, Jennifer and Frank have both delivered sessions of FabTime's newly refocused cycle time management course. The course is now offered remotely to companies via Teams in two two-hour sessions. The course is tailored to production personnel such as production managers, module managers, shift supervisors, hot lot coordinators, equipment supervisors, equipment and process engineers, and production control. If you find the topics discussed in the newsletter useful, you may wish to consider hosting a session of the course at your site. More information is available on FabTime's website.

Highlights from Jennifer's LinkedIn

Jennifer continues to share articles about business management, the semiconductor industry, and productivity improvement on her LinkedIn feed. Recent topics have included these:

- **Austin Power Outages:** We were happy to see the news that the Infineon and NXP fabs in Austin had resumed operations after shutting down due to the severe winter storms. Nitin Dahad reports in EE Times: "Infineon said revenues are likely to be impacted in the short term, but it doesn't expect full year revenue to be negatively impacted. NXP said there could be an impact of $100 million for second quarter revenue, though it didn't give any indication of impact over the full financial year." The Samsung fab took a bit longer, but was reported back online, per Mike Cronin in Austin Business Journal, by March 30th.
- **Renesas Fab Fire:** Global chip production was also impacted by a fire in a Renesas fab in Japan. Data Center Dynamics reported that "About two percent of the fab's manufacturing equipment was damaged. The area burned totaled 600 sq m (6,460 sq ft), around 5 percent of the entire clean room." The Wall Street Journal later reported that according to Renesas "it would take three to four months to recover full production".
- **Global Chip Shortage:** The incidents in Austin and Japan came on the heels of an existing chip shortage, one that has particularly impacted the auto industry. The shortage has been widely reported, but we especially note this brief WSJ piece by Dan Gallagher about how complex it's going to be to fix the production shortage in the US. Gallagher says: "Chip fabrication plants take years to build and equip. And catching up on a technological basis isn't simply a matter of dollars spent… A long-term solution may require rethinking just-in-time manufacturing practices that minimize inventory on hand." But, of course, our newsletter readers know that higher inventory levels mean longer cycle time. The other approach discussed in the article, maintaining spare capacity in fabs, is better for cycle time, but isn't cost effective. Yes, the factory physics of wafer fabs is a complex thing. We expect to hear much more about this topic in the coming months.

For more industry news, connect with Jennifer on LinkedIn:
http://www.linkedin.com/in/jenniferrobinsonfabtime

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

FabTime® User Tip of the Month

Use Green-to-Green Charts to See Where You Are Grouping PMs

Our main article below is about the impact of scheduled maintenance on fab cycle time. In that article, we propose the use of the Green-to-Green metric as a way of tracking long PM instances. One key point in the article is that in most cases, fabs should not group PMs, but should instead keep them separate, so that tools can come back online and work off WIP in between downtime instances.

You can use the data table for FabTime's Green-to-Green (G2G) chart to identify situations where you may be grouping PMs. G2G time is the elapsed time from when a tool goes down (to unavailable status for scheduled or unscheduled maintenance) to when it comes back up again (available status). It's called "Green-to-Green" time because it measures the elapsed time between two good states (with green color indicating as good). The main concept of this metric is to be able to see (visually) the elapsed time between two available slots and know by the G2G types what happened and whether the unavailable time involved scheduled or unscheduled maintenance work.

A Green-to-Green instance for a tool begins when the tool goes from an Up state (productive, standby, engineering, nonscheduled) to a Down state (scheduled, unscheduled), and ends when the tool returns to an Up state. Within a single G2G instance, the tool may enter more than one Down state (scheduled or unscheduled) or SubState.

To get an idea whether you are grouping PMs in your G2G instances:

1. Select Tool Green-to-Green (G2G) List from the FabTime Charts page.
2. Use the chart filters to select the date range and set of tools you would like to include. You can filter by tool group, area, individual tool, etc.
3. To look at all G2G instances that started with scheduled maintenance (whether or not a period of unscheduled downtime was also included), enter "PM*" into the "G2GType:" filter. FabTime will display all G2G instances that started with a PM, where the height of the bar is the duration of the instance. To see any states that included a PM, enter "*PM*".
4. Now look at the data table for the chart. It may be below or to the right of the chart. Click in the heading of the "G2G Total SubStates" column to sort by the number of sub-events in each instance. Click again (until a down arrow appears in the column heading) to sort in descending order by number of sub-events.
5. Look for cases where the number of sub-events is high. Some of these may be cases where a PM led to an unscheduled downtime. However, in cases where the "G2G Type" is "PM Standard" (or where the only category that you see in the bar of the chart is "PM"), you may be looking at a case where PMs were grouped.

The Green-to-Green chart has many other uses, of course. We will discuss this metric again in future tips. We hope that you find this tip useful.

Subscribe to the separate Tip of the Month email list (with additional discussion for customers only) here: http://www.fabtime.com/tip-of-the-month.php (note new link). Thanks!

Subscriber Discussion Forum

Dedicating Weekends to Maintenance

A participant in one of our cycle time management sessions recently asked us if any other fabs were dedicating weekends to maintenance (and minimal production) with the goal of clearing the decks for 5-6 days of constant production without downtime.

We hadn't heard of anyone doing this with entire weekends, but we did dig up a subscriber contribution from back in issue 12.05 that is relevant:

> An anonymous subscriber wrote in response to Issue 12.04: "I worked for a while at a fab that would shut down completely on Wednesday day-shift for PM work. All maintenance was combined and performed on that shift. It may seem crazy, but it maximized throughput. The techs not doing the PM work did jobs like wiping down tools, walls, and floors. A predictable 8 hours of down-time out of 168 hours per week is less than 5%. I don't know how successful this strategy was in practice. This was back in the days of 4M DRAM in the late 80's on 200-mm wafers. It probably couldn't be done now but the principle is sound."
>
> **FabTime Response:** We can see that policy being nice in a management sense, with the downtime being utterly predictable (and they probably had a nice, clean fab). Thinking about it in terms of cycle time, you're adding 8 hours per week onto the cycle time of every lot during the shutdown. The question, then, is whether you get back those 8 hours per lot due to not having to do PMs at other times. We would imagine that the answer is yes in some cases. You can envision a lot waiting for 4 hours over here for a PM, and then waiting for 3 hours over here, etc. But we're guessing that you wouldn't recover the lost time in all cases. Especially for hot lots, and especially if you have sufficient redundancy in your toolset to not be taking down entire tool groups at one time. Which is probably why you don't see this type of shutdown in practice today (at least we haven't seen it). But it's an interesting idea.

Have any other subscribers tried something like this? If so, have you found it successful?

Analyzing Failure Events for Time-of-Day Patterns

Another question that arose during a recent cycle time management course was whether any fabs are analyzing failure events to look for time-of-day patterns. We have not specifically heard of this but could see it being a reasonable thing to do. Does anyone have experience to share on this? Do you think this is something we should make easier to do in FabTime's software?

Comparing OEE Across Fabs

Avi Turgeman from Tower Semiconductor wrote: "We are Using OEE in all of our fabs. Lately we have started to do some comparison between fabs that are located in different regions / different countries. My question is: How we can compare OEE between Fabs on different tools? Does this have any value? Can we conclude anything from such comparisons?

FabTime Response: As to comparing OEE across fabs, we think the validity of that depends on whether the fabs are measuring OEE the same way. This is most relevant for things like cluster and linked tools, where there may be some assumptions built in with the OEE calculations. Calculating OEE for those tools is quite complex.

Our general feeling about OEE is that it is most useful for bottleneck tools, particularly if you look closely at the different loss factors to identify improvement opportunities. OEE for tools that are not bottlenecks (in a capacity sense) is less useful.

So, if you have similar tool types that are bottlenecks in multiple fabs, we think there is excellent learning to be had by comparing the OEE loss factors on those tools. For example, why is FabA doing better than FabB in minimizing rework losses, or losses due to operator unavailability? But we think that blanket comparisons of OEE across fabs on different tools is not so useful, especially if those fabs are at different places on the utilization curve.

What say you, other subscribers? Are people using OEE to compare performance across different fabs? What issues have you run across in this effort?

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

On Breaking Up PMs and Other Unavailable Periods

Back in Issue 12.04 we wrote about the impact of preventive maintenance (PM) scheduling on cycle time. We recommended that to improve cycle time, fabs focus on reducing the duration of time that a given tool is unavailable, rather than focusing on the time between maintenance events. This can involve breaking up PMs instead of grouping them together. We have made that case many times in our cycle time management course. In Issue 20.02 we introduced a new metric called Green-to-Green (G2G). G2G seeks to track and minimize the time that a tool is unavailable for scheduled or unscheduled maintenance, or any combination of the two. In today's article, we revisit the case for breaking up PMs and propose that fabs consider G2G as a metric for tracking progress.

Background

Equipment downtime is considered by many people to be the largest contributor to wafer fab cycle time. We have been surveying people about cycle time contributors for more than 20 years now. Downtime has consistently been rated the top issue. As we discussed in Issues 4.04 and 5.07, downtime increases fab cycle time through its effect on both tool utilization (by reducing available standby time) and variability.

Equipment downtime events are normally classified as unscheduled or scheduled. The SEMI E10 standard for definition and measurement of equipment reliability, availability, and maintainability (RAM) is an

industry guideline for classifying downtime events. Under E10, preventive maintenance and associated activities are classified as scheduled downtime (along with other planned events like setups, facilities downtime, etc), while unplanned downtime events (AKA random failures) are classified as unscheduled downtime.

While unplanned downtime events often cause more serious cycle time problems than planned downtime events, scheduled events are also significant. Preventive maintenance is something that affects fab cycle time every day, but it's also a relatively controllable effect. The mere fact that we're talking about scheduled downtime means that we have in our power to schedule the events to minimize their effect on cycle time. It's been our experience, however, that this doesn't always happen, in part because of a traditional emphasis on increasing the mean time between failure events.

Shorter, More Frequent vs. Longer, Less Frequent Events

Historically, one of the key metrics for tracking equipment performance in fabs has been mean time between failures. The longer a tool stays up without failing, the better. This is generally a good thing when one is looking at unscheduled downtime events, where the time that the tool is down is relatively independent of the length of time that it was up before going down. The longer the tool is up, in this case, generally correlates with a smaller overall percentage of time spent down. This makes mean time between unscheduled downtime events a useful metric.

However, the mean time between scheduled downtime events, though often reported, is not particularly useful as a metric, and can in fact be counterproductive. The reason for this is that with preventive maintenance, the total amount of time that the tool is required to be offline is usually relatively fixed. There is a certain amount of maintenance that needs to be done on the tool per year, and the question is how to schedule that maintenance. You can have longer, less frequent events, or shorter, more frequent events, for the same total amount of unavailable time.

And while longer, less frequent events result in a higher mean time between downtime events, longer, less frequent downtime events are much worse for cycle time than shorter, more frequent downtime events. This is because long downtimes (whether scheduled or unscheduled) contribute greatly to variability and cycle time, particularly for single path tools.

When a tool is unavailable for an extended period, WIP piles up in front of that tool. When the tool comes back online, it can take quite a long time to work off the pile of WIP, with consequently long per-visit cycle times. Even when you have multiple tools in a tool group, having one of those tools unavailable for an extended period causes the other tools to be run at a higher utilization, and still leads to cycle time problems.

PM Scheduling

PM schedules are, to some extent, a controllable knob (more so than unplanned downtime events, at least). You can't just decide to do all the year's maintenance at one time, because you run the risk of unplanned failures occurring if you don't keep up with maintenance schedules. So that (hopefully) doesn't happen very often. But it can still be tempting to group smaller maintenance tasks, or to take care of some scheduled downtime when a tool is already down for unscheduled downtime. This reduces the number of times that the tool is reported offline over a given period and can reduce tool qualification time (time spent preparing the tool to run wafers once again, after a downtime event).

However, as discussed above, grouping scheduled maintenance items together, or grouping them together with other downtime events, is terrible for cycle time. What you want, from a cycle time perspective, is to always have the time that the tool is unavailable be as short as possible. Then you want to bring the tool back up, work off the pile of WIP that has accumulated, and only then take the tool down again to take care of the next planned event.

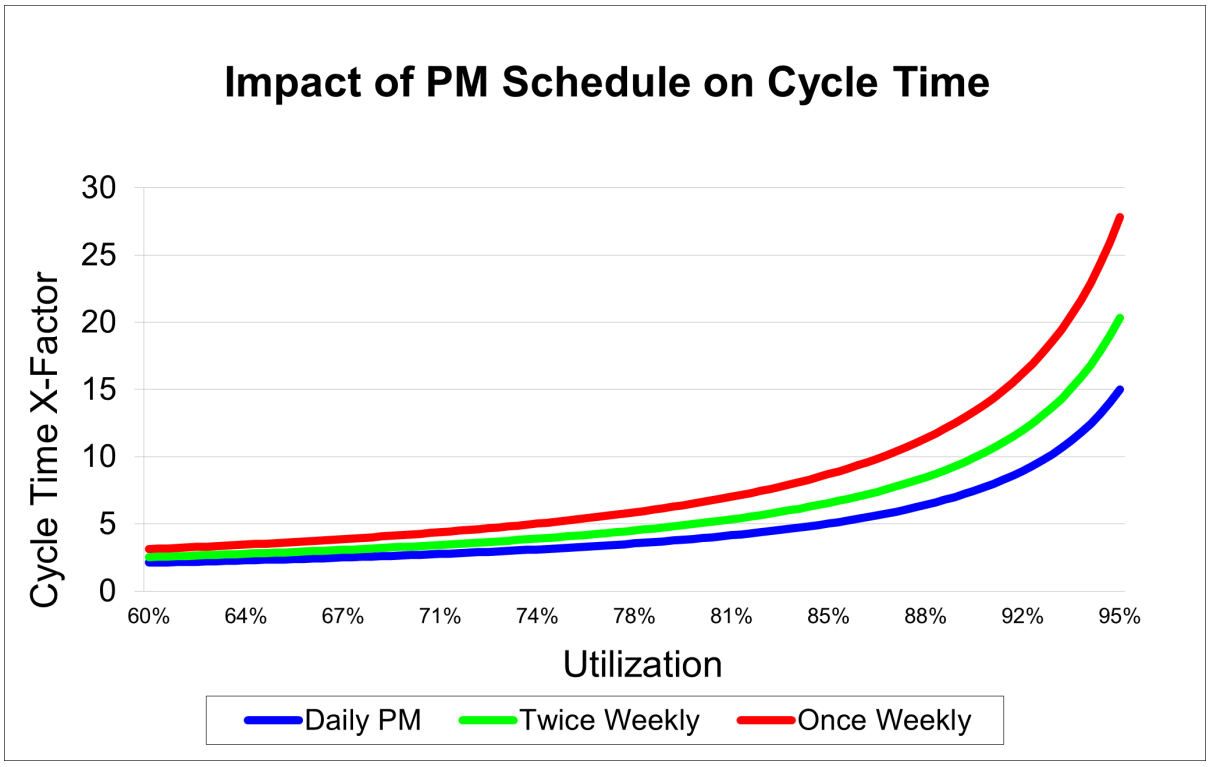
Obviously, there are limits to this. If re-qualifying the tool takes 2 hours, and you have two separate 10 minute maintenance tasks, by all means group them together. But if you're looking at a four-hour task and an eight-hour task, you're probably better off bringing the tool back up in between, especially for a one-of-a-kind tool. Assessing the question of exactly where to draw this line is a good use of small simulation models, or even queueing models. It's quite easy to find examples where even if the total amount of time that the tool is unavailable is a bit larger (due to quals), breaking up the unavailable time still results in a lower overall cycle time through the tool.

Queueing Model Example

Let's use FabTime's Operating Curve Spreadsheet to look at a simple example. This spreadsheet tool was discussed in Issue 12.03. The full version is only available to customers of FabTime's software or our cycle time management course (contact Jennifer for more information). A simplified version, the FabTime Characteristic Curve Generator, is available for download from FabTime's website.

Suppose we have a one-of-a-kind tool that is 85% utilized, has moderate variability (arrival coefficient of variation = 1.0, process time CV = .5), and requires 16.8 hours of PM time per week (10% of total time). Suppose that the repair time variability is relatively low, to reflect fixed PM requirements (CV = .2). If we do the maintenance all at once, in one 16.8 hour chunk each week, the average cycle time for lots passing through the tool will be approximately 8.7X, according to FabTime's queueing-based operating curve generator.

If we break up the PM time into two 8.4-hour chunks, then the average cycle time for lots going through the tool will drop to ~6.6X (at 85% utilization). And if we break the PM time into 7 chunks (one per day), then the average cycle time per visit drops to ~5X. That's a greater than 40% reduction when we go from a weekly PM to a daily PM. The impact is even greater at higher utilizations, or if the repair time variability is higher.



Of course, this is an upper bound on the effect. Breaking up the maintenance may require additional qualification time, driving up the cycle time for the shorter/more frequent maintenance configurations. However, again looking at the graph above, we can look across to see that we could increase the utilization of the system with daily PMs up to about 93% utilization, before the cycle time would match the system with the weekly PM at 85%. Or, conversely, we would have to lower the utilization of the system with the weekly PM down to about 70% to match the cycle time of the system with daily PMs at 85%. That is, breaking up the maintenance reduces the cycle time by so much that we can afford a bit of extra re-qualification time, if needed, in this example.

Simulation Example

In Issue 18.02 we shared a reference that used simulation to show the benefit of breaking up PMs (see Rozen and Byrne in Further Reading). The authors not only recommend breaking up long maintenance events but identify the best situations in which to do so. They do consider the fact that breaking up (or segregating) a PM will require additional setup time. They then look at the fab-wide impact of splitting PMs on overall fab cycle time, via simulation.

They find that "there are only certain types of candidate tools that will improve factory velocity by segregating PMs. Most notably, non-constraint toolsets with many operations, few machines, long PMs and where possible short PMSUs (post-PM setups) are the best candidates for selection."

They find significant improvement at the fab level (in some cases) due to reduction in departure variability from the affected tools. While queueing models like our Operating Curve Generator certainly predict the highest impact for toolsets with few tools, short setup times, and long PMs, it takes a full-fab model to explore the impact of number of operations passing through each toolset.

We recommend that newsletter readers interested in this topic take the time to download and read this paper in full. It is a practical application of simulation that offers a concrete method of improving wafer fab cycle time through changes in PMs.

Metrics for Tracking PMs

If mean time between events isn't a good thing to track for scheduled downtime, what should you track? Let's think about our goals. We want the average duration of the maintenance events to be as short as possible, the CV of the maintenance time to be as short as possible, and the total percent of time spent down to be as small as possible. The mean time between scheduled downtime events isn't important, and can be detrimental, if you, for example, keep a tool up instead of doing an important PM.

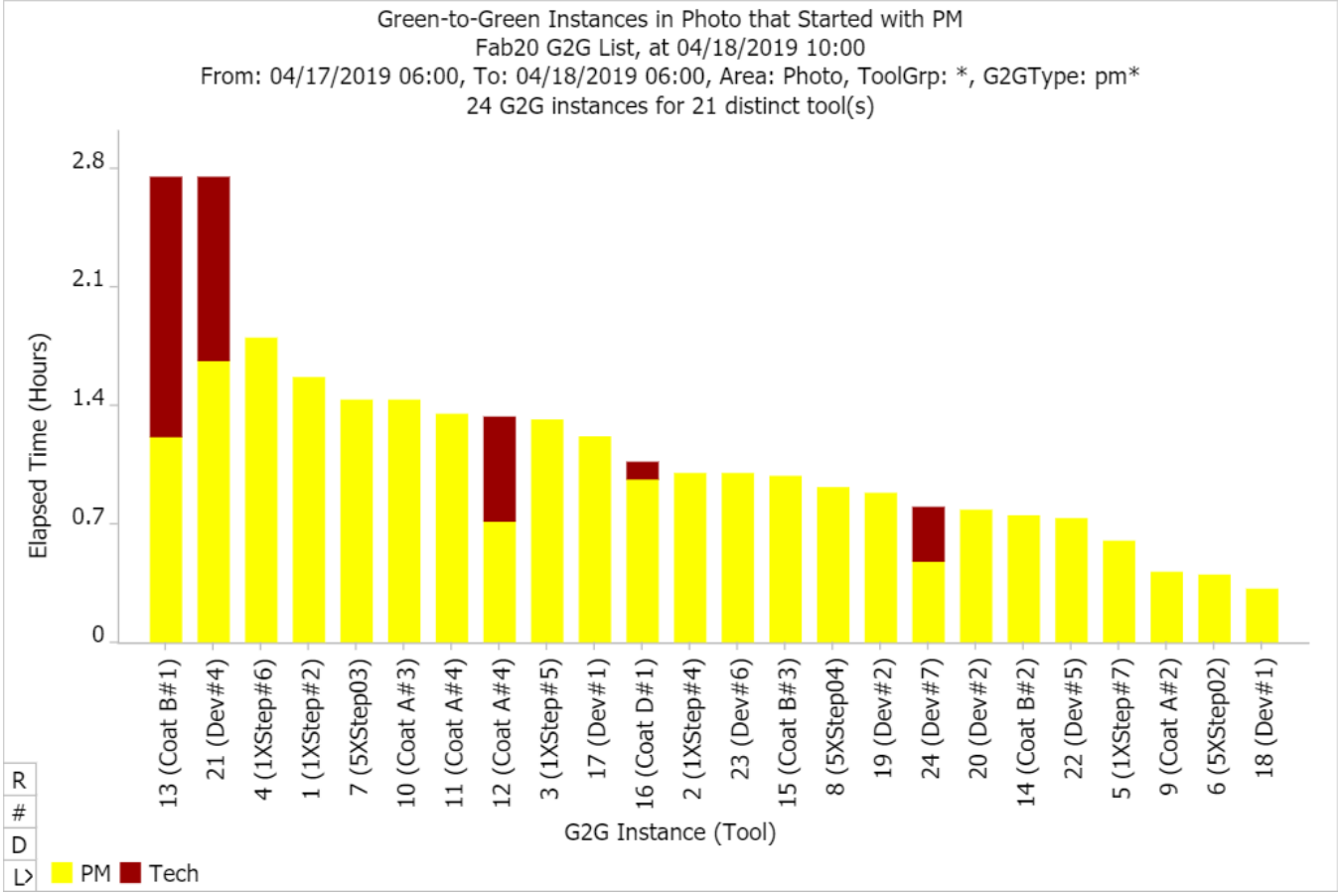
This is where Green-to-Green charts come in. G2G time is the elapsed time from when a tool goes down (to unavailable status for scheduled or unscheduled maintenance) to when it comes back up again (available status). It's called "Green-to-Green" time because it measures the elapsed time between two good states (with green color indicating as good). We wrote about G2G two years ago, in Issue 20.02, and have continued to work with our User Group since then on implementing and enhancing this metric.

We classify G2G instances into six categories:

- PM Standard: All the downtime in the G2G instance is scheduled downtime.
- Repair Standard: All the downtime in the G2G instance is unscheduled downtime.
- PM to Repair: The downtime starts as scheduled downtime but ends with unscheduled downtime. E.g. it starts as a PM but ends as a failure repair.
- PM with Repair: The downtime starts and ends as scheduled downtime but includes unscheduled downtime somewhere in the middle.

- Repair to PM: The downtime starts as unscheduled downtime but ends with scheduled downtime. E.g. it starts as a failure repair, but along the way a PM was added.
- Repair with PM: The downtime starts and ends as unscheduled downtime but includes scheduled downtime somewhere in the middle.

As an example of G2G analysis, we can look at recent PM events in the Photo area, as shown below. Note that the two longest instances are "PM to Repair".



If you group multiple PMs and do them together, they will show up as a longer G2G instance on the above chart. During the instance, FabTime's software ignores transitions to productive, standby, engineering, or nonscheduled time that are less than 2 minutes long (though of course you could select some other threshold).

Future enhancements will involve goal setting and trends for G2G instances.

A Few Other Points on PM Tracking and Scheduling

When we wrote about this topic in Issue 12.04, we received a detailed response from subscriber V.A. Ames (then with ISMI). V.A. made a couple of important additional points. Here are the highlights. See Issue 12.05 for more detail.

- The practice of breaking up PM time "is effective for any scheduled event, like changing consumables or performing regularly scheduled tool qualifications when possible."
- "One of the goals that should be incorporated is to have no scheduled activity last longer than 8 hours. This allows the work to be started and completed on the same shift by the same technician.

As many of your subscribers can attest, much time can be lost if the activity crosses over from one technician to another, especially on swing days."

- "The PM, or any scheduled activity, is composed of work performed when the tool is down (internal) and much more work performed when the tool is running product (external). Things like gathering tools and parts, ensuring any test equipment that may be used is ready, inspecting removed parts, and putting things away are not done when the tool is down."

FabTime agrees with V.A.'s points, and would also add:

- We believe that this concept can be extended to engineering time. Any time that the tool is unavailable to manufacturing is time during which queue time can build up.
- Although we're recommending breaking up maintenance events into smaller chunks, instead of grouping them, it's still true that if you have a fab shutdown, or an extended period when you're not expecting any WIP to a tool, then you should go ahead and get whatever maintenance you can out of the way. See also the subscriber discussion topic above about dedicating weekends to maintenance.
- Just as it doesn't make sense to take one tool down for longer than necessary at one time, it also doesn't make sense to take more than one tool in the same tool group down at the same time, if you have a choice. Staggering maintenance events is much better than doing them simultaneously, so that some amount of WIP continues to get through the tool group. This, we believe, is already common practice in fabs, so we haven't felt the need to spend much time talking about it here.

Conclusions

There are many sources of variability in wafer fabs, including preventive maintenance events. PM schedules, however, are a relatively controllable knob. Scheduling PMs well can reduce variability in the fab, and thus reduce overall cycle times.

While it can be tempting to group smaller maintenance activities together, or to group them in with other downtime events, this is generally counterproductive for cycle time. What's best for cycle time is to have each period of unavailable time be as short as possible, particularly for one-of-a-kind tools, to keep lots moving through the tool smoothly. For cycle time, then, it's better to break PM activity into the smallest possible chunks and make the tool available for production in between.

Clearly, there are limits to this approach, depending on the qualification time required to bring a tool back up, staffing issues, etc. However, it may be worth checking your PM schedules, to see where you may be introducing more variability into the fab than needed. Tracking average and maximum time offline for scheduled downtime, rather than tracking the time between events, is a very good place to start. Even better, we believe, is to use the new Green-to-Green metric for capturing the total time that a tool is down, for scheduled and unscheduled downtime, per instance. Using G2G gives you a way to monitor efforts to shorten periods of unavailability, whatever their cause.

Closing Questions for Newsletter Subscribers

Does your maintenance team try to group preventive maintenance events, or break them up into the smallest possible chunks? Or something in between? Do you measure mean time between downtime events for scheduled downtime, or only for unscheduled downtime? Have you implemented Green-to-Green charts?

Further Reading

- The SEMI E10 Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM) and Utilization, SEMI, 2014. Available for purchase from the SEMI website.
- J. Robinson and F. Chance, "Cycle Time Effects of Equipment Downtime," *FabTime Newsletter*, Vol. 4, No. 4, 2003.
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- J. Robinson and F. Chance, "Queueing Models for Wafer Fabs," *FabTime Newsletter*, Vol. 12, No. 3, 2011.
- J. Robinson and F. Chance, "PM Scheduling and Cycle Time (Issue 12.04)," *FabTime Newsletter*, Vol. 12, No. 4, 2011.
- J. Robinson and F. Chance, "Using OEE to Enhance Factory Performance (Issue 12.05)," *FabTime Newsletter*, Vol. 12, No. 5, 2011. (See subscriber discussion forum.)
- J. Robinson and F. Chance, "A Metric for Green-to-Green (G2G) Analysis (Issue 20.02)," *FabTime Newsletter*, Vol. 20, No. 2, 2019.
- Kosta Rozen and Néill M. Byrne, "Using Simulation to Improve Semiconductor Factory Cycle Time by Segregation of Preventive Maintenance Activities," *Proceedings of the 2016 Winter Simulation Conference*, 2016. Available for PDF download from http://www.informs-sim.org/wsc16papers/235.pdf.

All past issues of FabTime's newsletter are available to subscribers for download from our website. Contact Jennifer.Robinson@FabTime.com for the current password.

Acknowledgements

Hani Ofeck from Tower Semiconductor suggested including Green-to-Green in FabTime's software. Members of our User Group helped us think through and test the implementation. We are grateful for their insights.

Subscriber List

Total number of subscribers: 2845

Top 20 subscribing companies:

- ON Semiconductor (218)
- Infineon Technologies (149)
- Micron Technology, Inc. (118)
- Intel Corporation (117)
- GlobalFoundries (102)
- Maxim Integrated Products, Inc. (84)
- NXP Semiconductors (81)
- Carsem M Sdn Bhd (70)
- Microchip Technology (70)
- Skyworks Solutions, Inc. (65)
- STMicroelectronics (64)
- Western Digital Corporation (63)
- Texas Instruments (56)

- Seagate Technology (54)
- X-FAB Inc. (51)
- Analog Devices (46)
- Qualcomm (39)
- Cree / Wolfspeed (37)
- Tower Semiconductor (34)
- Honeywell (30)

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- Ecole des Mines de Saint-Etienne (EMSE) (9)
- Arizona State University (8)
- Virginia Tech (7)

New companies and universities this month:

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- Kinesic Semi Inc.
- Melexis
- Micro Crystal AG
- Ozotech Inc.
- Principality Building Society
- PureWafer
- Q&D Wire Cable Assembly
- R Systems Computaris
- SEMI
- Seoul National University
- Sunbelt-Solomon Solution
- Zillionix

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